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Evaluating possible indicators of insensibility and death in cetacea

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Abstract

The International Whaling Commission (IWC) currently uses imprecise indicators of death to evaluate the welfare consequences of whaling. A recent independent meeting of animal welfare scientists proposed a series of tests to determine the states of sensibility/insensibility/death of whales. As a precursor to assessing these tests in the field, conjoint analysis was used to evaluate expert opinion and to identify tests deemed most suitable for establishing insensibility and death. The results of this study indicated that experts considered measurement of breathing rate, cardiac activity, coordinated swimming and ocular temperature to be among the most useful for determining that animals were not dead. Furthermore, experts considered that judgements that an animal was dead should be made only after application of a series of different tests. The tests identified may be valuable for assessing stranded whales or animals taken as part of whaling operations.

Keywords: *animal welfare, cetacean, sensibility, stranding, time to death, whaling*

Introduction

The International Whaling Commission (IWC) is the regulatory body overseeing whaling and, since 1957, it has included as part of its remit discussion and work on whale killing and welfare. Whilst some IWC members do not recognise that regulation of killing methods is within the remit of the IWC, this controversy was resolved *de facto* when the IWC agreed to ban the cold harpoon for use in Minke whaling.

There has been considerable discussion about the effects of various harpooning and killing methods on the welfare of hunted whales in this journal and others (Kestin 1994). For an assessment of the welfare implications of any commercial slaughtering process, accurate knowledge of the 'Time to Death' (TTD) is important because it allows a reference point for the period during which the animal could potentially suffer. In 1980, recognising the need for data in this area, the IWC defined three criteria that could be used by observers on board whaling vessels to establish the time of death in hunted whales. The fulfilment of any single criteria was deemed sufficient to classify the whale as dead. These criteria were: relaxation of the lower jaw; or, no flipper movement; or, sinking without active movement (Anon 1980). Various interpretations of these criteria have been made in subsequent IWC documents: muscles relaxed, mouth opened wide, lower jaw drifting in the waves (Anon 1994), relaxation of the mandible, cessation of flipper movement, or sinking without any active swimming (Anon 1999).

Norway and Japan currently kill whales on a large scale using harpoon technology, and a number of other countries carry out smaller scale subsistence whaling. All are requested to submit data on killing methods and killing efficiency, based on the three criteria described above, to the IWC annually. Analysis of recently collected data indicates that the average TTD for hunted minke whales is 2–3 min (Kestin 2001). However, variation is high and the maximum recorded TTD can exceed 1.5 h. The number of whales recorded as killed immediately is variable, with Norwegian hunts achieving an immediate kill rate of 3/4 and Japanese hunts in the Antarctic achieving an immediate kill rate of only 1/3.

The interpretation of the three criteria used to determine time of death is critical, as differences in the perception of 'flipper movement' (passive or active), or 'sinking without swimming' could create inconsistencies in TTD data. For example, whales are capable of sinking without swimming during normal activity. In practice, the use of these indicators in the field by observers of the Japanese and Norwegian whaling operation highlighted inconsistencies in the interpretation of these criteria (Anon 1999, IWC/51/WK15). Because of concerns over the validity of the criteria used to determine death, there have been repeated calls for the development of more reliable indicators of the point of insensibility and death (IWC/44/18 IWC/47/18 IWC/47/18 IWC/51/WK15 IWC/51/WK12).

An International Scientific Workshop on Sentience and Potential Suffering in Hunted Whales, attended by internationally recognised scientists and veterinarians with expertise in welfare, physiology and anatomy, was hosted by the Royal Society for the Prevention of Cruelty to Animals in London on 14–15 June 2001, with support from the UK Government (RSPCA 2001). The purpose was to review

Table 1 The 34 potential measures of sensibility in hunted whales. Each measure is described by a question and referred to by an abbreviation in bold capitals.

	Question	Possible outcomes
1	'Does the animal react physically to sound? **(SOUND)**	Yes / No
2	'Does the animal react physically to bright light?' **(LIGHT)**	Yes / No
3	'Does the animal react physically to direct touch?' **(TOUCH)**	Yes / No
4	'Does the animal react physically to application of a novel substance placed into the mouth?' **(TASTE)**	Yes / No
5	'Does the animal respond to sharp object stimulus around the blowhole?' **(PRESH)**	Yes / No
6	'Does the animal show rhythmic swimming activity?' **(SWIM)**	Yes / No
7	'Is the animal showing violent muscular convulsions?' **(SPASM)**	Yes / No
8	'Does the animal show fine muscular tremors?' **(TREMB)**	Yes / No
9	'Is the animal moving its pectoral fin(s)?' **(PECT)**	Yes / No
10	'Is the mouth of the animal open or closed?' **(JAWT)**	Open / Closed
11	'Are the eyelids open or closed?' **(EYELID)**	Open / Closed
12	'Does the jaw have muscular tone?' **(TJAW)**	Yes / No
13	'Does the tongue have muscular tone?' **(TONGUE)**	Yes / No
14	'Does the anal sphincter have muscular tone?' **(ANAL)**	Yes / No
15	'Does the pectoral fin have muscular tone?' **(TPECT)**	Yes / No
16	'What is the breathing pattern?' **(BRPAT)**	Regular / Irregular / No breathing detected in 1 h
17	'Does the blowhole react to application of water?' **(BCW)**	Yes / No
18	'Number of minutes between breaths?' **(RATE)**	>0.25 >1 >4 >16 >32 >60
19	'How long does the blowhole remain open (s)?' **(BLOW)**	>0.5 >1 >2 >4 >8
20	'Is there a change in the breathing rate when the animal is stimulated around the blowhole with a blunt object?' **(REFS)**	Yes / No
21	'Does the animal have a vestibulo-ocular reflex?' **(VEST)**	Yes / No
22	'Does the animal have a pupillary reflex?' **(PUP)**	Yes / No
23	'Does the animal have a corneal reflex?' **(CORN)**	Yes / No
24	'Does the animal have a palpebral (eyelid) reflex?' **(PALP)**	Yes / No
25	'What is the temperature of the surface of the eye?' **(OTEMP)**	Ambient <25°C <35°C <40°C
26	'Does the animal have a detectable electrocardiogram?' **(ECG)**	Yes / No
27	'Is an AER (auditory evoked response) detectable?' **(AER)**	Yes / No
28	'Is a VER (visually evoked response) detectable?' **(VER)**	Yes / No
29	'Is there measurable facial nerve activity?' **(FAC)**	Yes / No
30	'Is retinal blood flow visible with an opthalmoscope? **(RETB)**	Yes / No
31	'If ocular pressure is measurable, is it? – ' **(OCPRES)**	Normal / Reduced
32	'What is the capillary refill time (s)? **(CAPR)**	>0.5 >2 >20
33	'As measured with a pulse oximeter on a mucous membrane, what is the % oxygen saturation?' **(PULS)**	<98% <95 % <80% <40%
34	'What is the heart rate, as measured with a stethoscope (bpm)?' **(HR)**	>100 >50 >25 >10 0

current criteria for assessing insensibility and death in cetaceans and to consider the welfare implications of these criteria. The group supported the view that current IWC criteria were not adequate to determine the point of onset of insensibility or death with any precision. A series of tests or potential indicators of sensibility that could be applicable for determining sensibility/insensibility and vital function in whales, and preliminary protocols for their application, were suggested. The hypothesis was that by applying the tests to disabled whales it would be possible to identify, with some precision, the state of sensibility of the whale and how the animal passed from consciousness to death. The Workshop agreed that there was an urgent need to validate the tests and to gather preliminary data relating to their use.

This paper describes an initial validation exercise where two groups of scientists classified a series of 'model' whales. Each model whale was described by a number of possible indicators of sensibility or vitality. Using conjoint analysis we then analysed how the scientists assessed each model animal, the objective being to identify the importance of each test/attribute. Conjoint analysis is a decompositional or attribute-free technique that infers the importance of attributes used by an observer in decision-making without asking the respondents to rate attributes directly (Hair *et al* 1998).

Methods

Proposed indicators/tests of sensibility/vitality

Table 1 lists the 34 measures proposed at the RSPCA Workshop. For the purpose of the conjoint analysis these have been phrased as 34 practical questions that could be interpreted by an observer. Note that below and in

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Table 2 An example of one the 85 model cases assessed. An example response is given by the "X". D, dead; UC, unconscious; C, conscious.

Case 1	Possible outcomes	Animal outcome			
'Does the animal react physically to sound?	Yes / No	**Yes**			
'Does the animal react physically to bright light?'	Yes / No	**No**			
'Does the animal react physically to direct touch?'	Yes / No	**Yes**			
'Does the animal react physically to application of a novel substance placed into the mouth?'	Yes / No	**No**			
'Does the animal respond to sharp object stimulus around the blowhole?'	Yes / No	**Yes**	**D**	**UC**	**C**
					——————————X—

subsequent tables and figures the abbreviated form of each question is used.

Generation of 'model' animals

The 34 indicators were combined into groups of 5 or 6 associated questions and an orthogonal array of 85 model animals was created using the 'plancard' programme in SPSS Conjoint 8.0 (SPSS 1997). Thus, model animals were described in terms of their physical reactions, spontaneous muscular activity, elicited muscular activity, respiratory measures, elicited reflex responses, neuro- and musculo-electrical measures and cardiovascular-related measures. See Table 2 for an example of one model animal from the physical reactions group.

Selection of experts

Thirty biologists and veterinarians were asked to assess each case description. The biologists and veterinarians had either:

a) specific cetacean or whaling experience, or

b) recognised animal physiological expertise, particularly associated with the dying process in mammals.

The respondents were asked to assess the state of consciousness/vitality of each of the 85 model animals and to mark their assessment using a written cross on a visual analogue (VA) line for each animal from 'Conscious' through 'Unconscious' to 'Dead' (see Table 2). The position on the line of the cross was then measured and converted to a number for analysis. The position of the cross described where the observer placed the model animal in terms of their assessment that it was conscious, unconscious or dead — in other words, its 'state of sensibility'. No specific guidance was given relating to the size of each whale or whether it was a stranding or was being killed as part of a whaling operation.

Analysis

The numbers derived by measurement of the position of each cross on the VA line formed the data set for the conjoint analysis of the cases. A programme for analysis using SPSS Conjoint 8.0 software was created, and the programme produced an output indicating the 'averaged importance' of each measure analysed. In addition, *t*-tests (uncorrected for the number of comparisons made) were used to investigate differences in the responses between the two groups of experts (cetacean scientists or animal welfare scientists).

Results

There were no significant differences between the scores of the two groups of scientists (combined two-tailed *t*-test statistic for equality of means = 0.743). Therefore the data for all 30 respondents were combined for the subsequent analysis.

For the 34 measures, importance values across all respondents were calculated. The average values ascribed to each test/indicator are shown in Figure 1, arranged in order of importance, each measure being referred to by its abbreviated title. To ease interpretation of the relative weightings given to each of the large number of measures examined, they have been subjectively split into three groups: high value, moderate value, and low value measures, as indicated in Figure 1.

Respondents placed highest value on the following indicators: a change in the breathing rate when the animal was stimulated around the blowhole with a blunt object (REFS); whether the animal had a detectable heart rate (by electrocardiogram [ECG] or stethoscope [HR]); whether the animal showed rhythmic swimming activity (SWIM); and whether the temperature of the surface of the eye was elevated above ambient (OTEMP).

Similarly, respondents placed lowest value on the following indicators: visible retinal blood flow (RETB); response of the blow hole to water (BCW); measurable intra-ocular pressure (OCPRES); breathing rate (RATE); and whether the animal showed fine muscular tremors (TREMB).

Many respondents indicated that judgements on the true state of the 'model' (or real) animals (whether they were conscious, unconscious or dead) would not be reliable if based only on the information provided from summaries of responses to five indicators (as shown in Table 2).

Discussion

The objectives of this study were to evaluate possible indicators of sensibility/vitality for use in determining the condition of disabled whales. Conjoint analysis of expert opinion was used to identify the criteria used to make decisions without the respondent having to articulate these directly. The approach was adopted because it has been used successfully in similar situations in critical care medicine (Johnson & Bingham 2001; Johnson *et al* 1998).

Respondents were asked to classify animals on a continuum from conscious though unconscious to dead. This approach

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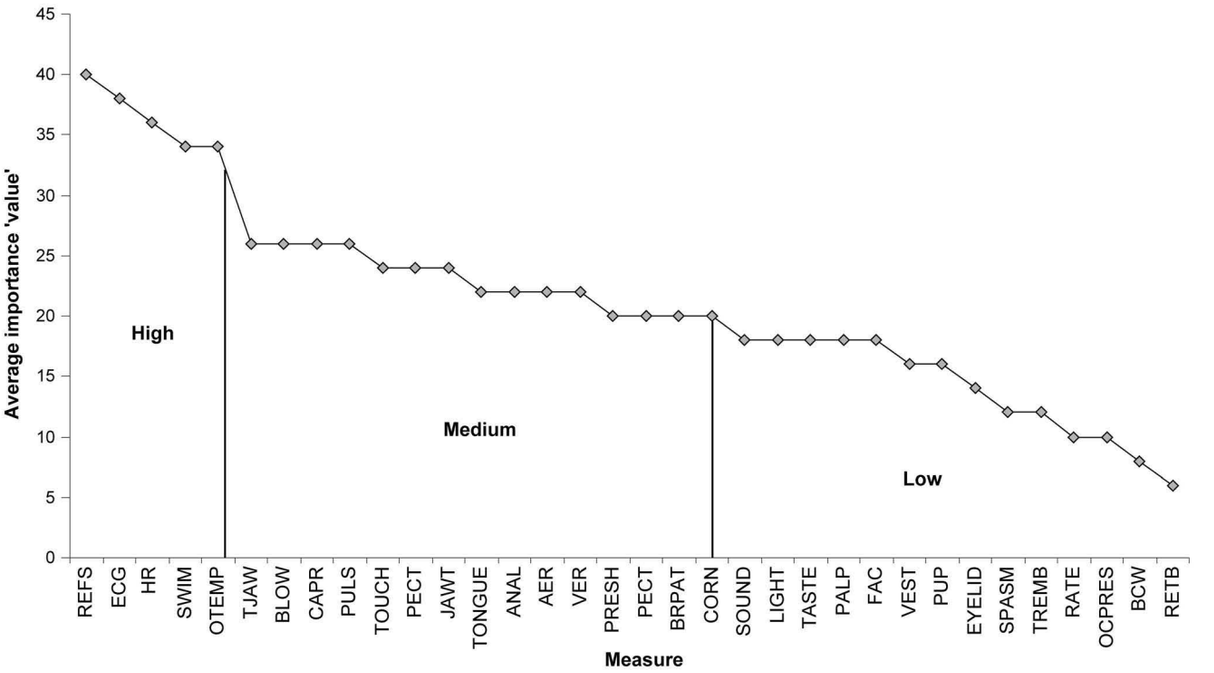
Figure 1 Averaged importance values (high, medium and low) for both cetacean and animal scientists for the pooled conjoint analysis of 34 potential measures of sensibility. Refer to Table 1 for key to abbreviations.



is similar to that used by anesthetists when they classify animals under anesthesia from 'light' to 'deep'. We were interested to identify whether some indicators could be used to reliably differentiate whales that were conscious from those that were unconscious and, in turn, those that were unconscious from those that were dead.

However, from the results of the study, it would appear that most respondents were using the indicators to classify whales into only two categories: live (conscious or unconscious) or dead. Of the five 'most important' indicators, REFS (change in breathing rate when stimulated around the blowhole with a blunt object) and SWIM (showing rhythmic swimming movements) could be expected to be detected in conscious animals, and ECG (electrocardiogram), HR (heart rate) and OTEMP (ocular temperature) could be expected to be detected in live animals, be they conscious or unconscious. Thus, if animals that are conscious are to be separated from those that are unconscious, and those that are unconscious separated from those that are dead, it would appear that there is a need to further evaluate these measures. Nevertheless, the results of this study are interesting because current IWC criteria are used to differentiate animals that are dead from those that are still alive.

Interestingly, of the indicators that had the lowest importance rating, two could be expected to be detected only in animals that were not dead (RETB [retinal blood flow] and BCW [blowhole reacts to application of water]). The low rating of these indicators could be a reflection of the unfamiliarity of respondents with these indicators. However, of the other low-ranking indicators (RATE [minutes between breaths], OCPRES [intra-ocular pressure] and TREMB [fine muscular tremors]), there is justification for respondents to lack confidence in them. There could be ambiguity in how respondents viewed an animal that showed normal intra-ocular pressure or showed fine muscular tremors, as these responses might be expected in an animal that either was alive or had very recently died. Similarly, it would be unreasonable to conclude that a cetacean that was breathing was dead. However, the converse cannot be concluded: a cetacean that has not been seen to breath cannot necessarily be deemed to be dead. Thus, the low rating of the indicators RATE, OCPRES and TREMB would appear to be justified.

In this exercise, the very wide-ranging set of possible indicators of sensibility generated at the initial workshop was presented to assessors. No attempt was made to delete potentially impracticable or ambiguous indicators, the objective being to use the expertise of the assessors and the statistical analysis to identify and prioritise those measures likely to be valuable for later *in vivo* evaluation. Thus, it was to be expected that some indicators would have low 'importance values'.

Indicators that approximate to the current IWC criteria (TJAW [jaw has muscular tone], PECT [animal moving pectoral fin(s)] and JAWT [mouth open or closed]) were not the highest ranked, indicating that respondents did not have the highest confidence in them. It was interesting that, without prompting, many respondents felt that judgements on the true state of the animals would not be reliable if based only on the information provided from summaries of responses to five indicators. In most cases, respondents felt that summaries of responses that gave information on

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several different systems would be required before reliable judgements could be made. This was either because not enough information about the state of an animal is contained in a set of five responses, or because some of the measurement methods may be prone to artefact. For example, failure to measure a heart rate could be a problem with the apparatus or its application rather than true lack of a beating heart.

Using the IWC criteria, an animal can be pronounced dead if either the lower jaw is relaxed, or no flipper movement is present, or the animal sinks without active movement. Any one of these responses or behaviours could be absent while the animal still retained vital function. Basing judgements on time to death on any single one of these criteria is likely to lead to a consistent underestimate of TTD. This implies that current IWC criteria for identifying death are less than satisfactory.

The indicators developed in this study could also have utility when whales are stranded and decisions need to be made regarding euthanasia, refloating, or disposal. As with whaling, in this situation there is a clear need to be fully aware of the state of the animal before potentially traumatic procedures are carried out.

This study outlines the first steps to attempt to refine criteria for assessing the state of sensibility of disabled whales. It has identified several potentially valuable measures. Subsequent progress will rely on application of these measures in the field where tests can be carried out on captive whales, stranded whales, or those caught as part of whaling operations.

Animal welfare implications

This study has reinforced concerns that existing IWC criteria for determining death in whales are not reliable. In particular, it has identified that assessments based on one measure alone are likely to underestimate the period of suffering in harpooned whales. New, potentially more reliable, measures have been identified and prioritised. If several of these measures were to be applied in combination, it is likely that the state of sensibility of disabled whales could be identified with increased confidence and that the quality of data on TTD submitted to the IWC could be improved.

Refining the tests further should allow us to discriminate animals that are conscious from those that are unconscious and, in turn, animals that are unconscious from those that are dead. This is important because unconscious animals cannot suffer and dead animals cannot recover or suffer.

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