

An analysis of the approaches taken around the world to whale euthanasia

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Abstract

The stranding of cetaceans raises significant welfare and associated logistical issues. A survey of opinions on euthanasia methods based on the recommendations of an International Whaling Commission (IWC) workshop was conducted. Descriptive statistics showed that the workshop recommendations were generally supported and understood, and these included the use of specific euthanasia techniques, but important barriers to adherence were identified, including lack of governmental support, lack of resources, and lack of experienced or trained personnel. Conjoint analysis of factors identified that ‘time to death’ was considered the most important determinant of welfare outcome. In view of the findings of this study, it is recommended that the IWC should consider creating a training programme for responders (both veterinary and non-veterinary) to ensure that trained personnel are available who can implement timely and tailored euthanasia techniques, if required, when strandings occur. Further research on this topic is also advocated to ensure a better understanding of what is being applied in different nations.

Keywords: animal welfare, cetacea, euthanasia, IWC, stranding, whale

Introduction

The International Whaling Commission (IWC) was created in 1946 under the International Convention for the Regulation of Whaling (ICRW) and comprises contracting governments that have adhered to the Convention (IWC 2020a). The Convention was created to conserve whale stocks at a time when hunting was the primary concern (ICRW 1946), but the IWC has progressed to focus on conservation of whales as well as consideration of welfare issues outside of whale hunting (Wright *et al* 2016). The IWC held a Workshop on Euthanasia Protocols to Optimise Welfare Concerns for Stranded Cetaceans, in 2013 (IWC 2014). This remains the most recent attempt by any international body to address large cetacean euthanasia and, as the workshop report shows, is a complex and difficult issue (see also the work of Barco *et al* 2016 and Harms *et al* 2018).

The UK Royal College of Veterinary Surgeons (RCVS) defines euthanasia as “painless killing to relieve suffering” (RCVS 2019). The American Veterinary Medicine Association (AVMA) defines it as “the use of humane techniques to induce the most rapid and painless and distress-free death possible” (AVMA 2013) and emphasises that euthanasia involves ensuring a high standard of welfare leading up to, as well as at, the point of death, including appropriate pre-euthanasia efforts, such as sedation and

proper animal handling (AVMA 2013). Euthanasia of domestic and laboratory animals is well documented and described (Close *et al* 1996, 1997; Cooney *et al* 2012; AVMA 2013; Passler 2014), with accepted standards and common procedures recognised for most species. For wild animals, such as marine mammals, including cetaceans, there are far fewer evidence-based guidelines to follow (Barco *et al* 2016).

Euthanasia of cetaceans is sometimes a necessary outcome for stranding events; where cetaceans become stranded on land and are unable to either refloat themselves or be refloated via human intervention, or when the animal is too severely debilitated, injured, or ill (Daoust & Ortenburger 2001). Euthanasia of whales and dolphins comes with unique challenges, such as location, safety of responders, and public influence (Harms *et al* 2018).

When cetaceans strand, and their weight is no longer supported in the water, they begin to experience muscle degeneration, skin-blistering in bright sun conditions, and difficulty breathing (Daoust & Ortenburger 2001; Harms *et al* 2014; Hunter *et al* 2017). Often the only humane option is to euthanase the animal, especially if the reason for stranding was an injury or illness (Greenwood & Taylor 1980), and as a stranded animal can take days to expire naturally (Harms *et al* 2018). A triage tree which addresses

Table 1 Principal recommendations from the International Whaling Commission Workshop (IWC 2014).

Recommendations
<ul style="list-style-type: none"> • The use of “several chemical and physical techniques for the euthanasia of large beached whales, including chemical sedation followed by potassium chloride (KCl), intra-cardiac injection for baleen whales... and high calibre ballistics and explosives (cranial implosion technique) ... for baleen and sperm whales” • “that euthanasia... should not be conducted by untrained personnel” • “attempts at euthanasia of beached whales should not be conducted when a whale is in the surf” • “all euthanasia methods should be tested on dead animals first” • “for chemical methods, removal of the injection site to limit risk of disposal and potential relay toxicity is a minimum requirement” • “that IWC member nations refine existing or develop new incident response protocols based on the principles and guidelines found in this report”

responses to stranded cetaceans can be found in the *British Diver's Marine Life Rescue Marine Mammal Medic Training Handbook* (Barnett *et al* 2017).

Factors relating to the extreme size of some species can also result in danger for the responders (Dunn 2006). For example, as a result of:

- The chemical euthanasia agent which may be needed in large volume or in very concentrated doses and is potentially highly hazardous to human health (and which is often expensive and difficult to source) (Dunn 2006);
- The use of heavy duty, high energy, ballistics (possibly requiring special licensing or unavailable in some countries) (Greer & Rowles 2000); and
- Close contact with very large animals which may suddenly move (Barco *et al* 2016), although this danger is relevant to all stranded cetaceans which may lash out or accidentally strike responders (Harms *et al* 2018).

Significant barriers to ensuring a high welfare outcome for stranded whales include:

- Difficulty of administration of agents (eg the need for very long needles or certain drugs);
- Availability of suitable methods (eg firearms of adequately large calibre);
- Legal acceptability of method (eg explosives, which EU legislation prohibits the use of [IWC 2016]);
- Access to the animal (eg rocky shores, steep cliffs, or being stranded in the surf may make this difficult or impossible (Harms *et al* 2018);
- Public safety (eg the threat of rising tides or thrashing animals may mean responders are unable to provide an adequate response (Harms *et al* 2018);
- Personnel experience and availability (eg no suitably trained personnel are nearby); and
- Cost of materials, drug agents, equipment, and personnel (Dunn 2006; Kolesnikovas *et al* 2012; Harms *et al* 2014).

These problems are exacerbated as there is little in the way of evidence-based guidelines for responders to refer to for cetacean species, especially larger whales (IWC 2014).

For smaller cetaceans, euthanasia techniques are less limited; for example, smaller calibre firearms which are more readily available may be able to produce an acceptable welfare outcome (IWC 2014). However, for larger species, such as sperm whales (*Physeter macrocephalus*), even common methods, such as ballistics and chemicals, are not feasible, due to size, physiological, and anatomical issues. Hence, new methods and devices (such as the Sperm Whale Euthanasia Device) have been developed (Marsh & Bamber 1999). Recent developments in this area include the Collaborative Development of Recommendations for Euthanasia of Stranded Cetaceans (Barco *et al* 2016), and the Report of the IWC Workshop on Euthanasia Protocols to Optimise Welfare Concerns for Stranded Cetaceans (IWC 2014).

The IWC held a workshop in 2013 with the aim “to bring together international experts to inform guidelines on the best welfare outcome when cetaceans strand” (IWC 2014). This reviewed the techniques for different methods of euthanasia and created recommendations to meet the challenges of euthanasia for large, stranded whales. The principal recommendations from the report are given in Table 1.

Although these recommendations are not legally binding or enforceable, implementation and adherence to these guidelines should arguably be a priority for any nation intending to adopt high standards of animal welfare when euthanasing stranded cetaceans. The workshop recommended that IWC member nations note the protocols discussed in the workshop and adopt them into their own national policies accordingly, but the extent to which this has been implemented is unknown (IWC 2014). These recommendations were developed in 2013 at the workshop and have been in circulation since 2014 when the report was made public and uploaded onto the IWC website.

This study aimed to determine whether these recommendations have been utilised and, if not, why not.

Materials and methods

A questionnaire was developed to explore the following questions:

- Are IWC member nations aware of the recommendations and protocols in the IWC workshop report;
- Are the recommendations appropriate and supported;
- Have the recommendations been adopted into national or other policy;
- If they have not, why not?
- What are the barriers to adherence to these protocols; and
- What aspects of euthanasia scenarios most influence the perception of the event being ‘high’ or ‘low’ welfare?

Ethical approval for this study was granted by the University of Bristol Animal Ethics Board (AWERB) (Reference no UB/19/027) and Human Ethics Board (HSSREC).

The survey was also designed to assess the stranding and euthanasia experience of responders and provided representative scenarios to allow assessment of responders’ experience by using the statistical analysis method, conjoint analysis.

The full questionnaire can be seen in Appendix A (see supplementary material to papers published in *Animal Welfare*: <https://www.ufaw.org.uk/the-ufaw-journal/supplementary-material>). The content of the questionnaire was informed by the literature cited in this paper, and by consultation with two veterinary pathologists working in the field of marine mammal strandings, who have many decades of experience, James Barnett and Andrew Brownlow.

We used a broad interpretation of who might be able to provide useful input to this study, including but not limited to those with hands-on experience of applying euthanasia. Our experts included people who were involved in rescue networks, had relevant veterinary experience and/or appropriate biological knowledge. Potential participants in the survey were found via the UK’s Marine Animal Rescue Coalition contact network and a search of IWC relevant meetings and panels attendees. Additionally, stranding organisations were researched using the Global Marine Mammal Stranding Organisations page on the Marine Mammal Centre site (MMC 2019), cetacean-related publications, and research groups. This process created an initial list of 344 potential participants, and 13% of those approached agreed to participate.

The survey was created using Jisc Online Surveys (Jisc 2019) and distributed via a link in the initial recruitment email to all the potential participants, with a request that respondents forward the survey link to additional respondents that they felt would be appropriate. A reminder email was sent out a week after the initial approach. Respondents were asked to complete a variety of yes/no/other, ranking, and free text questions, as well as being presented with ten scenario-based questions for the conjoint analysis. The responses were automatically coded by Jisc Online Surveys to anonymise individuals. NVivo 12 (QSR International 2019) response analysis was utilised to identify common themes within the free text responses for individual questions, whilst ranked

Chi-squared tests were used to identify relationships between some of the nominal data questions.

Conjoint analysis was chosen in order to explore which aspect of a euthanasia event had the most impact on the perceived welfare outcome (see Butterworth *et al* 2004). This method deciphers participants’ choices as trade-offs within scenarios, or elements of choice where scenarios contain multiple variables (Hair *et al* 2014).

Scenarios were generated using an SPSS (IBM SPSS Statistics Version 25) orthogonal conjoint design. SPSS generated 1,200 scenarios and presented a subset of 49 potential scenarios for each use during the questionnaire. All 49 scenarios are available from the authors as supplementary material. Orthogonal design ensured the coverage of all the inputted variables with a reduced set of scenarios, without having to ask the respondents to look at all the possible created scenarios (Guru99 2019). As 49 scenarios per participant was still excessive, the scenarios were divided into sets of ten (and organised into five questionnaires), with one set being sent to each participant (one of the scenarios was repeated). The scenarios were randomly allocated to each questionnaire using Google’s random number generator.

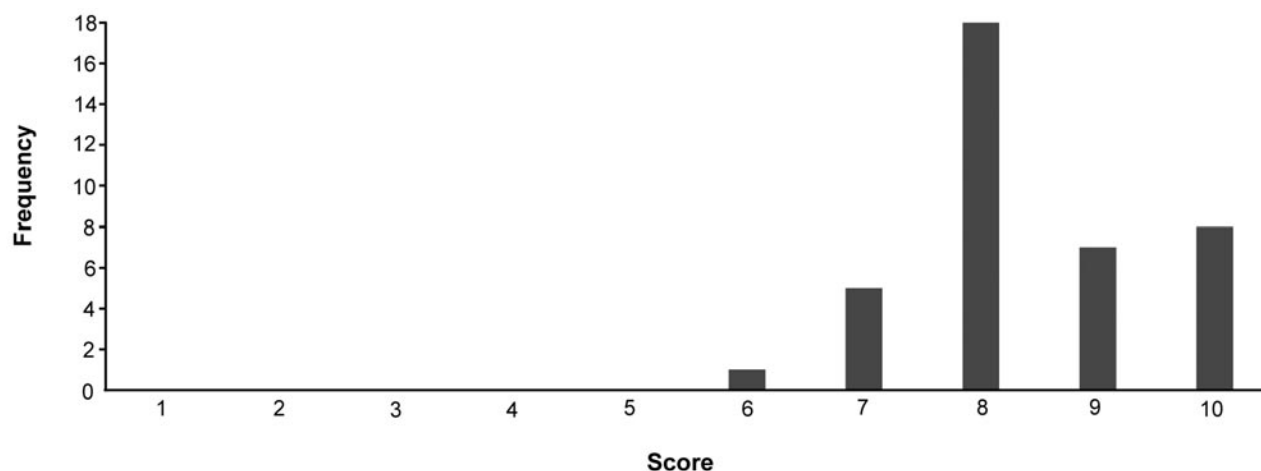
The variables were chosen to represent aspects of a stranding event which affected the variety of euthanasia method available, and the potential range of welfare outcomes. Some variables, such as ‘species’, were left out due to the nature of a conjoint analysis, as the size and species did not ‘match up’ in all scenarios where the variables were randomly allocated.

The variables which were chosen included:

- Was the size estimated? This was included as the IWC Workshop reported several cases where the animal to be euthanased had not been accurately measured, and rough estimates of length (and so of mass) had been made, resulting in a prolonged and inadequate euthanasia event (IWC 2014).
- Other factors (In surf/On beach): When a whale strands in the surf the event becomes much more dangerous for the responders. The IWC recommendations state that euthanasia attempts should not occur whilst the whale is in the surf (IWC 2014).
- Premedication, is it used? The IWC workshop reported that “sedatives are generally used to sedate an animal prior to physical and chemical methods of euthanasia including exsanguination” to improve welfare (IWC 2014).
- Time to death/Size/Method of euthanasia? These were included as the separate elements of this were interlinked, ie the size of animal often affects the euthanasia method chosen, and the method chosen affects the time to death (IWC 2014). The time until death is a period in which the animal could be suffering (Butterworth *et al* 2004).

The participants ranked each scenario on a scale of 1 (very poor welfare) to 10 (very good welfare) for ten scenarios. Once responses were received, they were combined, giving the 49 scenarios at least four rankings each. The data, after collation, were run through SPSS Conjoint Analysis to create a summary output.

Figure 1



Frequency of response (number of responses) to the question 'how relevant did participants find the IWC recommendations?'

Summary output is presented as graphs with 'utility' values and 'averaged importance' values.

Utility values were scaled (sum to zero), and were arbitrary in terms of the actual numbers, with the comparison to zero being important (Orme 2010). Utilities higher than zero are 'preferred' to those below, and attributes allocated the highest utility are the most preferred.

The 'averaged importance' value indicates "how much difference each attribute could make in the total utility of the product" (Sawtooth 2019), in this case: which attribute has the largest effect on welfare.

Results

Forty-four survey responses were received, with additional information from experts contained in their individual email responses.

For the purpose of the presentation of our findings, questions and statements are referred to by their question number from the questionnaire (Appendix A; <https://www.ufaw.org.uk/the-ufaw-journal/supplementary-material>).

The number of replies reported ('n') by each respondent is variable, because some respondents left some answers blank.

Respondents (Q1,2)

Respondents were from mainland Europe (13) and the UK (6), as well as the USA (5), Argentina (5), New Zealand (3), and elsewhere (Brazil, China, Ecuador, Israel, Canada, South Africa, Mexico).

Most were researchers (34.1%) or veterinarians (27.3%), the remainder being stranding co-ordinators (13.6%), scientists (6.8%), pathologists (4.5%), and 'other' (13.6%) (ie ecology expert, ranger, animal welfare advocate, policy officer, volunteer responder, animal care manager) (n = 44).

The amount of 'Experience' of the participants in relation to strandings and euthanasia events ranged from 'none' to 'extensive' (None: 13, Low: 12, Middle: 9, Extensive: 10).

IWC Recommendation opinions/Awareness (Q3–6)

Of the respondents, 83.7% were aware of the recommendations set out by the IWC, and of those who were aware, 78.4% found them straightforward, whereas 21.6% did not. When asked to expand on why they were 'not straightforward', common themes such as 'Lack of financial or governmental support' (25.0%), 'Cetacean euthanasia is difficult in general' (16.7%), and 'Lack of equipment' (16.7%) were noted. Other themes mentioned were 'Limited evidence or data to support the methods' (8.3%), 'Unclear when euthanasia should be performed' (8.3%), 'Unclear who the recommendations are directed at' (8.3%) and 'Communication problems' (8.3%).

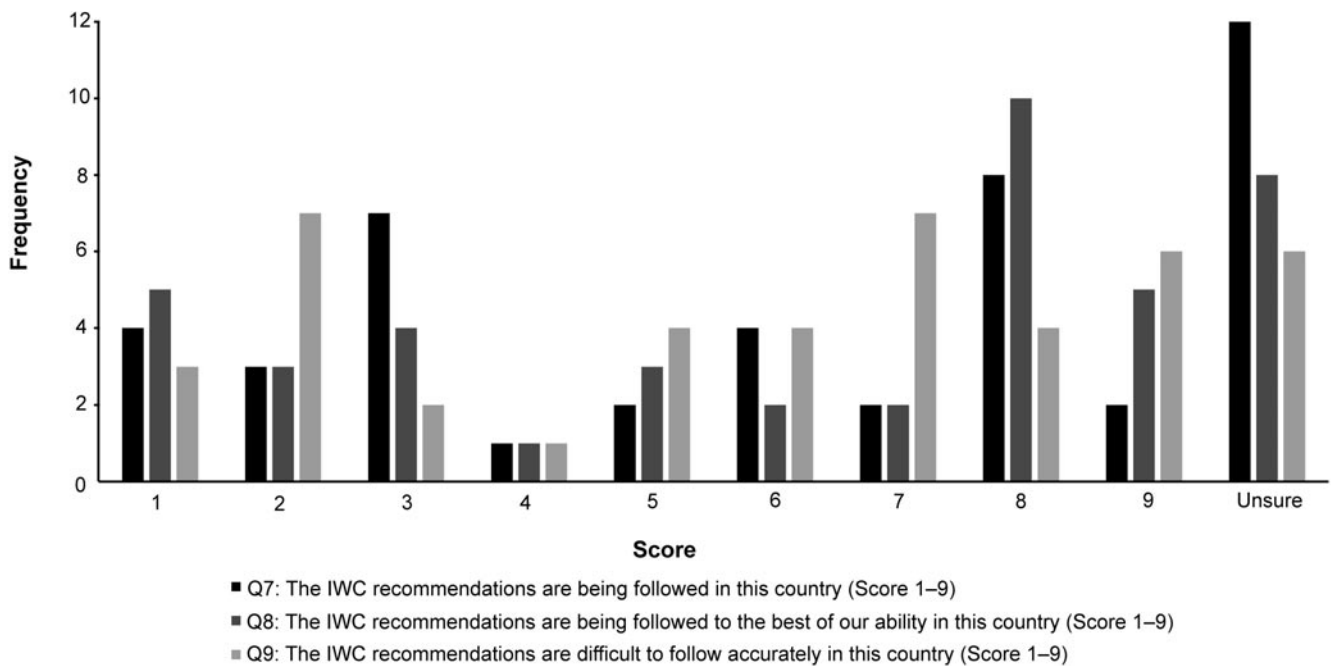
To assess if there was a relationship between level of experience and awareness of the recommendations, a ranked Chi-square test was performed, and no significant difference was observed ($\chi^2_{[3]} > 3.598$; $P = 0.308$), which suggests that level of experience did not affect awareness of the presence of the recommendations. It is worth noting that while some of the respondents did not have experience with strandings, they did have an interest in cetaceans, so this finding cannot be applied overall to the lay population with no experience.

Respondents were asked to score the relevance of recommendations from 1 (not relevant) to 10 (very relevant). Analysis of results shows a mean of 8.4 and a range of 5, the full results are shown in Figure 1.

When asked if they had heard of the recommendations, 21 (48.8%) of respondents had heard of them but had not implemented them, nine (20.9%) had not heard about them prior to then, seven (16.3%) used them in practice, and six (13.9%) knew of them, but had to use alternative methods for practical reasons.

When asked whose responsibility it was to ensure the implementation of protocols, 28 (63.6%) of respondents believed it was the veterinarian's responsibility to ensure the protocols were implemented at the stranding site at the time of

Figure 2



Frequency of response (number of responses) to questions 7, 8, and 9 where 1 denotes 'strongly disagree' and 9 'strongly agree.'

euthanasia, eight (18.2%) selected 'Other', five (11.4%) selected Local Animal Health Officer, and three (6.8%) selected Ranger. None of the respondents selected 'Police.'

Of the 'Other' responses, common themes were 'The most experienced marine mammal expert', 'Stranding coordinator', 'The relevant authority that permits euthanasia', 'Government agency with management responsibility for the marine mammals', and one respondent suggested that it depended on the location of the stranding.

Agree/disagree statements (Q7–10)

Respondents scored three statements relating to implementation of the IWC recommendations, from 1 (strongly disagree) to 9 (strongly agree), or 'unsure', shown in Figure 2. For Q7 (please see questionnaire in Appendix A; <https://www.ufaw.org.uk/the-ufaw-journal/supplementary-material>) the mean score was 5 (n = 33). For Q8, the mean score was 5.5 (n = 35). For Q9, the mean score was 5.4 (n = 38). Overall, there was no strong trend towards either, agreement or disagreement.

For those who strongly agreed with this statement (scores of 7–9), the countries included Canada, Spain, Bulgaria, Argentina, Mexico, Belgium, the UK, and Australia. Those who strongly agreed/agreed with the statement 'The IWC recommendations are difficult to follow accurately in this country' were asked to expand on why this was; common themes were identified, such as 'Lack of money/equipment' (33.3%), 'Lack of experience or experienced personnel' (25.0%), 'Lack of governmental support' (12.5%), 'Lack of public acceptance' (8.3%), 'Unable to access certain methods, eg ballistics/explosives' (8.3%), 'No euthanasia policy/euthanasia is illegal' (8.3%), and 'Inaccessible locations' (4.2%).

The next statement participants were asked to score was 'The IWC recommendations are not being followed/used', shown in Figure 3.

The results for Q10 were strongly polarised, the mean for the scores being 4.49, but the modes were 2 and 3 (and unsure).

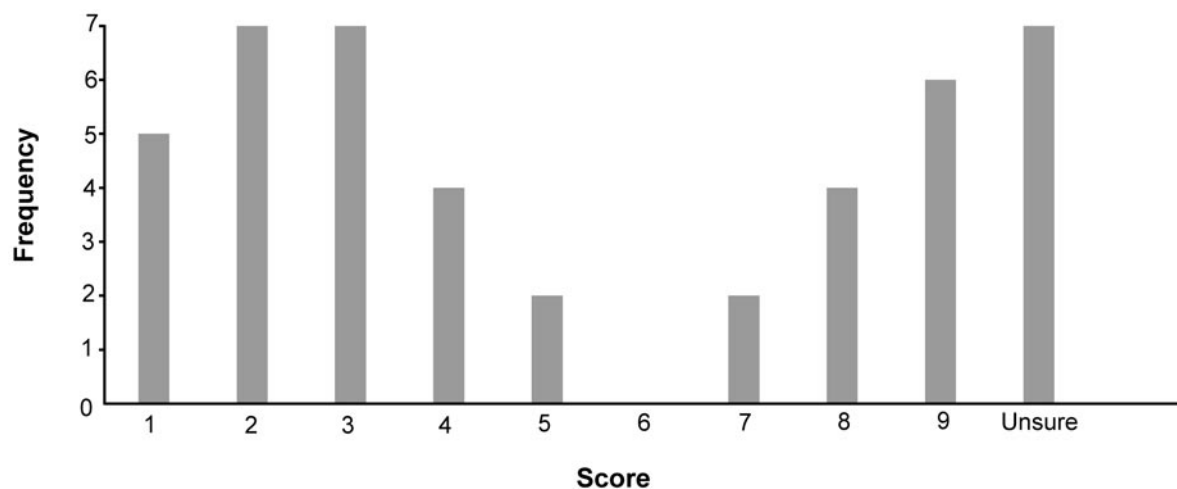
Country guidelines and welfare (Q11–14)

Participants were asked to rank which aspect (out of 'Animal welfare', 'Public safety', and 'Emotions of public') of a euthanasia/stranding event was the most important. Figure 4 depicts the ranking by respondents (from most to least important) given to each aspect.

Of the respondents, 66.7% believed their ranking of importance was reflected in their country's protocols, 95.1% believed their ranking was an accurate representation of IWC protocols, 53.8% believed their country's guidelines were an accurate representation of the IWC recommendations, and 95.1% of respondents considered the IWC recommendations were 'reasonable' from a welfare perspective. For those who disagreed, when asked to expand, the reasons given related to improving rescue techniques (including refloating procedures), and the need for further research.

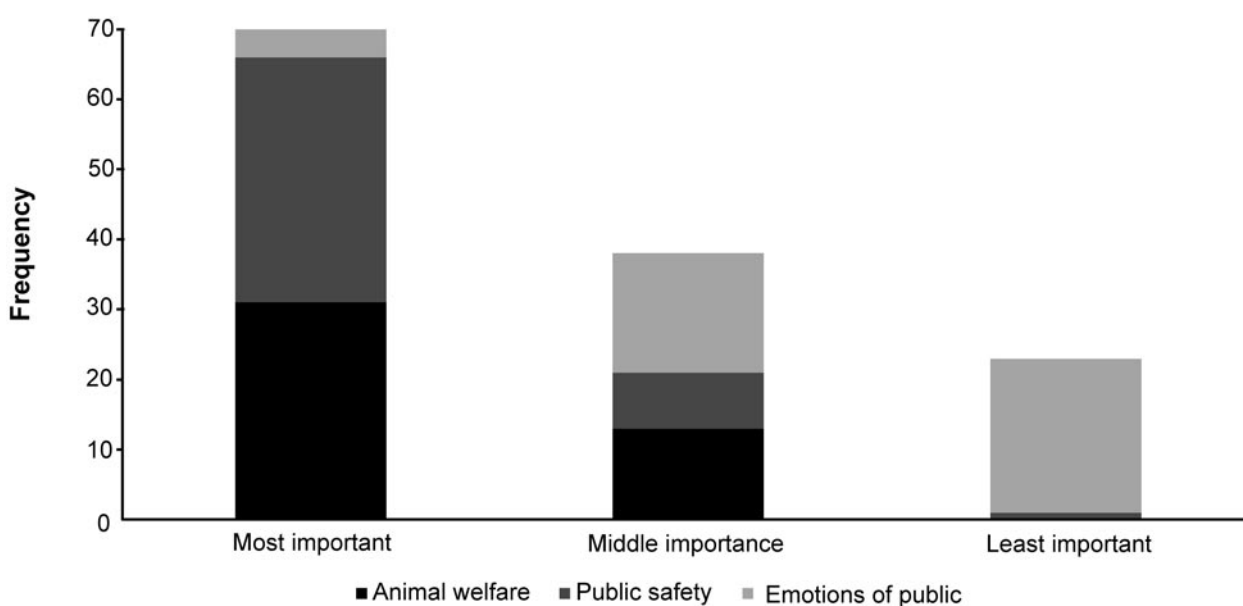
When asked if the IWC recommendations were 'reasonable' considering practical limitations in their country, 80.0% of respondents said they were. For the 20.0% who disagreed, common response themes were 'Lack of government contribution/support' (in terms of policy, and government experience) (40.0%), 'Lack of alternatives for those who cannot comply' (30.0%), 'Lack of experience or trained personnel in general' (20.0%), and 'Lack of resources/equipment/drugs' (10.0%).

Figure 3



Frequency of response (number of responses) to Q10: 'The IWC recommendations are not being followed/used.'

Figure 4



Frequency of response (number of responses) to 'the importance' that respondents allocated to three aspects of a euthanasia/stranding event, from most to least important.

Stranding and euthanasia events (Q15–21)

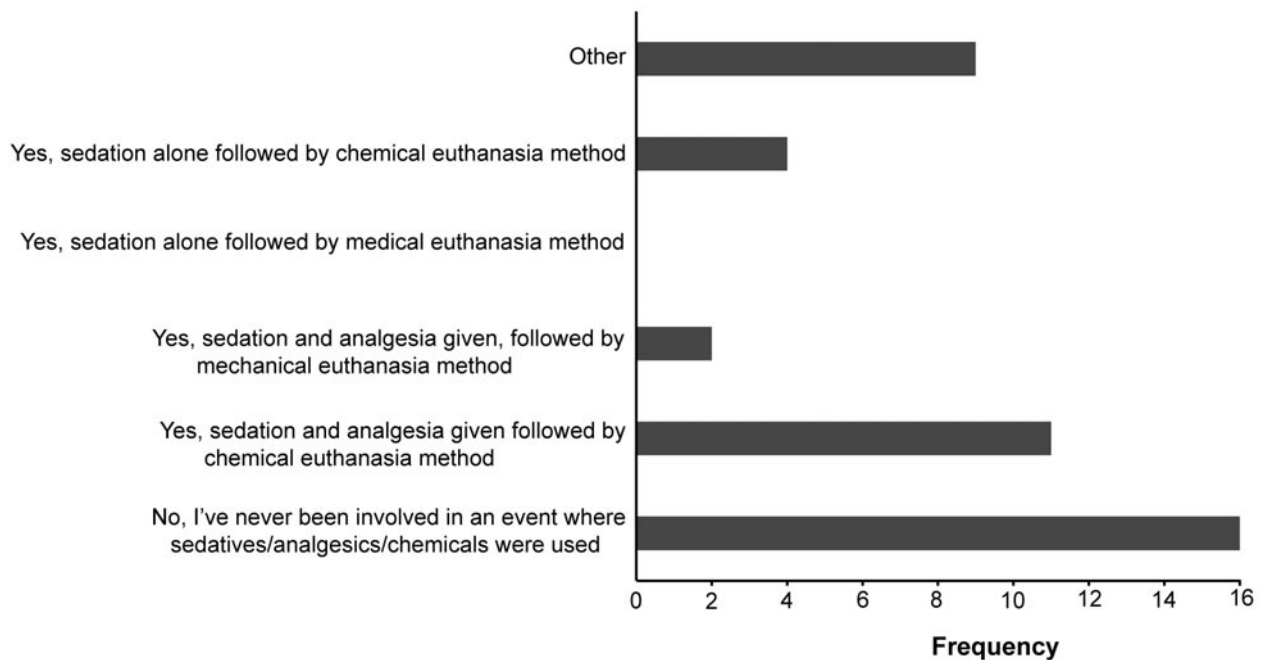
This section of the questionnaire was caveated with: 'If you have been involved in strandings, then please answer the following questions. If you have not been actively involved/have no experience of strandings, please skip to Q22.'

The most common/recent techniques employed for euthanasia (as far as the respondents were aware in their locality) consisted of 'None' (50.0%), 'Ballistics' (19.4%), 'Barbiturates' (19.4%), 'Sedation (overdose with potassium chloride [KCl]/with T-61)' (8.3%), and 'Cranial implosion' (2.8%).

When asked 'To your knowledge, during a stranding where euthanasia is the outcome, are sedatives and analgesics used as routine?', 51.4% said no. Figure 5 depicts the different combinations of sedation/analgesia/euthanasia methods. If the category 'Other' was selected, then participants could explain with a written response, to which all wrote 'Chemical euthanasia alone.'

Participants were then asked whether, in events where chemical agents were used, they had been involved in calculating the weight of the animal, and/or were aware of a weight estimate being carried out. Of 36 respondents, 61.1% said no.

Figure 5



Frequency of response (number of responses) for the different question elements in Q17 'Is death achieved using a chemical sedative/agent.'

For those who said yes, they were asked to expand on how the weight was calculated/estimated: 'Calculations (eg standard equations)' (16.7%), 'Estimated from length' (8.3%), 'Length-weight graphs' (33.3%), 'Online resources, based on length' (16.7%), 'Veterinary tables comparing to horses' (8.3%), 'Weighed (for smaller cetaceans)' (8.3%), 'Whale scale app'; this is an app specifically developed to assist with strandings (Harms 2020) (8.3%). One participant noted that body score was also taken into consideration.

Q19 asked 'When making a decision about which method to use, is disposal of the carcass a consideration?' Of those who answered the question ($n = 40$), 55.0% said yes and 45.0% no. When asked to expand on how disposal influenced euthanasia choice, the main theme identified was 'If the animal could not be moved/was to be buried, then chemicals were not used (other than KCl).' This was due to concerns over eco-toxicity (eg ground water contamination), and secondary toxicity (eg scavengers). Another response was that 'Ballistics were the only method used' for the same reasons of concern over eco-toxicity risks and contamination.

Q20 related to species' differences and asked participants 'Do the technical difficulties of euthanasia (resulting from species' differences) influence practicalities/conformity to the recommendations?' Thirty-six respondents answered, 63.9% said yes, 36.1% said no.

Participants responding 'yes' were asked to expand; common themes included 'Size of animal: Some species too big for any of the methods' (35.0%), 'Volume of drug/Size of equipment' (20.0%), 'Location and accessibility' (15.0%), and 'Anatomical variations' (10.0%). Other reasons (20.0%) included 'Carcass disposal', 'Human safety', 'Public perception', and 'Specific equipment for certain species (eg sperm whales).'

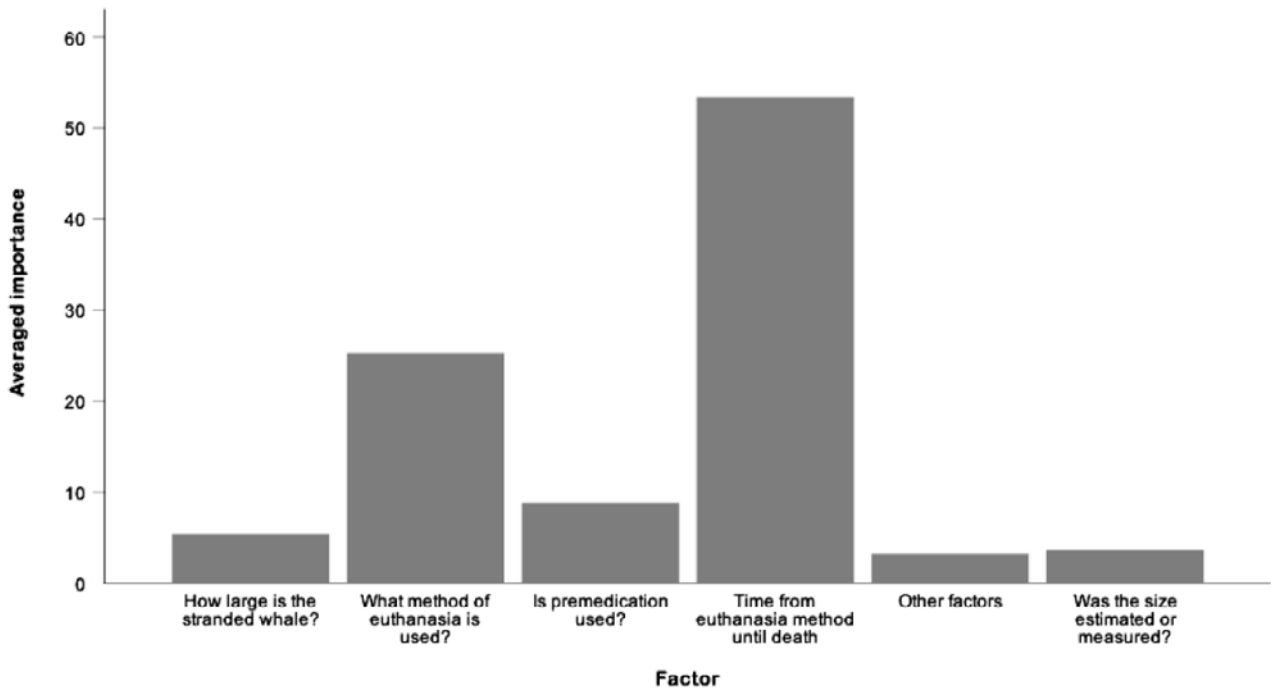
Limiting factors (Q21) for the selection of euthanasia method were suggested as 'Available expertise' (27.1%), 'Available drugs/chemicals' (17.1%), 'Cost' (14.2%), 'Available equipment' (11.4%), 'Location of stranding' (10.0%), 'Public (safety/perception)' (7.1%), 'Species/Size of animal' (5.7%). Other reasons included 'Carcass disposal'/'Effectiveness of method'/'Ethics'/'Government policy'/'Welfare' (7.1%).

Conjoint analysis results

For the different variables presented to the participants as scenarios, importance values were calculated, and a summary of the findings can be seen in Figure 6. The highest value was allocated to 'Time to death' and then 'Method of euthanasia' by participants, and the lowest to 'Size estimation' and 'Other factors.'

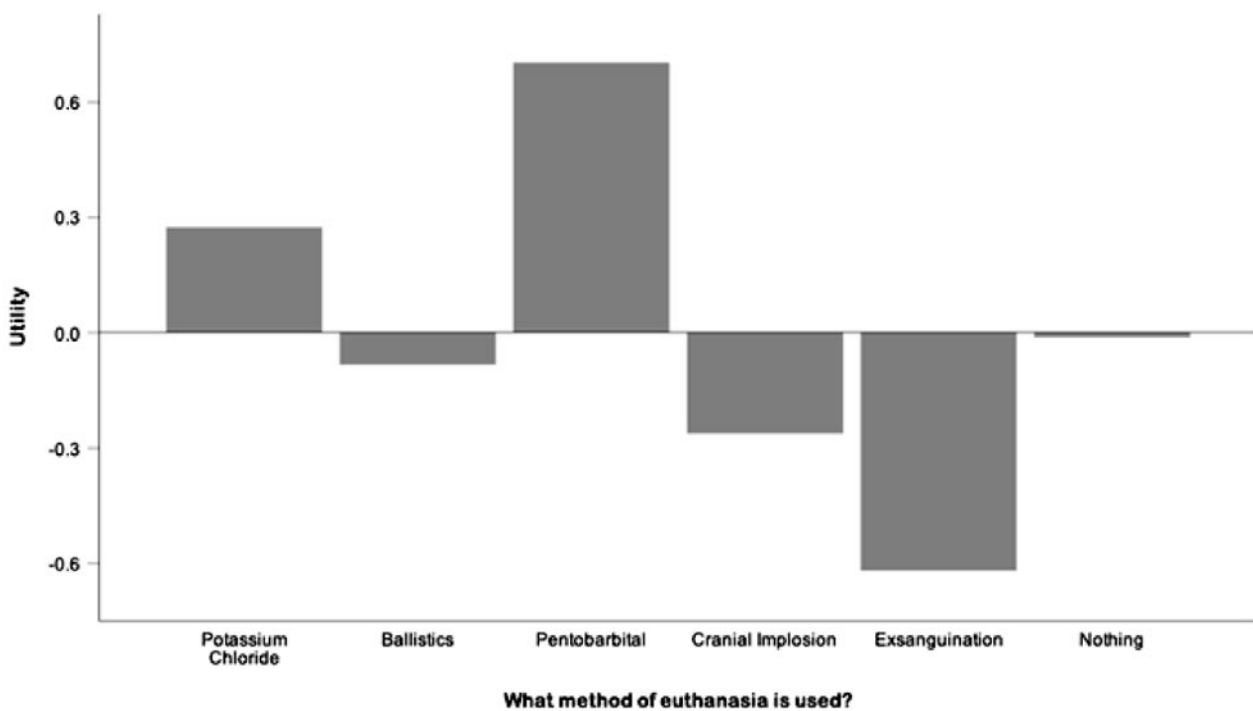
For the variable 'Method of euthanasia', the averaged utility values were calculated, and can be seen in Figure 7. 'Pentobarbital' was given the highest value by respondents, followed by 'Potassium chloride' and then 'Nothing.' The lowest value was given to 'Exsanguination.'

Figure 6



Importance summary: the averaged importance values allocated to each variable from the scenarios presented to the participants, determined using conjoint analysis.

Figure 7



Summary utility values for the response of participants to the scenarios presented to them: averaged utility values for the methods of euthanasia, determined using conjoint analysis.

Discussion

Most respondents said that they were aware of the recommendations contained in the IWC euthanasia workshop report (IWC 2014) and believed that the recommendations were relevant and straightforward (and this was regardless of the respondent's stated level of expertise). However, only a small proportion of respondents had actually utilised them. This suggests that dissemination of the recommendations and awareness of the content of the report were not, in themselves, barriers to adoption of the recommendations. The most commonly identified barriers were identified as themes in the findings of the survey, and in the surrounding dialogue with respondents, and were:

- Lack of government support (which often leads to);
- Lack of resources (money, equipment, drugs); and
- Lack of experienced or trained personnel.

These findings support a view that the work by Barco *et al* (2016), and by the IWC, aimed at collating and presenting euthanasia guidelines in an accessible manner, were successful.

The issues identified in our study reinforce the recommendations of previous work, ie that there is a need for more trained personnel (Barco *et al* 2016).

While governmental support is not an aspect over which the IWC has control, the IWC could implement or encourage the development of training programmes, in a similar way to the way that it has successfully facilitated the existing disentanglement training programme (IWC 2020b). An online course could potentially reach stranding networks which are unable to afford expensive 'face-to-face' training courses. Such an approach could make information available to those in government who have the appropriate oversight and responsibility to adapt and implement policy and to resource initiatives. Access to training and information could improve the capacities and capabilities of strandings' organisations in relation to adopting 'best practice' and 'best welfare outcomes', in (often difficult) stranding situations.

Most respondents (63%) believed that it was the job of the veterinarian (if one was present) to ensure the recommendations were followed at the point of euthanasia. Legally, however, this is not always the case, at least in the UK, where members of the public can perform euthanasia on a wild animal if it presents as the most humane option (Meredith 2016).

If more non-veterinary responders could be trained in the methods that are available to them (for example, via an IWC euthanasia training programme) then there is the possibility that euthanasia events could be more successful and welfare-friendly. Improvements in welfare outcomes would likely result from improving access to current training for a wider spread of people involved in strandings (not just veterinarians), and by increasing the number of trained personnel overall. This is because training is necessary for the optimal implementation of any chosen euthanasia method (Barco *et al* 2016). Methods, such as ballistics, that would be available to non-veterinary personnel may require specific licensing, and it would be useful to have set guide-

lines laid out by the IWC regarding which firearm to use for the different sizes of cetacean. We note here the work of Hampton *et al* (2014) on firearm use and also the usefulness of testing methodologies on already-dead cetaceans. Alongside training non-veterinarian responders, it would be useful to develop a similar tool for veterinarians, as they can implement methods (such as pentobarbital) which are inaccessible to non-veterinary responders.

For concerns regarding eco-toxicity and secondary contamination, training is again likely to be very helpful, for example, training in use of the newer methods developed, such as the low residue technique reported by Harms *et al* (2014) involving KCl. This method also has the benefit of KCl being a low cost, and readily available chemical, although we emphasise here that the deployment of KCl alone would not be humane, and pre-euthanasia sedation and analgesia is necessary (Harms *et al* 2018). Another option to avoid eco-toxicity would be the deployment of ballistics or explosives, although this may have more application as emergency procedures rather than primary euthanasia choices. Explosives are illegal, or require special licensing, in many countries but Coughran *et al* (2012) have suggested a cranial implosion technique that could be a safe and effective method in large humpback whales (*Megaptera novaeangliae*), and which could be utilised in areas where this is allowed.

The use of sedation before either physical (for example, ballistic) euthanasia, or use of chemical euthanasia techniques, was emphasised by the IWC Report (IWC 2014), along with the necessity for accurately assessing the size/mass of the stranded animal. However, both sedation and estimation of size/mass were under-utilised according to respondents. The under-utilisation of sedation may be due to concerns over eco-toxicity, or because giving the injections requires the responder to be in close proximity to the animal, which can be dangerous. Training in remote darting could help improve use of sedation (Harms *et al* 2018). Many sedative drugs (such as opioid drugs) may be hard to acquire, especially in large quantities, as they are controlled drugs, but some such as xylazine may be more easily accessible for veterinarians in a stranding situation (Harms *et al* 2018). Any training programme that is developed needs to ensure that cohesive guidelines are created for calculating weight and the use of sedatives.

The conjoint analysis identified 'Time to death' as being the aspect that most influences the perception of a poor or good euthanasia event. The time to death is often influenced by the experience of the person administering the euthanasia method (which was emphasised in cases reported to IWC workshop [IWC 2014]). Therefore, by improving or providing training for responders, there is the potential for welfare to be improved by decreasing the time between the administration of the method and the time of death. Although the AVMA guidelines have been updated since this research was conducted, and now state that "As a general rule, a gentle death that takes longer is preferable to a rapid, but more distressing death" (AVMA 2020), it is still

imperative that the methods used are utilised as effectively as possible, to ensure that loss of consciousness is achieved prior to cardiac or respiratory arrest (Harms *et al* 2018). We did not provide a definition in this study for ‘Time to death’ or ask participants in the survey how they judged this and also if they also considered ‘Time to insensibility.’ According to a study by Butterworth *et al* (2004), most respondents classified animals as either alive or dead using specific parameters (eg ‘a change in breathing rate when the animal was stimulated around the blowhole with a blunt object’), as opposed to conscious, unconscious, or dead. The IWC uses criteria such as jaw tone and flipper movement to assess death, but Butterworth *et al* (2004) suggest that these would be insufficient, as an animal could still be alive whilst lacking these responses. Clearly, these are key topics, deserving of further consideration.

Animal welfare and human safety (safety of both the public, and of responders) needs to be prioritised at euthanasia events; the authors believe that training is likely to be the best way to ensure both aspects are adequately addressed.

We had limited time and resources for this study, and there are some limitations. The survey had a response rate of 13%. Although the response rate may seem low, this is still quite a specialist area and, hence, this is a reasonable level of responses.

There are some areas that we would have liked to explore further; and may be able to do so in future studies. For example, a quarter of respondents said they had no direct experience with strandings or euthanasia events, which could have affected the results, although there was often the option to answer ‘unsure’ which removed some of the disparity that might have resulted. Had there been sufficient time and resources, it would have been beneficial to have followed up on the question of whether or not participants believed their country’s guidelines were an accurate representation of the IWC recommendations. For example, this might have helped to determine whether the country’s guidelines were similar purely through coincidence, or because efforts had been made for guidelines to be adapted to fit in with the recommendations.

There was strongly polarised opinion as to whether IWC recommendations were not being followed or used, with some areas saying that they were, and some that they were not, and it would be worth investigating further whether this was country-dependent, and what the reasons behind this were.

The conjoint analysis could have been refined had it been created as a stand-alone survey, where participants could respond to more than ten scenarios, and more variables included. On this occasion (due to the limited possible number of variables that could be used before the orthogonal output was excessive, and the practical number of scenarios that can realistically be presented to entirely voluntary participants), the number of scenarios sent to each participant were reduced, and not all variables were presented. If this part of the study were to be repeated, it would be useful to find a way to include ‘species,’ as this has such an effect on choice of euthanasia method.

Animal welfare implications and conclusion

The survey indicates that the IWC recommendations are generally well received and understood, and that the barriers to adoption of the recommendations include lack of governmental support, lack of resources, and lack of trained personnel.

It would be helpful going forward if training programmes could be supported by the IWC, which would:

- Increase the number of trained personnel available at strandings;
- Increase the number of methods available to use at stranding events;
- Increase the positive welfare outcomes for stranding events.

We also recommend that more consideration be given to two related issues which would further help understanding of how whale euthanasia is being conducted around the world:

- Firstly, it would be helpful to compile and contrast information related to how ‘Time to death’ and/or ‘Time to insensibility’ are being judged; and
- Secondly, to identify specifically which countries are applying the IWC guidelines.

Declaration of interest

None.

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