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Immediate immobilisation of a Minke whale using a grenade harpoon requires striking a restricted target area

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Abstract

Approximately 1500 Minke whales are killed annually under permit from the International Whaling Commission (IWC). This hunt supports a modest industry in Norway and in Japan; however, the welfare of whales during hunting and killing is such a cause of concern that in 1980 the IWC formed a sub-group entitled 'Working Group on Whale Killing Methods and Associated Welfare Issues' devoted to discussing the issue. This commentary suggests that, when using the Norwegian penthrite grenade-tipped harpoon ('Whalegrenade-99'), it is necessary to hit a relatively well-defined target area in order to effect an immediately immobile, and presumed unconscious state in the Minke whale.

Keywords: *animal welfare, grenade, harpoon, hunt, killing, Minke whale*

Introduction

In 2004 Knudsen described data on the effects of detonation of the Norwegian penthrite grenade (the 'Whalegrenade-99') on the brains of Minke whale (*Balaenoptera acutorostrata*) following impact of the harpoon (Knudsen & Øen 2003). Knudsen (2004) also demonstrated that a shot from a .375 or .458 calibre rifle was capable of penetrating the skull of a Minke whale. The data presented by Knudsen (2004) were collected during Norwegian hunts and recorded 69 whales hunted by two boats during the 1998–2000 hunting seasons using 60 mm harpoon canons and the Whalegrenade-99; information was also provided on the grenade detonation site in whales hit by a single harpoon. The time to unconsciousness/death was recorded in accordance with the published 'IWC criteria' (Anon 1980). In brief, the criteria are based on the moment when there is (1) relaxation of the lower jaw, (2) no flipper movement, or (3) sinking without active movement. The Minke whales in the study (Knudsen 2004) ranged from approximately 5–9 m, with an average length of approximately 8 m. In this commentary the data provided by Knudsen (2004) are used to indicate the target area that has to be hit in order to produce immediate immobilisation and presumed unconsciousness in Minke whales.

Materials and methods

The data presented by Knudsen (2004) were displayed on two schematic drawings of a Minke whale: the first schematic showed the harpoon detonation sites in 37 whales (Knudsen & Øen 2003); the second schematic showed the detonation sites in 26 whales (Knudsen 2004). Although 69 whales were caught by the two whaling boats, data for only 63 whales were presented because 3 whales were harpooned twice and 3 whales suffered no internal detonation: one harpoon misfired and two harpoons passed through the bodies of the whales.

In this commentary, the data from these two papers were amalgamated and the longitudinal distance of the detonation from the tip of the lower jaw, relative to the total length of the whale (measured from the tip of the lower jaw to the point where the flukes divide), was calculated from the schematic diagrams. The detonation sites were recorded as either having or not having resulted in immediate immobility. Knudsen (2004) had based this assessment on the IWC criteria outlined in the *Introduction*. A binary logistic regression model was initially used to analyse the data.

Results

Using the simple model of longitudinal distance of detonation site alone it was possible to correctly classify 77.8% of the whales according to whether or not they were immediately immobilised. Although additional variables were tested to potentially enhance the model, the final model included just two explanatory variables: the longitudinal distance along the whale and whether the detonation was above or below a midline, which differentiated a ventral explosion from a dorsal explosion. The final model resulted in only one detonation being predicted incorrectly: it was predicted to cause immediate immobilisation, but it did not.

The pattern of detonations is shown in Figure 1: detonations that resulted in immediate immobility are indicated by red marks and those that did not result in immediate immobility are indicated by blue marks; the single misclassified detonation is shown in yellow. Following Knudsen (2004), larger marks indicate a cluster of five detonations and the smaller marks, a single detonation. When the data are viewed together in this way, the target area, which resulted in immediate immobilisation, is apparent. Furthermore, the single detonation that was misclassified by the model is located marginally in the ventral rather than the dorsal region. Given the subjective error inherent in the recording of the location of the detonations and the extremely high correct classification rate of the logistic model, it is acceptable to disregard this misclassified detonation and to move from a stochastic model to an empirical classification of a target area that results in an immediate 'stun' when the Norwegian grenade is used. When the misclassified detonation is disregarded, a probability model is no longer required as it is sufficient to simply look at the position of a detonation to determine whether or not it resulted in immediate immobilisation. Because of the coarseness in the data, Figure 1 shows the approximate minimum and the potential maximum target area in which a detonation will result in immediate immobilisation. Additional data would be required to more accurately identify the true extent to which the real target area is greater than the minimum shown. The regions immediately above and below the delineated target area are not included as target area; there are no data for these regions but a detonation here would be superficial and occur in blubber with a reduced likelihood of immediate immobilisation.

The extreme anterior of the potential minimum target area begins at the anterior of the brain, approximately 0.22 of the total body length from the tip of the lower jaw (Knudsen *et al* 1999). The target area extends back dorsally from this point to approximately 0.30 the length of the whale from the tip of the lower jaw, and ventrally to 0.49 the length of the whale from the tip of the lower jaw. These distances are given as the furthest detonation sites which caused immediate immobilisation. The recorded detonation sites that failed to produce immediate immobilisation were 0.38 dorsally and 0.53 ventrally the length of the whale from the tip of the lower jaw. The longitudinal section of the whale, in which the brain occurs, is outside the minimum target area. Although a detonation in this area may cause immediate immobilisation, it is not appropriate to aim at the head of the Minke whale because it is relatively small and remains underwater when the whale breaches to breathe; therefore it is a poor guide to targeting and a poor target. The Norwegian hunters are taught to aim for the thorax, above the white band on the flipper which is visible underwater (Knudsen 2004).

Discussion

The data indicate that there is a relatively well defined area that determines whether or not a detonation will be effective; on the basis of this, the minimum and maximum target areas, which are likely to result in an immediate immobilisation/stun, are presented (Figure 1). The proximity of the detonation to the brain is of obvious importance in determining its effectiveness. The energy from a detonation is transmitted more efficiently through body fluids than through body tissues. Therefore, the dorsal region of the whale, which is predominantly muscle, will tend to cushion the brain from the explosion; in this region a detonation closer to the brain is required. The ventral region contains the major organs and blood vessels. In this region the shock waves from the explosion may be propagated more efficiently through the major blood vessels and the cerebrospinal fluid to the brain. Hence detonation may produce immobilisation/stun at greater distances from the brain. This means that the greater part of the critical target area — the ventral region — is difficult to sight as it is generally beneath the water; however, the flight path of the harpoon does have a downward angle and detonation occurs at a depth within the whale.

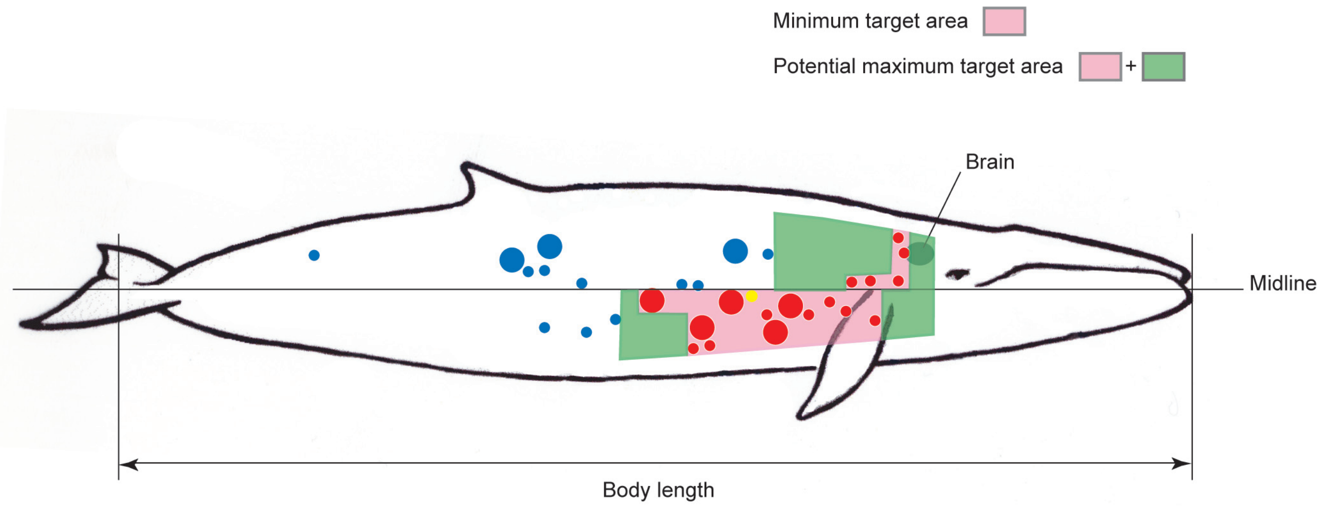
The data provided by Knudsen's research (2004) are two dimensional and no record was available of the position of the detonations in the third dimension. However, within the accuracy of these data, two dimensions were sufficient to allow a complete description of the results of a detonation.

The Norwegian penthrite grenade was gradually introduced between 1984 and 1986. Since its introduction it has been extensively redesigned and improved to produce the 'Whalegrenade-99', which has been used by all boats in the Norwegian hunt since 2000. Detonation is triggered when twin hooks at the rear of the grenade, which itself is at the tip of the harpoon, embed in the surface of the whale extending a nylon cord attached to the grenade. The twin hooks stay at the surface of the whale, the nylon cord uncoils and once pulled taut detonates the grenade, which has continued its passage into the whale. Detonation of the 30 g penthrite charge occurs at a depth of 50–70 cm within the whale. The boats used in the Norwegian hunt are small fishing vessels of approximately 15 m, therefore the harpoon, positioned in the bow, is only a few metres above the water. The whale should be within 30 m of the harpoon gun before the shot is fired and the recommended shot is at a 90º to 60º angle between the harpoon gun and the whale. This means that shots are generally taken as a 'broadside', with a downward angle, and the site of initial impact will be approximately in line longitudinally but above the site of the detonation.

The time to unconsciousness/death was recorded by Knudsen in accordance with the published 'IWC criteria' (Anon 1980). These are a set of relatively subjective assessments using specific behavioural measurements as an indicator of unconsciousness. The assumption that immobile animals are either unconscious or dead may be an erroneous one and the distinction between an immobile animal, which may retain the potential to suffer and one that is insensible to pain, continues to be the focus of research and debate in the IWC (Brakes *et al* 2004; Butterworth 2005; Knudsen 2005).

The Norwegian government has implemented an obligatory programme of training for whalers, which includes harpoon and rifle shooting tests. In association with this and the improvement in equipment, there has been an increase in the percentage of whales recorded as immediately

Figure 1



Impact sites that resulted in immediate immobilisation are shown in red, impact sites that did not, are shown in blue. The misclassified shot that did not result in immediate immobility is shown in yellow. Large marks indicate a cluster of five impact sites and small marks, a single impact site. The measurement of body length, the midline, the minimum and potential maximum target areas are shown.

immobile. In the 1993 hunt 54% of Minke whales were recorded as immediately immobile, this rose to 59% in 1994, with a current annual estimate of approximately 80% since 2000 (Øen 2001). However, it should be noted that for the whales reported by Knudsen (2004) the average rate of immediate immobilisation for the two boats was only 54%. This suggests a very rapid improvement in the rate, or that the variation between boats and/or gunners may be high or, perhaps, that different methods for the assessment of immobilisation were used.

An alternative design of grenade is used by the Japanese and historically the rate of immediate 'stun' in Japanese hunts has been substantially lower than the Norwegian hunts (Kestin 1999). Although in the Japanese hunting trials the Norwegian design of grenade has always outperformed that of the Japanese, the Japanese have been reluctant to switch because of the increase in cost (Anon 2003).

Conclusions and animal welfare implications

The data drawn together in this commentary suggest that in order to cause immediate immobilisation and, perhaps, an immediate stun in Minke whales harpooned using the Norwegian 'Whalegrenade-99' it is necessary to hit a relatively restricted target area. The reported rate of 80% of whales immediately immobile following harpooning in the Norwegian hunt suggests proficient marksmanship under difficult conditions. However, it also suggests that an improvement in this rate may be unlikely. While the acceptability of 20%, as a minimum, of whales left with the potential to suffer following grenade detonation is a significant focus of debate, the question of whether an immediately immobile whale is stunned remains.

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