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Description and Analysis of the use of Cold Harpoons in the Norwegian Minke Whale Hunt in the 1981, 1982 and 1983 Hunting Seasons

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Øen, E. O.: Description and analysis of the use of cold harpoons in the Norwegian minke whale hunt in the 1981, 1982 and 1983 hunting season. Acta vet. scand. 1995, 36, 103-110. – Until 1984, cold harpoons, i.e. harpoons with no detonating device, were used to hunt minke whales in Norway. To investigate the effectiveness of such harpoons and compare them with alternatives, data on kills using cold harpoons were collected as part of a project dealing with alternative killing techniques for whales. Data on 353 whale kills were collected in 1981-83. The criteria used to determine the time of death were cessation of flipper movement, that the mandible relaxed, or that the whale hung immobile from the harpoon line. These criteria do not take into account any movements caused by spinal reflexes. About 17% of the animals died instantaneously (≤10 s). The median survival time was 570 s. Animals died most rapidly if hit in the brain, heart or major blood vessels. If only the lungs were injured, minke whales died less rapidly than terrestrial mammals. For whales that did not die immediately, shooting range, animal size and the angle of the shot all influenced the time to death. The efficiency of cold harpoons could be improved, but their use was no longer considered acceptable, and they were replaced by harpoons with penthrite grenades in 1984.

hunting methods; survival time; whaling.

Introduction

In 1981-83, the Norwegian minke whale hunt took place in spring and summer in the Northeast Atlantic, the Barents Sea and along the coast of Norway. Two types of harpoon guns were used, calibre 50 mm (Kongsberg) and 60 mm (Henriksen). Each vessel had a gun mounted on the bow and some also had an additional gun, usually mounted behind the wheelhouse. The harpoons had a line, the fore-runner, with a minimum length of 130 m, tied directly on to or connected to the harpoon legs by a wire. The line was further connected to a wire running through a shock-absorbing system into a winch with a braking device. From the 1981 season, all vessels were also equipped with a heavy calibre rifle of minimum calibre 9 mm, which was used to kill whales not immediately killed by the harpoon by a shot to the brain. The projectiles were fully jacketed and had a minimum impact energy of 3430 joule (350 kgm) at 100 m range. When the whale was dead it was hauled on to the deck from the side of the boat for butchering.

Roughly 90 vessels took part in the 1981-83 seasons. These varied in size from 10.4 to 39 m (three-quarters were under 25 m), were crewed by about 500-600 men and shared a quota of 1,690 minke whales per year.

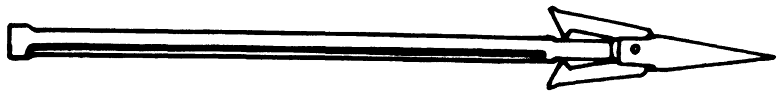

Figure 1. Cold harpoon.

Until 1984 minke whales were caught using the "cold" harpoon, which had no detonating device. The most commonly used cold harpoon had a welded conical, sharp-pointed tip (head) of iron with 2 or 4 claws fixed at the neck and a shaft with 2 legs running from the neck into a base at the rear end of the harpoon (Fig. 1). The overall length was about 120 cm and the harpoon weighed about 12 to 18 kg depending on its calibre and manufacturer. The cold harpoon, with its pointed, conical head, functioned in much the same way as an arrow *(Øen* 1994a) and like other hunting techniques that did not kill quickly, eventually came to be regarded as inhumane. A project to investigate and develop alternative killing methods for minke whales in Norway was therefore started in 1981.

The effectiveness and suitability of a killing method for a particular hunt can be determined by measuring the time it takes to render an animal unconsious or dead. When the project started, no exact information was available on how the cold harpoon worked during hunting or how rapidly the animals were killed. In order to compare alternative methods with cold harpooning, it was necessary to collect data on the killing process. The collection of time-to-death data for the cold harpoon therefore started immediately and continued until cold harpoons were replaced by grenade harpoons in 1984. Some data from the 1981 and 1982 hunting seasons have already been published *(Øen* 1983a) and some data from 1981-83 have been presented to the IWC in the form of unpublished reports *(Øen* 1983b, 1985, 1992a). This article describes and analyses all the data on the use of the cold harpoon from the minke whale hunt in Norway which were systematically collected during the 1981-83 seasons.

Materials and methods

Twenty-six official inspectors collected data from 27 vessels during the 3 seasons. In addition to inspecting hunting operations, the inspectors were instructed to collect data and scientific material for scientific institutions. The data collected on killing included details of the weapons and equipment used, information on shooting conditions, position of hits, reactions to hits, time from strike to death, and tissue and organ damage. The information was given on special forms designed for the project.

The survival time, i.e. the time from a strike until the whale was declared dead, was recorded with a stop-watch. The time of death was recorded as the moment at which cessation of flipper movement, relaxation of the mandible, or sinking with no active movement occurred, as established by the IWC *(Anon* 1980). Organ damage was inspected during butchering, and shooting range and angel of the shot relative to the animal's long axis were estimated without instrumental aid.

Reports were received for a total of 383 minke whales. Four whales were lost, 3 because the fore-runner broke and 1 because the harpoon pulled out. Two of these whales were so lightly wounded that they probably survived. These 4 whales were excluded from the material. There were large gaps in the data in a further

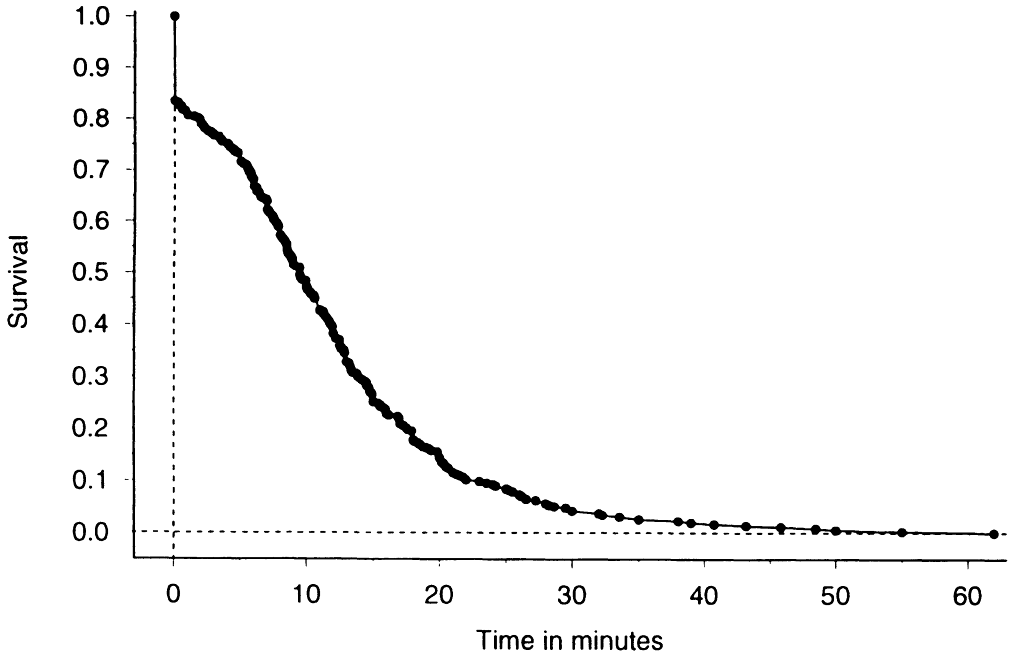

Figure 2. Survival plot for minke whales after hits with 50 mm and 60 mm cold harpoons during the Norwegian minke whale hunt in 1981-1983. Horizontal axis: Time in min. Vertical axis: proportion of whales still showing signs of life. The symbol • indicates one or more whales.

26 cases, and these were also excluded from some of the analyses.

Results

The survival plot for the remaining 353 whales caught during the 3 seasons is shown in Fig. 2. Instantaneous death (≤10 s) was reported for 17.1% of the whales (Table 1). The median value for time to death was 570 s, the lower quartile (Q_1) was at 208 s and the higher quartile (Q_3) at 956 s. The mean survival time was 680 s. Seventeen whales (4%) survived for 30 min or longer and the longest time registered was 62 min.

The median value for hits in the central nervous system (CNS) was 0 (Table 1). The median survival time was 31 s for whales injured in the heart and 450 s in cases where the lungs but not the heart were injured. The median time for hits in main blood vessels in the thorax or abdomen was 292 s. The CNS was hit in 13% of the cases and the thorax in 31% of the cases. Fifty six per cent of the whales were hit where the injury was unlikely to cause instantaneous or rapid death, e.g. in the abdomen or musculature. The median survival times for hits in these regions were 690 and 870 s, respectively. Seventeen per cent of the whales were reshot with harpoons, and rifle shots were fired into the brain in 56% of the cases. Complete penetration of the body by the harpoon was seen in 87% of the cases. The whales varied in size from 4.9 m to 9.2 m with a median length of 6.7 m. The shooting range varied from 5 to 100 m, with a median value of 30 m. Four per cent were shot in front (di-

Table 1. Percentage of minke whales dead instantaneously (≤10 s), median survival times, lower (Q_1), upper (Q_3) quartiles and mean survival times in s for minke whales caught with cold harpoon after hits in different organs/tissues in 1981-83.

Tissue/organ	Instantaneous death (%)	Survival time (s)			
		Median (Q_2)	Lower quartile (Q_1)	Upper quartile (Q_3)	Mean
CNS	71.4	0	0	46	69
Heart	37.0	31	0	349	168
Blood vessels	28.0	292	0	600	364
Lungs	24.1	450	60	790	467
Abdomen	1.6	690	483	960	725
Musculature	1.3	870	590	1290	1071
All whales	17.1	570	208	956	680

rectly in front to 45° to the animal's long axis), 60% from the side (45-135°) and 36% were shot from behind (135°-directly from behind). The range, the size of the whale and the angle of the shot relative to the animal's long axis all strongly influenced survival time.

The influence of shooting range and whale size on killing time was studied by Cox regression (proportional hazard) and by a combination of logistic regression for the whales killed instantantaneously and Cox regression for whales surviving longer than 10 s. The time to death was significantly dependent on both covariates in the Cox regression. Fig. 3 illustrates this dependence between time to death and the 2 covariates, shooting range and animal size. The analyses based on a combination of logistic regression and Cox regression gave similar results. However, the fraction of the whales killed instantaneously was only dependent on shooting range and not significantly on animal size.

Shots fired from in front or behind produced poorer results than shots from the side. The effect was quite clear both on the median and mean survivival times.

Twenty three per cent of the whales were shot with 50 mm and 77% were shot with 60 mm harpoons. The results showed that there was no significant difference between 50 mm and 60 mm harpoons in survival times or frequency of total penetration.

Discussion

The statistical analyses of the dependence between survival times and the 2 covariates, shooting range and animal size, showed that the fraction of the whales killed instantaneously in 1981-83 was only dependent on shooting range and not significantly on animal size, whereas survival time for animals not killed instantaneously was significantly dependent on both shooting range and animal size.

In general, the lethality of non-explosive projectiles such as the traditional sharp-pointed cold harpoon is directly related to the damage caused by the projectile itself to the organs and tissues it passes through. It must therefore hit vital organs like the brain, heart or major blood vessels to kill the animal rapidly (*Øen* 1992b, 1994a). When such vital organs are injured by large projectiles like 50 mm and 60 mm harpoons, the animal would die very rapidly regardless of the harpoon calibre or the animal's size. As long as an animal was alive,

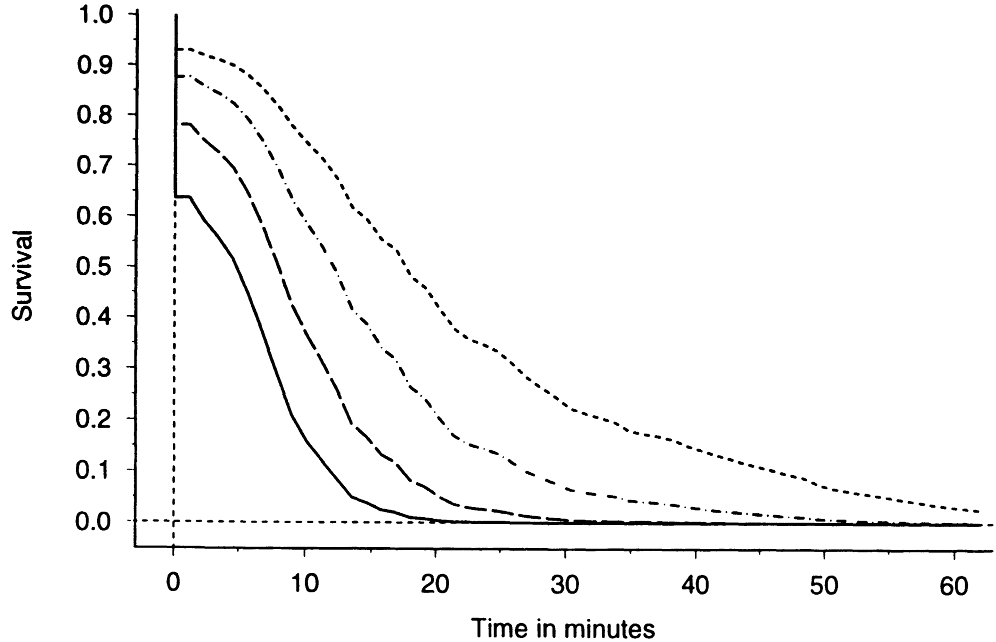

Figure 3. Estimated survival plots for minke whales after hits with cold harpoons based on the Cox regression for selected values of the 2 covariates. Axis as in Fig. 1.

——— : Length = 5 m, Shooting range = 10 m
— — : Length = 5 m, Shooting range = 50 m
— • — : Length = 9 m, Shooting range = 10 m
- - - - : Length = 9 m, Shooting range = 50 m

however, the hunters would be careful not to haul it in too fast because they were anxious not to lose whales alive, and the larger the whale the more time this process took, thus prolonging the time to death.

Another factor that prolonged killing times for some whales was outdated hunting techniques inherited from earlier days with poorer equipment and ropes, which were still in use. These meant that the harpoon line could only be connected to an air-filled buoy that was thrown out after the harpoon had hit. In the case of a non-lethal hit, a long time could elapse before the whale could be killed either by a second harpoon or by a rifle shot. This hunting method which is still used by Eskimos during aboriginal subsistence whaling *(Øen* 1995) has been prohibited in Norway since 1984. In other cases some wounded whales were not hauled in before being played out to reduce the risk of losing them.

The shooting range influenced the results, which were poorer for ranges exceeding about 30 m. The reduction of accuracy at longer ranges is also a well-known phenomenon in other types of hunting using projectiles, but the accuracy of the relatively heavy, slow harpoons (v_0 = 80 m/s) will decrease substantially at longer ranges. In addition, the sharp-nosed harpoons which were used in 1981-83 had a tendency to ricochet or turn upwards under water (*Øen* 1994a). Shots from directly in front or behind the animal gave poorer results than shots from the side because the likelihood of hitting the animal in the most vital organs was considerably lower at such angles.

The inspectors were instructed to confirm death by personal observation of the prescribed criteria before reading the stopwatch. If the weather was poor or the distance between ship and whale too long to observe flippers and jaw before the whale sank, it had to be hauled in to the ship before the inspector could determine whether it was dead and the time of death could be recorded. In such cases the recorded survival time might be appreciably longer than the actual time.

It has been recognized at slaughtering of livestock that uncoordinated movements may continue for several minutes after unconsciousness has transpired (*Blackmore & Delaney* 1988). Such reflex movements are due to the loss of inhibitory control of spinal reflexes by the brain (*Breazile* 1977) and do not necessarily mean that the animal is conscious and able to register pain (*Fricker and Riek* 1981, *Blackmore & Delaney* 1988). The criteria set out by the IWC for determination of the time of death do not take such spinal reflexes into consideration. However, as described by *Øen* (1994b) it is reasonable to expect that such reflexes also occur in whales.

Death usually occurred very rapidly (seconds) if the heart was injured, but in one case where the right atrium was damaged, the inspector reported that movements could be detected for 8 min. This is one of the cases in which the animal was probably already unconscious. Lung injury appeared, however, to have less effect in whales than in large terrestrial mammals where according to the author's observations, damage to the central parts of the lungs usually produces rapid internal haemorrhaging in the thoracic cavity and collapse within a few (1-3) min. The median time to death after a shot in the lungs on minke whales was 7½ min, and a survival time of 24 min was recorded for a whale with 1 lung punctured.

The difference between terrestrial animals and minke whales is likely to be related to whales' adaptations to diving. Unlike land mammals, whales do not breathe several times per minute. The respiratory rate of minke whales in Norwegian waters is about 32-60 per hour, depending on their activities (*Øen* 1990, *Folkow & Blix* 1993), in sequences of 1 to 4 blows in rapid succession every 3 to 5 min (*Øen* 1990). If a minke whale is hit by a cold harpoon and not instantaneously immobilized, rendered unconscious or killed, it usually dives. During diving blood flow is restricted to certain organs by peripheral vasoconstriction and a decrease in heart rate and cardiac output (*Elsner et al.* 1966, *Blix & Folkow* 1983). The abdomen and thorax will be compressed by the increasing water pressure, and at a depth of about 100 m the lungs of a fin whale are completely collapsed (*Bonner* 1980). The flow of blood, and thus haemorrhaging from the lung tissue and the pulmonary vessels, are therefore reduced during diving. The fall in blood pressure and resulting brain ischaemia are delayed. The blood in the alveoli and bronchioles does not cause the whale major respiratory problems before it must surface again to breathe. The blood in the lungs will then restrict or reduce the uptake of oxygen and haemorrhaging will increase as the lung circulation is resumed.

More accurate shooting and hits in the most vital body areas would undoubtedly improve results with the cold harpoon. However, even if accuracy were to be improved by optimizing weapons, sighting implements, harpoons (*Øen* 1994a), other hunting equipment and by training the gunners better, this would probably not be sufficient to once again accepting cold harpoons as weapon in the Norwegian minke whale hunt.

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Sammendrag

Beskrivelse og analyse av kaldharpun brukt i norsk vågehvalfangst i fangstsesongene 1981-1983.

Fram til 1984 ble det brukt harpun uten sprenggranat, såkalt kaldharpun, til fangst og avliving av vågehval i Norge. I et prosjekt som tok sikte på å forbedre fangst og avlivingsmetodene ble det samlet inn data om avliving med kaldharpun som grunnlag

for sammenligning med nye metoder. De kriterier som ble brukt til å bestemme om dyret var dødt, var enten at forlemmene, sveivene, var i ro, underkjeven hang ned eller at hvalen hang i harpunlinen uten å bevege seg. Disse kriteriene var det enighet om i den Internasjonale hvalfangstkommisjonen (IWC). Slike dødskriterier tar imidlertid ikke hensyn til bevegelser som kan oppstå på reflektorisk grunnlag etter at hjerneaktiviteten er falt bort. I årene 1981-1983 ble det samlet inn data fra avlivingen av 353 vågehval. Resultatene viste at ca. 17% døde momentant (≤10 s). Den mediane overlevelsestiden var 9 min 30 s med lengste overlevelsestid på 62 min. Kaldharpuner hadde best effekt når de skadet sentralnervesystemet (CNS), hjertet og sentrale blodkar. Dersom bare lungene ble skadet ved treff i thoraxregionen, døde ikke hvalene like raskt som større landpattedyr med tilsvarende skuddskader. Treff utenfor CNS og thorax ga oftest overlevelsestider over 10 min. Både skuddavstand og skuddvinkel i forhold til lengdeaksen på dyret, hadde betydning for om dyra døde momentant (≤10 s) eller ikke. Dersom dyret levde i mer enn 10 s, økte overlevelsetidene i tillegg med størrelsen på dyret. Selv om avliving med kaldharpun utvilsomt kunne blitt bedret, var metoden ikke akseptabel og kaldharpun ble erstattet med granatharpun i 1984.

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