REPORT OF THE EXPERT GROUP MEETING ON ASSESSING TIME TO DEATH DATA FROM THE LARGE WHALE HUNTS

4 – 6 November 2015, Copenhagen, Denmark

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INTRODUCTION

NAMMCO Council in February 2015 tasked its Committee on Hunting Methods to organise the second Expert Group meeting to assess large whale killing data. The first assessment meeting was held in 2010 (NAMMCO 2010).

People's right to hunt and utilise the marine mammal resources is one of the founding principles of NAMMCO. Embedded in this right is the obligation to ensure that the hunt is sustainable and that it is conducted responsibly with respect to killing efficiency, hunter's safety and animal welfare. To facilitate NAMMCO's work in this field, the Committee on Hunting Methods was established in 1994. The Committee gives advice on hunting methods and practices to the NAMMCO Council and the member countries. The advice should be based upon the best scientific findings, technological developments and user knowledge with due considerations to hunters' safety and efficiency of utilisation.

TERMS OF REFERENCE of the Expert Group as provided by the NAMMCO Council:

The expert group meeting shall undertake a review and evaluate the whale killing data submitted to NAMMCO by member countries and associated hunting nations, as well as data and information on recent and ongoing research on improvements and technical innovations in hunting methods and gears used for the hunting of large whales.

The aim of the Expert Group was to assess the presented whale killing data and give recommendations with respect to possible improvements. Data and information were presented from Greenland, Iceland, Norway, Japan, USA (Alaska and Makah hunts) and Canada.

In setting up the Expert Group, the Committee on Hunting Methods identified a small group of qualified persons with extended experience and knowledge in general and/or marine mammal specific biology, physiology, anatomy, pathology and statistics. All members of the Expert Group (Appendix 1) were invited in a personal capacity, without affiliation to country or organisation, as experts in fields related to the issue of killing mammals.

The meeting agreed on the agenda (Appendix 2) and established a drafting group with the responsibility to formulate conclusions and recommendations. Based on the discussions and deliberations of the meeting they presented some draft recommendations on the last day. These recommendations were discussed in plenary point by point and adopted by consensus. The finalising of the full report was done afterwards by correspondence.

The Expert Group met under the chairmanship of Dr Christina Lockyer on 4 – 6 November 2015 in Copenhagen, Denmark. Charlotte Winsnes acted as rapporteur. The present report summarises the discussions of the Expert Group and gives the conclusions and recommendations.

BACKGROUND

Time to death (TTD) or Survival time (ST) and the Instantaneous death rate (IDR) are terms used to measure and quantify killing efficiency and the state of art of killing methods and practices. Standardised collection and analysis of TTD/ST and IDR data with covariates that may influence these make it possible to compare how rapidly whales are killed using different techniques and gears. It also makes it possible to calculate effects of new developments, modifications or changes in hunting practices and of systematic training of hunters.

CRITERIA OF DEATH

Definition of death has changed over the centuries depending on cultural views as well as technological and biomedical advances. In biology, death was traditionally determined by behavioural signs such as termination of movement and respiration, and for a long period of time it was widely accepted that death equalled the absence of pulse and breathing *i.e.* the classical cardio-respiratory criteria of death (Knudsen 2005[1]).

No official criteria of death have been formulated for animals except for whales. A definition was adopted by the International Whaling Commission (IWC) in 1980 and reiterated in 1992 (IWC 1980; 1992) to make a standard ruling to compare the efficiency of different hunting and killing procedures in the field as well as evaluation of research into new methods. As the exact time of death might be difficult to observe for animals dying in or under water the time of death was defined as "… the moment the mouth (was) slackened, the flippers (were) slackened (along the sides) and/or all movements (had) ceased". However, neuropathological investigations of minke whale brains from whales hunted and killed with penthrite grenades showed that the IWC criteria were not always met as whales with permanent brain damage of sufficient severity to account for instant or very rapid loss of sensibility and death still (like terrestrial mammals) could show uncoordinated movements (reflex movements) for several minutes after they were dead (Knudsen 2005).

Knudsen in her doctoral thesis "Assessment of insensibility and death in hunted whales – a study of trauma and its consequences caused by the currently used weapons and ammunition in the Norwegian hunt for minke whales, with emphasis on the central nervous system" (Knudsen 2004, p. 100) concluded that "...when times to death (TTD) are solely determined on the basis of the IWC criteria which in practice is immobility, a significant portion of animals will be recorded as being sensible or alive when they actually are unconscious or dead." Hence one may conclude that TTD based on the IWC criteria is biased negatively *i.e.* overestimated.

Discussion

The Expert Group (EG) acknowledged that no clear definition of death exists for animals. It can therefore be argued that by definition measuring time to death (TTD) is not feasible. However, for the purpose of comparison both between and within hunts the IWC criteria has proven to be an adequate and internationally agreed upon tool to measure efficiency and to assess improvements. Furthermore the EG emphasised that the IWC criteria is applicable not only for veterinarians but also for hunters, a not insignificant point since hunters often are the ones reporting TTD with their watch as the only available technical measuring tool.

The EG agreed that the IWC criteria was not an exact criteria of death but that it was a working criteria that for all practical purposes functioned as a measuring tool.

COLLECTION OF TTD DATA

The NAMMCO Expert Group Meeting on Assessment of Large Whale Killing Data in 2010 emphasised the importance of recording TTD/ST/IDR. The meeting recommended that all hunts use the Norwegian method of collecting and analysing TTD data in order to identify needs for improvements.

In Norway, TTD data were collected for more than 5,000 minke whales killed in the period 1981 to 2012. During this period, the hunting equipment and methods changed primarily because of research

[1] Knudsen SK, 2005. A review of the criteria used to assess insensibility and death in hunted whales compared to other species. The Veterinary Journal 169 (2005) 42 – 59.

and development work done to improve killing efficiency and reduce animal suffering. The IDR increased by 65% from 17% to 82% and the average TTD was reduced from 11.5 min to 1 min.

The standardised collection and analysis of TTD, ST and IDR data from hunts using different techniques were instrumental in improving the hunting methods and gears. The data were analysed with covariates like animal size, shooting distance and angle of harpoon gun shot, hit region and detonation area. The results of the analysis not only documented the need to develop better weapons and improved hunting techniques and practices, but also gave indications as to which factors might be of special significance for improvement. It also highlighted the importance of organising training courses for hunters.

How to collect TTD data the "Norwegian Way" – Appendix 3
The data collectors should be independent, designated, competent persons that do not have other tasks to attend to in the killing and flensing (butchering) phase. Qualification requirements are veterinarians, large mammal biologists and large whale physiologists and hunting- and fisheries inspectors, in that order.

The profession of the veterinarians enables them to better understand and assess the behaviour of the animal when hit, and relate the animal's reaction to the death criteria, and it is assumed that large mammal biologists and physiologist also have this understanding. For example when the question is whether an animal is dead or unconscious it is important to understand the concept of reflex movements and to be able to distinguish between these as uncoordinated movements and movements made by a conscious and living animal. Typically, a hit whale swimming on its back shows that the whale is unconscious or dead and what one sees are reflex movements.

Ideally, every kill should be followed by post mortem examinations, and thus anatomical and pathological knowledge is important when assessing damage to organs and gross (macroscopic) changes in vital organs. Pathological findings are especially important when verifying differences between reflex and conscious movements.

A specially designed reporting form has been developed covering primary observations of the animal during the hunt and kill, such as, among others, reaction pattern, hit area and estimated TTD, and secondary observations typically related to variables like animal size, shooting distance and angle, *etc.* Prior to collecting TTD data all personnel should receive special training covering *inter alia*: general introduction to national laws and equipment used in the hunt, and a thorough review of the reporting form.

Quality control of data
Each separate reporting form must be examined closely to make sure that errors or possible misrepresentations of facts are taken out or corrected before the data are analysed. Inconsistencies must be explainable for the data to be included in the dataset that will be analysed. The more knowledge and experience a person has of the hunting methods and practices, the more capable he or she will be to undertake this quality control of the collected data.

When doubt exists concerning reports, it is required that supplementary information be acquired by interviewing the inspector and hunters, and/or by checking catch data or other data from other existing reporting systems. In Norway, an additional source of information for a person specifically trained in Norwegian minke whale hunt is the electronic recording system "the blue box". The electronic system does not record TTD but it records time and position of every whale shot and taken on board for flensing through various movement sensors placed in strategical places on the boat connected to a GPS. This means that data from this system may give an indication as to whether the whale died quickly or slowly.

To be able to carry out this kind of quality control satisfactorily it is a prerequisite to have the necessary biological knowledge in addition to detailed knowledge of, and experience from, whaling.

Discussion
The EG underlined the importance of collecting data in a standardised manner. It also noted the importance of doing a quality control of individual datum to ensure that the data used is "true" in the sense that it is not a product of misinterpretation or obvious errors.

The person measuring TTD might not be one of the above-mentioned professions. Sometimes hunters will collect TTD. It was noted that as long as the person collecting the data is trained in what to look for it is better to record TTD than not recording TTD at all.

ANALYSIS AND PRESENTATION OF TTD DATA

From the early 1980s the IWC started to question whaling member countries about statistical data on TTD. At that time the results were usually presented as mean TTD (perhaps with either the corresponding standard deviation (SD) or standard error (SE)). Usually the maximum TTD was also presented as well as the number of whales behind the calculations. As long as only a few whales died instantaneously this was a fair way to present the TTD results. These measures could be compared *e.g.* between different years or between different types of harpoon guns to investigate whether there were improvements in the hunt. Already at that time it was obvious that both mean and the SD were strongly influenced by one or a few whales with very long TTD, but an advantage was that the measures were easy to calculate.

Today statisticians advise the use of more robust measures of location and spread in situations where there are possibilities of outlying observations. The Norwegian method is based on Professor Walløe's advice to use the simplest of these robust alternatives: the median and the 0.25 and the 0.75 fractiles in the distribution. However, since a large fraction of the whales die instantaneously today in many whaling operations the analysis should be divided in two parts.

First the Instantaneous Death Rate (IDR) should be analysed by methods for estimating a binomial probability, usually combined with methods to estimate a 95% Confidence Interval (CI). These IDRs can then be compared between years or between hunting methods, if necessary by such statistical tests as Fisher-Irwin test or Campbell's chi-square (n-1) method. If covariates such as shooting distance, shooting angle or length of the whale are recorded, the analysis can be extended by logistic regression to investigate whether any of these covariates influences the IDR.

The whales that survive the first hit by the harpoon should then be analysed by the methods described in the second paragraph above. The median and the two quartiles in the distribution should be presented, for the median also the nonparametric 95% CI. A Kaplan-Meier plot of the results is usually very informative. If covariates are available, Kaplan-Meier plots could be made for different sub-groups, or the possible influence of the covariates could be investigated by a Cox regression. If some of the survival times are censored *e.g.* because a secondary killing method is applied, the median and fractiles should be estimated by methods from 'survival analysis'.

Discussion
The EG noted the presentation and agreed with the statistical advice, especially to divide the data into 2 parts: the IDR group and the remaining survivors.

DESCRIPTION OF KILLING METHODS – REVIEW OF TTD DATA

NORWEGIAN MINKE WHALING

Norwegian fishermen are hunting minke whales from small (50 feet) or medium sized (60-120 feet) fishing boats that are rigged for whaling in the spring and summer season. The weapons are 50 mm and 60 mm harpoon guns. The harpoon is equipped with a penthrite grenade (Whale grenade-99) developed in Norway in 1997-1999. The grenade is loaded with 30g pressed penthrite as explosive. The back-up weapon is a rifle of calibre .375 or .458, using full metal jacket, round-nosed bullets. The vessels usually search for whales at slow speed (4-6 knots/h) and the whales are often shot from a relatively short range (< 30m). No sonar or similar instruments are used during the hunt as such instruments are considered to scare the whales off.

Starting in 1984 all gunners and licence holders have been required to attend obligatory training courses. The recommendation is to fire the grenade at the whale from a side position (45°-135° - relative to the animal's long axis) and aim at the thorax (chest). The rifle is usually fired at close range and when the whale's head is over water. The shot is directed to the brain.

Research programmes

From 1981 to 2005 several research programmes and studies to assess and improve the hunting and killing methods for minke whales were conducted in Norway.

*1981- 86: Research programme I***:** Project manager E.O. Øen.
Development of improved killing methods in the Norwegian minke whaling, improvements of weapons and hunting methods and training of hunters.
The research programme aimed to find alternatives to the "cold" harpoon (harpoon without explosives). The programme included collection of TTD data from the "cold" harpoon hunt for comparison with other killing methods, field trials with high velocity projectiles (HVP), alternative designed harpoons, the use of explosives and rifles and ammunition used for back-up. The trials with HVP showed that such projectiles under certain conditions had abilities to kill minke whales fast, but since minke whales sink when dead HVP had to be combined with simultaneous harpooning to retrieve shot whales. The studies also included the possible use of high-pressure gases, drugs and electric harpoons. After reviewing the possible use of gases, drugs and electricity to kill whales no trials to test such methods were found necessary. The work resulted in the development and implementation of a harpoon grenade (Raufoss) with 22 g of penthrite fuse as explosive implemented in the hunt from 1984-85 onwards. The data sampled during the research period showed that while the "cold harpoon" killed only a maximum of 17% of the whales instantly or within a minute the new penthrite grenade killed 45% of the whales instantaneously.

*1992- 96: Research programme II***:** Project manager E.O. Øen.
Further developments of alternative hunting gears and hunting methods in Norwegian minke whaling.
The studies included development of methods for *in situ* fixation of whale brains and histological examination of brain tissues, ballistic studies and further trials with harpoons, ballistic studies of rifle bullets, harpoon gun sights and marksmanship contra shooting ranges, improvements of catching gears and routines. In addition to the development of a method for *in situ* fixation of whale brains the studies resulted in implementation of obligatory shooting tests for gunners with harpoon guns and rifles prior to the hunt and new regulations in the hunt. After implementation of the shooting tests and the new regulations the IDR was elevated from 45% to about 60%.

1996- 2004: Research programme III: Project manager E.O. Øen.
Further developments of explosives and weapons in Norwegian minke whaling: Development and

field testing of a new and improved harpoon grenade for minke whales (Whale grenade-99).
A relatively high rate of malfunction of the Raufoss harpoon grenade in the 1990s initiated studies that resulted in a new, safer and more reliable penthrite grenade for Norwegian minke whaling. The Whale grenade-99 was implemented in the hunt from 2000 and data sampled during the hunt in 2000-2002 for 1667 minke whales showed an IDR of 80%.

*1998-2004: Research programme IV***:** Project manager S.K. Knudsen and E.O. Øen
Assessment of insensibility and death in hunted minke whales; study of trauma and its consequences caused by the currently used weapons in the Norwegian minke whale hunt
The aims of the study were to: (1) investigate lesions caused by penthrite grenade detonation in minke whales, with special emphasis on the central nervous system (CNS); (2) confirm that the rifle ammunitions used in the Norwegian hunt were capable of penetrating the skull of minke whales and causing sufficient damage to the CNS to account for an instantaneous loss of sensibility; and (3) find out if the "IWC criteria" of death were valid to determine TTD in whales.

The results of post mortem examination of minke whale brains fixed *in situ* proved the deadly effect of penthrite grenades detonating in the whale body. They confirmed that unconscious whales show agonal reflex movements, an issue that had been under discussion for years in IWC. They also confirmed that the "IWC-criteria" were not fully adequate to determine exactly when a whale loses consciousness or dies when TTD are solely determined on the basis of the "immobilisation" criteria; and that a significant proportion of animals will be recorded as being sensible or alive when they most likely are unconscious or dead. However, if the IWC criteria are used in conjunction with a post mortem examination, the estimated TTD will be close to the real TTD for the majority of the whales. The method can therefore be used to compare different hunting techniques and methods provided that competent personnel collect the data and the same protocol is used for data collection and analysing. If the pathological examination does not include investigations of the brain, it is likely that the TTD of some animals still will be overestimated.

Collection of TTD data and results from the 2011 and 2012 seasons
Data collection
Data was collected and recorded on specific reporting forms by fisheries inspectors trained in a two-day course. In addition to TTD, the behaviour of the whale after being shot, whale length, estimated range of shooting, the angle between the shot direction and the whale's long axis, the impact point on the whale, the detonation site, necropsy findings, grenade function and re-shootings were recorded. The time from a strike to the animal's death was recorded by using stop-watch. The IWC criteria were used to decide TTD.

Results
TTD data were collected for 271 minke whales. Instantaneous death was recorded for 222 whales (82 %). The median TTD for the 49 whales not registered instantly dead was 6 min. One whale that had only been wounded was re-shot and died after 20-25 minutes.

The shooting position/angle is registered for 94% (255) of the whales. Of these 62% were shot from the recommended side position (45°-135° - relative to the animal's long axis), 22% in a narrower angle from behind (135°-180° - relative to the animal's long axis), 16% were shot from the front (0°) or from behind (180°). 92% of the whales shot from the recommended side position (45°-135°) were registered instantly dead while only 70% of whales shot in the narrower angle either from front or behind positions (0°- 45° and 135°-180°) died instantly. The result for the other 16% of whales which were shot from the front (0°) or from behind (180°) was 63%. No misfire of grenades due to technical errors was reported during the two seasons.

The instantaneous death rate of 82% is the highest IDR ever recorded in the Norwegian minke whale hunt (see Figure 1).

Detonation in the thoracic cavity, detonation near the spinal column in the thoracic part and rostral to the thorax (neck and brain) resulted in 100% instant death. The detonation caused massive bleedings, damages and injuries to vital organs like heart, lungs, major blood vessels and central nervous system (CNS). Former studies of minke whale brains from whales killed with penthrite grenades (Knudsen 2005) show that the detonation in thorax and neighbouring regions like the rostral part of the abdomen creates fatal haemorrhages (bleedings) in the spinal column and the basis and cortex of the brain, probably due to concussion and the extremely high, undulating pressure/shock waves that spread out through the body to the brain through natural openings like the spinal column, large vessels and other openings in the skull.

The angle of the shot relative to the animal's long axis influences the TTD significantly. Shots directed at the thorax from the recommended side position of about 45°-135° relative to the animal's long axis resulted in 92% instant kills while shots directed in narrower angles from front or from behind resulted in 70% and 63% instant kills, respectively.

The results from this study are concurrent with earlier studies. Shots from a narrow angle to the body of a moving target will significantly increase the risk of stray shots or hits and detonation outside vital areas and seem to be the main reason for the longer survival times.

Presently, due to continuous modification of components that have showed weaknesses, and close surveillance and quality control of the production process, malfunction or misfire of the Norwegian penthrite grenade is very unusual. The high quality of the grenade together with the introduction and use of the NAMMCO handbook "NAMMCO Instruction manual for the maintenance and use of weaponry and equipment deployed in hunting of baleen whales in NAMMCO member countries" should potentially increase further improvements of IDR and TTD if all gunners become patient and wait until the animal is in the recommended side position before the gun is fired.

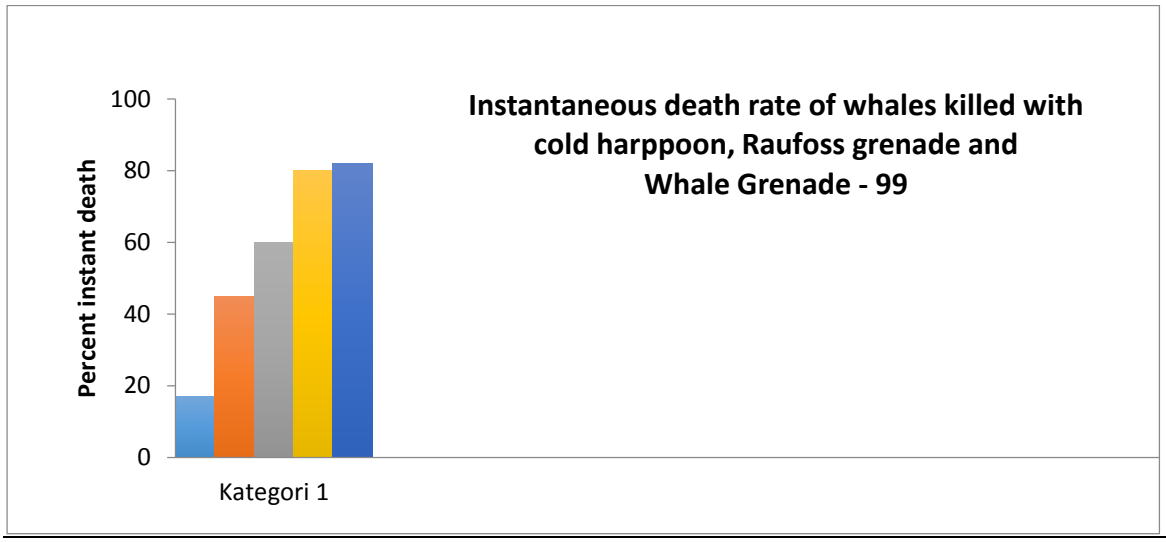

Figure 1: IDR of whales killed with different weapons
Light blue: cold harpoon 1981-83, Orange: Raufoss harpoon grenade 1984-86, Grey: 1994-96, Yellow: Whale Grenade-99 2000-02. Blue: Whale Grenade-99: 2011-12.

Discussion

The EG acknowledged the extensive research and developmental work undertaken by Norway since the early 1980s. The EG further noted that the TTD data collected in 2011 and 2012 confirmed and gave a slightly improved result to the last survey undertaken in 2000-2002. Presently the IDR was 82 % as compared to 80% the last time. The survey covered all hunting boats over a period of 2 years.

The EG reiterated and emphasised the conclusion from the 2010 meeting of the importance of the angle of the shot relative to the animal's long axis in harpoon gun hunts. The recommended angle is from 45 to 135 degrees relative to the animal's long axis and the shot should be aimed at the thorax.

The EG acknowledged that all 2010 recommendations had been followed up. It further recommended that Norway continue to monitor the hunt with regard to TTD and IDR at 10-year intervals unless important issues arise that require more frequent monitoring.

ICELAND –MINKE WHALES

The minke whale hunt in Iceland is carried out with similar weapons and boats as are described for the Norwegian minke whaling above. Minke whales are hunted in Icelandic coastal waters from small or medium sized (60-70 feet) fishing boats that are rigged for whaling in the spring and summer season. The weapons are deck mounted 50 mm Kongsberg harpoon guns equipped with the penthrite grenade (Whale grenade-99) developed in Norway in 1997-1999. The grenade is loaded with 30g pressed penthrite as explosive. Back-up rifles of calibres .375 or .458 using full metal jacket, round-nosed bullets are used if the whale is not instantly dead by the grenade detonation. The vessels usually search for whales at slow speed (4-6 knots/h) and the whales are often shot from a relative short range (< 30m). No sonar or similar instruments are used during the hunt as such instruments are regarded to scare the whales off.

Collection of TTD data in the 2014 and 2015 seasons

An experienced veterinary officer well-trained for TTD data collection was engaged to collect the TTD data using the data-collection form that is used for collection of TTD data for minke whales in Norway. In addition to TTD data, supplementary information like the behaviour of the whale after being shot, whale length, estimated range of shooting, the angle between the shot direction and the whale's long axis, the impact point on the whale, the detonation site, necropsy findings, grenade function and possible re-shooting was recorded. The post mortem examinations of the whales were carried out when the whales were processed on board. On board examinations do not include examination of the brain.

The time from a strike to the animal's death was recorded by using a stop-watch. The time of death was recorded as recommended by IWC in 1980. In addition to these behaviour signs of death the recorded TTD was verified through the findings of organ damage demonstrated at the autopsy. Shooting range and angle of the shot relative to the animal's long axis were estimated without instrumental aid.

Nine (69%) of the 13 minke whales were reported instantly dead after detonation of the grenade in the thoracic region. Eight of these were shot from the recommended side position (45°-135° - relative to the animal's long axis) and one from a narrower angle from behind (135° - 180° - relative to the animal's long axis). The median survival time for the four whales that did not die instantly was 4 min. The longest survival time was 13 min.

The size of the whales varied from 6.2 to 8.1m. Shooting distance varied from 20 to 60 m with an average shooting distance of 45m.

Discussion

The EG acknowledged that Iceland had followed up on the 2010 recommendation (NAMMCO 2010) to collect TTD data. The presented data had been collected and analysed with covariates (animal size, shooting distance and angle of harpoon cannon shot, hit region and detonation area) in line with the Norwegian methods like it had been done in Norway during 1981-2002.

The weapons used in Iceland are identical to the ones used in Norway for minke whales and the results show an IDR of 69% which is lower than the IDR registered in the Norwegian hunt (82%). The EG did not find that they could draw any firm and strong conclusions regarding killing efficiency due to the very limited set of data from the two seasons. In such a small sample each unit will represent 7-8% of the result making it possible for one single whale to tip the balance considerably in a positive or negative direction.

The EG noted that these results were somewhat inconclusive. The EG recommended that Iceland should work towards future collection of data for minke whales, for improved assessment of TTD. As was the case with Norway, the EG recommended that as a general rule, the hunt be monitored with regard to TTD and IDR at 10-year intervals unless important issues arise that require more frequent monitoring.

ICELAND – FIN WHALES

Fin whale hunting is conducted from medium-sized boats that are exclusively used for whaling. Hunting grounds are within Iceland's 200 miles exclusive economic zone and the whales are towed to a land station for flensing and processing. The whales are killed using 90 mm Kongsberg harpoon guns and a modified Whale Grenade-99 designed to trigger the detonation of 100 g of the explosive penthrite at a depth of 110 cm after penetration into the whale. The back-up weapon is a new grenade. Hvalur hf., the company hunting fin whales in Iceland, has since 1985 worked to improve the killing efficiency in the hunt. Whale Grenade-99 replaced the former "Black Powder Grenade" (filled with 650 g of black powder as explosive) that had been used for large whales for at least 70-80 years. The killing by the "Black Powder Grenade" is a combination of the concussion from the blow and the wounds and tissue lacerations caused by the heavy splinters from the cast iron grenade. However, the wounding and killing efficiency of such splinters is highly unpredictable.

When black powder was used, some TTD data were collected for 16 sperm whales and three fin whales during butchering of large whales in 1979. Based on organ damages it was concluded that onset of unconsciousness was rapid in eight whales, while onset of unconsciousness was slow in seven whales. In 1983 observations were made of the kill and butchering of 19 fin whales. The median TTD was estimated to three minutes. No whales were recorded instantly dead but six whales were recorded unconscious instantly or within 10 seconds. The median time to unconsciousness was two minutes. The longest survival time recorded was 16 minutes.

Development work to improve killing efficiency

1985-1989

Experiments on 90 mm harpoon grenade technology started in Iceland in 1985 and continued to 1989 in conjunction with the Icelandic programme on whale research. A prototype penthrite grenade was made using the core of the contemporary Norwegian minke whale grenade in 1986. Based on information from the gunner on behaviour of the whales after being hit and observations from flensing, the IDR was estimated as approx. 70-80%. However, no systematic necropsy of the hunted whales or any statistical analyse of killing data were undertaken. The conclusion that could be drawn was that detonation of 100 g of penthrite fuse in the chest or near the spinal column in the chest or neck resulted in instant death.

2009-2014
A second prototype of penthrite grenade was tested with some success in 2009 and 2010 and finally a third grenade was developed and tested in 2013. This grenade is made of stainless steel, has a new trigger line and trigger hooks. Gunners and crews were trained how to handle and use the new grenade. The training course was repeated in 2014 and the gunners were instructed to aim the harpoon grenade at the chest and to hold the shot until they could fire at the whale from the side (45°-135° relative to the animal's long axis).

Electronic sights for 90 mm Kongsberg harpoon canon
Harpoon guns are traditionally equipped with fixed simple open sights that cannot be easily adjusted. After studies of telescopic sights, Red Ring Holosight® (RRH) were used in the last half of the 2014 hunt. The trial took place too late to be included in the sampling of TTD data in 2014. However, the gunners claim that the new sights were successful and that they did not want to go back to use traditional open iron sights.

Collection of TTD data and results from the 2014 season
The data-collection that had been used for minke whales in Norway was adapted to fin whales and an experienced and well trained veterinary officer from Norway collected data during the 2014 season. In addition to TTD data, supplementary information like the behaviour of the whale after being shot, whale length, estimated range of shooting, the angle between the shot direction and the whale's long axis, the impact point on the whale, the detonation site, necropsy findings, grenade function and possible re-shooting was recorded. The post mortem examinations of the whales were carried out at the land station.

The time from a strike to the animal's death was recorded by using a stop-watch. The time of death was recorded as recommended by IWC in 1980. In addition to these behavioural signs of death the recorded TTD was verified through the findings of organ damage demonstrated at the autopsy. Shooting range and angle of the shot relative to the animal's long axis were estimated without instrumental aid. Reports were received for 50 fin whales. No whales were reported lost.

IDR was recorded for 42 whales (84 %). The whales not instantly killed (8) were re-shot with penthrite grenade. The median survival time for those whales was 8 min with the shortest survival time of 6.5 min and the longest survival time of 15 min. The recorded size/length of the whales varied from 50 to 69 feet.

Shots directed at the thorax from side position of about 45°-135° relative to the animal's long axis resulted in 92% instant kills while shots directed in narrower angles gave poorer results. The gunners shot several whales slightly more from behind (about 135°-180° - relative to the animal's long axis) than recommended, but the analysis showed that most of these whales also had high IDR. Of the eight fin whales that survived the first shot five had been shot from behind or from the front.

Detonation in the chest, in or at the thoracic spine, neck or brain resulted in 100% instant death. Detonation inside the chest caused bleedings and severe damage and injuries to vital organs like heart, lungs and major blood vessels.

Discussion
The EG noted the work that had been undertaken to improve hunting methods through modifications of the penthrite grenade, and acknowledged that an IDR of 84% was very good. Although the data presented on the use of the black powder grenades were incomplete and limited, the killing efficiency of the penthrite grenades used in 2014 was seen as clearly superior.

In 2010 it was recommended to look into the potential use of acoustic monitoring of grenade detonation in order to enhance human safety during flensing. Hvalur hf. contracted a consultant in Iceland, who is an expert in this field. Today both their catcher boats are equipped with underwater hydrophone sensors and an accelerator meter situated on the gun.

The system works such that when the gun is fired then the accelerator meter triggers a signal to the computer that records the shot from the gun and a very short time later records the blast from the grenade. This can then be printed out and handed to the flensing crew on land. They will then know better whether the grenade has exploded or not and will then take special care when handling the harpoon and the grenade during flensing operation, if the printed document from the catcher boat does not show that the grenade has exploded.

The EG noted that all the recommendations from 2010 were fully completed.

JAPAN

Japanese whaling for common minke whale in the western North Pacific is carried out in two very different operations. One is carried out offshore from one large catcher boat. This operation uses a rifle or a cold harpoon as a secondary weapon if the grenade harpoon does not kill the whale. The coastal whaling operation is carried out close to the coast from a number of small catcher boats. A lance or a cold harpoon is used as the secondary killing weapon, and the flensing of the whale takes place on the shore. Data from the offshore operation is available from 1994, and from the coastal operation from 2002. Data from both operations were available for analysis. The data included information about TTD and the covariates whale body length (BL), whale sex (SEX) and body hit point (HP; three levels), but not shooting distance.

For a detailed description of hunting methods with primary and secondary killing devices see NAMMCO Expert group meeting 2010.

The analyses were carried out as recommended by the NAMMCO Expert Group in 2010: "*The EG recommended logistic regression analysis on IDR from Japanese minke whale catches, both coastal and offshore, to try to identify the reasons for the differences between Japanese and Norwegian IDR, and to use Cox's regression methods on TTD for whales not killed instantaneously, to study the efficiency both of the harpoon method itself on these whales and the efficiency of the secondary killing methods."*

First the IDR was analysed by logistic regression with the two types of whaling operations as the only independent variable. The results showed that the IDR was higher in the offshore operation than in the coastal and that the difference was statistically significant at the 5% level ($p=0.003$).

Then IDR for each of the two whaling operations were analysed by logistic regression with covariates and interaction terms. The best models were selected by Akaike Information Criteria (AIC). For the coastal operation the best model included HP, BL and an interaction term between HP and BL. For the offshore operation the best model included HP and BL. For both operations HP in the thorax or abdomen resulted in higher IDR, and the IDR decreased with increased BL of the whale. There were no statistically significant sex differences.

For the surviving whales TTD was estimated by the Kaplan-Meier method and the influence of the covariates was explored by Cox regression. The Kaplan-Meier plots show that the killing of surviving whales is more rapid in the offshore hunt than in the coastal, especially the secondary killing method used in the coastal whaling is less efficient than the method used in the offshore whaling. For the Cox

regression the starting model for the explanatory variables of HP, BL and Sex and their first order interactions. Again AIC was used as the selection criterion.

For the coastal whaling the resulting best model included HP and SEX. For the offshore whaling the best model only included SEX. No interactions were selected in either of the models. For both operations surviving female whales die faster than males, but the difference is only statistically significant at the 5% level in the coastal operations ($p=0.006$). In coastal operations, TTD is longer compared to the offshore operations. This is probably explained by type (or size) of harpoon, which is smaller in coastal operations. In both whaling operations, surviving whales die faster if they are hit in the thorax or abdomen, but again the difference is only statistically significant in the coastal whaling ($p<0.001$).
The efficiency of the secondary killing methods rifle, cold harpoon and lance have not been analysed by logistic regression or survival analysis.

Discussion
The EG focused its discussion on the presented material for common minke whales.

The EG noted that IDR continues to be substantially lower than in other comparable hunts (Norway, Iceland) where the penthrite grenade is used as the primary weapon. The EG reiterated the advice given in 2010 that the use of sonar and high speed boats to chase the whales has effects on behaviour of whales. It is probably counterproductive in relation to achieving a high IDR. Chasing the whales usually results in shots at too narrow an angle from behind and the tail instead of from the side, and it is well documented that this reduces the efficiency of the grenade detonation and hence reduces the IDR and increases TTD. It was further noted that the logistical regression analysis on IDR showed that the difference in IDR between coastal and offshore operations can be explained by both body length and hit point.

When asked why the shooting distance differed between the coastal and the offshore hunts it was explained that this was linked to the amount of propellant charge and the weight of the harpoon. In the offshore operations 75mm harpoon guns and harpoons are used while the smaller 50mm harpoon guns and harpoons are used in the coastal operation.

The EG acknowledged the work that has been done since 2010 in relation to statistical analysis of data, in particular the number of parameters that have been considered.

Based on survival analysis it is clear that the lance is not as effective in the coastal hunt as the rifle used in the offshore hunt. In this connection it was noted that rifle was not used in the coastal hunt due to relative proximity of humans. The EG recommends that Japan develops and uses a more effective back-up weapon than the lance for the coastal hunt.

The EG notes that the 2010 recommendations included a study of the efficiency of the back-up (secondary) killing methods but that this does not appear to have been addressed.

Acknowledging that a rifle shot through the brain kills an animal instantaneously while a bleeding out caused by one or several stabs from a lance may take several minutes, the use of the lance as a back-up killing method should be evaluated.

GREENLAND

Minke whales, fin whales, bowhead whales and humpback whales with harpoon gun

The hunt is conducted opportunistically and seasonally, *i.e.* the hunters are not full-time whalers but also fishermen and they can also have other seasonal employment. Fin whales and humpback whales are caught in West Greenland, south of Uummannaq. Fin whales are caught either by two boats of a minimum length of 30 ft working together, or by one boat of a minimum length of 36 ft. One boat with a minimum length of 36 ft is required for the humpback whale. Bowhead whales are caught in West Greenland in the Disko Bay area. They are caught by three boats of a minimum length of 36 ft working together. The majority of the minke whales are also taken by this method by one boat with a length of 30-70 ft. Each boat should be equipped with one certified 50mm Kongsberg cannon, which is checked every second year.

The primary weapon is a harpoon with the Norwegian penthrite "Whale Grenade 99". This whale-grenade was produced for minke whales, but has been modified to accommodate the hunt of the larger whales (triggering cord extended from 40 cm to 90 cm, and explosive increased from 30 g to 45 g of penthrite). Primary and secondary weapons for the three larger whale species are the modified "Whale Grenade 99". Gunners shoot in the heart and lung region by aiming at an area close to the pectoral fins.

The secondary weapon for the minke whale is either a new grenade or rifle of a minimum calibre of 7.62 mm (30.06) employing full mantled bullets. Some hunters use solid round- nosed bullets together with rifles with higher calibre (.375), due to its better penetration. Rifle shots are aimed at the neck, in the back of the animal's head.

Hunting generally occurs in good sea conditions only (<Beaufort 3) as the main method of hunting is stealth. Trips generally last less than 24 hours and once a vessel has caught a whale it tows it to the nearest suitable flensing site. Hunting usually occurs within 60 nmi of the home port of the vessel and depending on conditions up to 10 nmi offshore.

Killing methods are continuously being improved, with a focus on hunters' safety and animal welfare. Data are collected for each hunt by the hunters and reported to the Ministry of Fisheries, Hunting and Agriculture.

Collective minke whale hunt

The collective minke whale hunt is carried out in settlements that do not have boats with a harpoon gun. The collective minke whale hunt takes place also to supplement the food products when the supply from the harpoon gun boats is not sufficient for the community. The collective minke whale hunt is the only hunt of large whales in areas with little infrastructure, such as East Greenland and West Greenland north of Disko Bay.

A minimum of five skiffs are required to carry out a hunt, but normally it will be around 8 -10 small (usually around 19 ft and never more than 29 ft) boats equipped with outboard motors. Each boat generally contains around 2-4 people. Boats of larger size without harpoon gun can also take part, but not as the leading boat. These are usually small fishing boats. Each skiff has to be equipped with at least one hand harpoon with line and buoys. This harpoon is attached to the whale at the first opportunity, to prevent the animal from sinking. During the course of the hunt, hunters attempt to herd the whale towards shallow and inshore waters.

The weapons of the collective minke whale hunt are rifles of a calibre of 7.62 mm. (30.06) or larger using full mantled bullets. As a rule, the whales are first wounded and then secured with the hand

harpoons. When possible, the hand harpoon is used before wounding the animal. One hunter is the designated leader and it is his task to secure the animal with the hand harpoon. Once a whale has been secured, it is killed by shots aimed at the neck. Round-nosed solid bullets together with rifles of higher calibre, such as .375, are often used to kill the whale.

TTD and IDR

The criteria used to indicate unconsciousness and death are when the whale does not move and the flippers are motionless. This includes when the whale has sunk and there is no movement in the harpoon line or floats. Number of whales killed instantly means whales reported killed within 1 minute. TTD is measured from the first impact regardless of if this is a handheld harpoon or grenade.

The TTD were scheduled to be analysed according to the 2010 recommendation, but due to unforeseen, external circumstances, this did not happen before the present EG meeting. The plan is now to do this in February 2016. Greenland has gathered data on hitting point, body length, sex and TTD.

The presented TTD data are biased high because the TTD are estimated by the hunters and are not corrected by post-mortem examinations. It was noted by the hunters that there is a clear difference in efficiency of killing between different geographical regions in Greenland.

Data were presented for all hunts and can be found in Appendix 4

Discussion

The EG acknowledged that Greenland had strived to follow up the recommendations from 2010, and that the recommendation to present data and analysis in a statistically more informative way will be fulfilled in the near future.

The EG acknowledges that Greenland has gathered data pertaining to the body position where the whale is hit and TTD, and looks forward to analysis and interpretation of these data to be made available.

The EG recognised that there had been a clear improvement and movement towards an IDR of more than 50% for the harpoon gun minke hunt. The IDR and TTD is still not as good as in the Norwegian hunt and it was suggested to do analysis of strike location as this might give indicators as to why this discrepancy exists. This information should then be part of future training of hunters.

The EG reiterated the recommendation from 2010 that debriefing meetings are organised for hunters at the end of each season to exchange information and experiences. It was noted by the hunters that there is a clear difference in efficiency of killing between different geographical regions in Greenland, and experienced hunters should meet with less experienced hunters to exchange information.

The EG expressed concern that the rifle hunt seems to be increasing as this hunt will seldom have an IDR above 0%. The character of the hunt is such that if the whale died immediately the risk of losing the animal is very high. In the rifle hunt the whale is first shot, then harpooned and then killed. The first shot is to slow the whale down in order to be able to get so close as to harpoon it and then kill it. It is not possible to get near enough to harpoon it first. The EG emphasised the importance of hitting above water as water will change the trajectory of the bullet. The EG encourages Greenland to evaluate the current sequence of the use of rifle and harpoon to catch the animals and also the efficiency of the harpoon in this sequence. It also encourages review of other types of harpoons.

The EG noted that the TTD is shorter and IDR higher in the minke whale hunt conducted by harpoon gun as compared to the rifle hunt. In addition Greenland documented a very low struck and lost rate for minke whales killed with harpoon gun, and a higher struck and lost rate for the rifle hunt.

Fin whale
The EG acknowledges Greenland for the change in the charge of the grenade that has resulted in a higher IDR for the fin whale hunt. The IDR is lower and the TTD greater than in the Icelandic fin whale hunt and the aim should be to improve the efficiency bearing in mind the differences in equipment used.

Data are needed with reference to the body position where the whale is hit in relation to TTD, and the EG looks forward to analysis and interpretation of these data to be made available.

Humpback
The EG noted that the increased penthrite charge deployed in the humpback whale hunt had not had the same positive effect on IDR as in the fin whale hunt, probably as a consequence of poor shooting angle.

Data are needed with reference to the body position where the whale is hit in relation to TTD, and the EG looks forward to analysis and interpretation of these data to be made available.

Bowhead
The EG acknowledges that shooting trials to study the trajectory of the harpoon through the water have been performed.
Data are needed with reference to the body position where the whale is hit in relation to TTD, and the EG looks forward to analysis and interpretation of these data being made available.

Fin, humpback and bowhead
The EG recommends that hunters be trained to measure and report on strike location and detonation location, and the distance between the two in order to evaluate the efficiency of the hunts.

Generally in relation to the recommendations from the 2010 meeting the EG noted that the only outstanding items to follow up were:

- Statistically analysing TTD data
- Debriefing after the end of the season

It was further noted that Greenland will do the analysis in February 2016 and that the intention is to hold a debriefing meetings after the end of the current season.

ALASKA

Bowhead whales are hunted there during spring (April – May) and fall (September – October) when the whales migrate between the Bering and Beaufort seas. In the spring hunt the hunting crews go out to leads in the pack-ice with their skin boats waiting for the whales to pass by. In the fall the hunt is carried out in open sea from larger outboard motor boats. The whales are killed with penthrite grenades developed in cooperation with a Norwegian scientist and charged with 22 g of penthrite or with traditional old black powder grenades. The grenades are fired from a "darting gun". In addition, as back-up, shoulder guns are used to fire black powder grenades. The darting gun, which best can be characterized as a multi purpose weapon, is attached to a strong wooden pole. The gun has a trigger rod in front that fires the gun when it hits the skin. A harpoon with line connected to a buoy is attached to the top of the darting gun. When a whale is spotted the skin boat is paddled up to the whale or in

the fall motored up to the whale and the darting gun is thrown at the whale aiming at the neck or the thorax (chest). The harpoon hits the skin/blubber and attaches to the whale the moment before the trigger rod hits the skin and fires the grenade into the whale. The penthrite grenade has a built-in delayer, which detonates the grenade 4.5 sec after penetration into the whale. The delay time of the black powder grenade is a little bit longer. When the whale is dead the carcass is towed to the beach where it is butchered. The bowhead hunt is subjected to considerable environmental interference from weather (wind speed and direction, fog, and temperature), stability of land fast ice, and sea ice concentration and type. The success of each hunt is greatly affected by these factors and shows considerable annual and regional variation.

Each Alaska Eskimo whaling vessel holds a captain and harpooner plus other hunters. The Alaska Eskimo Whaling Commission's weapons improvement programme has been working for several years to improve the hunting efficiency as well as providing a more humane method of taking the whales. Manuals and training courses are made and set up to teach the hunters how to safely and effectively use the penthrite grenade. The introduction of the penthrite grenade in the darting gun combined with training programmes organised by the AEWC has resulted in a significant reduction in whales struck and lost from around 50% to less than 10%. Up to now AEWC has only recorded struck and lost data as part of their reporting to the federal government and there has been no collection of TTD data.

Discussion

The EG noted the presentation and acknowledged that struck and lost had been dramatically reduced from around 50% to less than 10% and that this was accredited to the introduction of the penthrite grenade in the darting gun and also the training programmes organised by AEWC.

The EG encourages the AEWC to start collecting TTD and IDR data from the bowhead hunt and present the results at the next EG meeting to allow comparison of bowhead hunt effectiveness with other nations. Also the EG thanked for presenting the training manual and program and would appreciate a future presentation on other aspects from the hunt or of training in the AEWC hunt.

CANADA

After many decades of being prohibited because of an estimated low population of bowhead whales in the Canadian eastern Arctic, the hunt for this species by Inuit communities was reinstated in 1994 under the Nunavut Land Claim Agreement. In 2006, a new evaluation of the size of the bowhead whale population in the eastern Arctic gave a much higher estimate, thus supporting existing Inuit claims that numbers of bowhead whales have increased noticeably over the past decades. The hunt for bowhead whales in Canada continues to be on a small scale, with 13 animals landed and 3 animals struck and lost between 1996 and 2010. This is the only communal hunt in Nunavut. It is also the only subsistence hunt for which Inuit hunters require a permit from Fisheries and Oceans Canada. In recent past, this hunt has been conducted between late July and late September. The current annual quota for the whole of Nunavut is three animals, with a goal to extend this number to five.

The hunt is truly a community event in which members of the hunting and flensing crews and their families establish camp at a good distance from the community itself, near waters that are propitious for the hunt. Before a community can obtain a permit to conduct a hunt, it must submit a plan that identifies the captain, the hunting crew (which consists of four to seven small vessels with outboard motors), and the flensing crew. This plan must also demonstrate the acquisition of necessary equipment, including harpoons with floats (typically two to four of which are deployed on a whale during a hunt), lances (anguvigaq) as secondary weapons, and flensing equipment. Two grenades,

each containing 20 g of penthrite, are provided as the primary weapon by Nunavut Tunngavik Incorporated (NTI) to a community that is successful in its bid to conduct a hunt. For a grenade to be deployed, the 'designated' harpooner needs to depress the tip of a metal rod extending from a modified darting gun on the whale's back, thus discharging a 'pusher' charge (.458 calibre) which propels the grenade into the body.

The presentation given during the meeting reported on detailed observations of five hunts conducted in different communities between 2010 and 2014. Each of these observations spanned the whole operation, from the very beginning of the chase to completion of the flensing process. Regarding the hunt itself, criteria used to identify death of the animal included cessation of all movements and the fact that the animal was floating upside down. Based on data available, the average time to death (TTD) was 54.1 min (range, 34-90 min; 5 animals) from deployment of the first harpoon and 32.4 min (range, 14.5-61 min; 4 animals) from deployment of the first grenade. No instantaneous death after the first strike was observed. The average time to tow the carcass to the flensing site was 4 hr (range, 2.75-5.5 hrs; 4 animals), and the average interval between death and the start of flensing was 7 hr (range, 4-10.5 hr; 4 animals).

Nine grenades were deployed in the course of the five hunts. One grenade did not explode for unknown reasons. One grenade penetrated only superficially in the animal (possibly because it had not fitted snugly enough into the barrel of the dart gun), and most of the energy of the explosion appeared to have dissipated on the outside. Four grenades exploded in the epaxial muscle mass (along the animal's back); in two of these cases, the grenade may have been delivered at too much an angle relative to the surface of the animal, and in another case the grenade struck and fractured two ribs. One grenade exploded in the chest cavity; one exploded in the abdomen (or possibly the lower region of the abdominal wall); and one exploded near the junction between the skull and vertebral column, killing the animal instantly (although a first grenade had already been deployed in this animal).

In three of the five hunts observed, profuse bleeding in the chest cavity caused by strikes from lances appeared to have been the primary cause of death, as the grenades had failed to reach this cavity. The very abundant blood supply normally found in muscles of the dorsal part of the chest wall, between ribs, could explain this massive bleeding resulting from the strikes.

In conclusion:
1) the penthrite grenade and lance (anguvigaq) are complementary tools for hunting and killing bowhead whales; 2) both require close proximity to the whale for their application, thus involving a major risk, although it is faster to deploy a grenade than to strike with a lance; 3) even if not lethal, explosion of the first grenade weakens the whale, making it easier to use the lance and/or the second grenade; and 4) explosion of a single grenade can kill a bowhead whale instantly if the strike is applied to the 'neck' area, but this is difficult and risky to do.

Discussion

The EG acknowledges the effort that has been made in recent years to gather data on the bowhead whale hunt by Canadian Inuit. Observations of the hunt have been few but detailed, and have offered a welcomed veterinary aspect. The EG encourages continuation of these observations.

The EG noted long TTD values in the hunts observed. It believes that these values could be substantially reduced through further training of hunters, including exchange of information with other bowhead-hunting nations in order to benefit from their expertise and experience with other hunting techniques. The hunting of bowheads with darting gun and penthrite grenades in Canada deviates considerably from the way bowheads are successfully hunted in Alaska. In the Canadian hunt harpoons are not attached to the darting gun. Instead one or several harpoons are being attached

to the whale first to slow down the animal. It was reported that after harpooning the whales often would show evasive reactions to the boats, which prevented the boats to get close enough or in position to hit with the darting gun and fire the grenade into the most vulnerable areas of the animal. It was also reported that some of the grenades did not penetrate deep enough to wound the animal sufficiently serious to get a rapid death.

In discussions some held the view that this way of hunting would never result in rapid death. The whole idea with the darting gun, which was developed in the 1870ies, was that the harpooning and the killing should be carried out in one single operation to avoid reactions of dangerous evasiveness and reduce the risk of lost whales. Canada was encouraged to adopt the Alaskan way of hunting bowheads, which has become very successful regarding rapid killing and reduction of losses of whales. In the discussion, also the efficiency of the lance to kill large whales was questioned and debated. Some held the view that the killing by bleeding out caused by one or several stabs from a lance may be both painful and prolong the killing time compared to reshooting with grenades. The EG encouraged Canada to do research on the efficiency of the lance (anguvigaq) as a back-up weapon to kill bowhead whales.

MAKAH

The Makah are currently prohibited from hunting whales, but are involved at this time in the US legal process working towards resuming the hunt. Their plans for when the hunt is resumed were presented at this meeting.

The Makah gray whale hunt will include a mix of traditional hunting methods with modern tools and weapons to ensure a quick and humane death for the hunted whale. The hunt method used will be the same method used during hunts in 1999 and 2000. A video of the Makah's 1999 whale hunt can be seen at https://www.youtube.com/watch?v=cGmc1-fbs5U.

The hunt will include a team of eight crew members in a 10 m long canoe and a team of at least three in a motorized chase boat of at least 6.5 m. The crew in the canoe will be the first to approach and harpoon a whale. The gray whale sinks on death and it is therefore imperative to have at least one or two lines attached. The crew of eight works together to paddle into position to harpoon the whale. The goal is to approach the whale to harpoon from the right side of the canoe. After the harpoon is deployed the crew member immediately behind the harpooner ties on floats and additional line. In 1999, the crew in the canoe held the harpoon line. In the future the whalers will either again hold the line or will let go of line and leave the buoys to retard the swimming speed of the whale. After the harpoon is deployed the chase boat will approach and harpoon the whale a second time.

After the whale is securely harpooned the chase boat will approach with a rifleman. The rifleman will shoot a .50 caliber or larger ammunition targeting the base of the brain stem and the first couple of vertebrae to cause the immediate death of the whale. Research by Dr. Allen Ingling[2] has shown that rifles of .460 caliber and larger are more than capable of firing shots that will sufficiently penetrate and damage the central nervous system to immediately kill a whale. A safety officer will work with the rifleman and keep track of other boats on the water and other potential hazards for a shot. When the rifleman has a clear and safe shot the safety officer will signal through oral and physical communication that the rifleman is safe to shoot.

[2] Ingling, Allen L., VMD: Ballistic Testing of Large-Calibre Rifles for the Makah Tribal Gray Whale Subsistence Hunt. Presented to IWC in 1999. Document IWC/51/WK14 APPENDIX

This approach was used by the Makah Tribe in its successful 1999 gray whale hunt. As shown in the video, the time to death of the whale from when it was first struck with a harpoon until it was dead was around 8 minutes. It is hoped with appropriate training and certifications that future hunts have similar or quicker time to death.

After the whale is dead a crew member will secure a line to the whale's tail or will dive in and attach a line through the lower jaw and upper lip of the whale. The whale will then be towed to shore by a larger support boat. On shore there will be crews to conduct the spiritual and cultural practices for the whale and a team to butcher the whale.

In 2007 some young hunters took one whale that took very long to kill. They shot the whale in the wrong spot due to lack of training and knowledge of whale anatomy.

Discussion
The EG appreciated the presentation. The video documents that it is problematic to use traditional methods like harpooning first and then shooting (see above – Canada). When the whale is first harpooned it will try to get away from the hunters. Grey whales are also known to attack boats if they are threatened.

COMPARISON OF HUNTS

The EG was asked to compare the hunting methods of different regions presented to the meeting, and also when applicable to make comparisons of different years within one hunt. To facilitate this exercise the EG developed an overview (Appendix 4) of the following data:

species, region and year of collecting data, primary and secondary weapons, TTD in minutes, mean, median of survivors, maximum survival time in minutes, IDR and sample size.

The EG agreed that it was not possible to make comparisons of TTD of different hunts as these data had been collected and analyzed using different analyzing methods and also were a result of very incompatible hunting methods.

For instance the Greenlandic data on TTD had not (for reasons explained above) been analysed in the same manner as the Norwegian and Icelandic, and data collection differed. Likewise, with the Japanese TTD numbers; the median includes the whole sample size, not only the survivors like it does in the Norwegian and Icelandic data.

The EG therefore agreed to review and comment on the IDR and sample size only.

Norway:
Significant increase in IDR from 17% in 1981-83 to 82% in 2011-12. The primary weapon in 1981-83 was the cold harpoon and in 2011-12 the penthrite grenade. However, comparison of IDR's using the same weapon also show a significant increase in IDR. The sample size in 2011-12 was less than in the last few survey years but the EG acknowledged that it was adequate to detect statistical significance.

Iceland – minke whale:
The sample size is too small to draw any strong conclusions, but the EG agreed that an IDR of 69% is looking favourable.

Greenland – minke whale caught with harpoon grenade:
The sample sizes are adequate and the EG acknowledged that there is a general movement towards IDR of 50%

Greenland – minke whale rifle hunt:
The sample sizes are adequate. The IDR is practically 0 with three years out of eight having positive IDRs of 3%, 3%, and 8%. The EG noted that the IDR might be related to the increasing quota allocations recruiting new, less experienced hunters into the hunt.

Japan – common minke whale, offshore operations (Pacific):
The 2013 sample size was so small that it should ideally have been statistically added to the previous year. Excluding 2013 the EG acknowledged that the IDRs are stable above 50% and increasing.

Japan – Antarctic minke whale:
The sample sizes are adequate and the IDRs are stable at between 57% and 63%.

Japan – common minke whale, coastal operations:
The sample sizes are adequate. The EG did not find obvious improvements in the IDR (majority of years below 50%), and noted that this probably was due to the use of sonar.

Greenland – fin whale:
The sample size is too small to draw any strong conclusions, but the EG acknowledged that there was a 1% increase in IDR after introduction of a higher penthrite charge in 2013 and 2014.

Iceland – fin whale:
The sample size is adequate and the EG acknowledged that an IDR of 84 % is very good.

Japan – fin whale:
The sample sizes are too small to draw any conclusions.

Japan – sei whale:
The sample sizes are adequate and the EG noted that the IDR was fairly stable around 41% - 60% with the majority from 52 % and above.

Japan – Bryde's whale:
The sample sizes are adequate but the EG could not see any trend in the IDRs.

Japan – sperm whale:
The sample sizes are too small to draw any conclusions.

Canada – bowhead whale:
The sample sizes are too small to draw any conclusions.

Greenland – humpback whale:
No IDR was presented.

Alaska – bowhead whale:
No IDR was presented.

Greenland – bowhead whale:
The sample sizes are too small to draw any conclusions.

EDUCATION AND TRAINING

NAMMCO member countries

NAMMCO has developed instruction manuals on weaponry and killing for all whale hunts in the member countries. The manuals give basic and vital information on the use and maintenance of weapons and ammunition deployed in whale hunting. The text is descriptive, sometimes giving step by step instructions with corresponding illustrations.

The aim is to

- Improve the safety for hunters and hunting crew
- Improve the hunters' knowledge and skill regarding use and maintenance of weapons
- Improve animal welfare

Target groups are whalers, gunners, riflemen, whaling inspectors, wildlife officers and international observers, and administrators and others engaged in whaling. See document 18 which contains the full manual on baleen whales.

Regulation

Whaling in all three member countries is subject to strict and detailed regulations concerning all aspects of the hunting activities. There are rules pertaining to hunting season, quotas, equipment and monitoring. The permission to go whaling is given on an annual basis, and certain requirements must be met in order to get a licence.

Norway

Training courses
It is a requirement for licence holders and gunners to have passed the obligatory training courses arranged by the Directorate of Fisheries.

In these courses, professional and technical personnel lecture on laws and regulations governing the hunt. Thorough information is given on all aspects of the hunting activity such as weapon maintenance and correct use (rifle, harpoons, harpoon guns), hunters' safety and animal welfare, anatomy and physiology of relevance for the killing and the understanding of the behaviour of the whales, and slaughtering and processing of the products from the whale. In addition, hunters are trained in how to report to the authorities and how to take biological samples of the catch for the DNA-register.

The courses are arranged whenever there are new regulations concerning the hunt or new licence holders. However, on a yearly basis prior to the beginning of each hunting season, the hunters (the gunners) are required to pass obligatory shooting tests, both with rifle and harpoon guns. The shooting tests with the harpoon guns take place from the boat at sea and are overseen and approved by inspectors from the Directorate of Fisheries. The rifle test (identical to ordinary tests required for big game hunters) is performed at a shooting range and must be approved by authorised personnel from a gun club.

From 2014, all whaling vessels have received the NAMMCO manual with a request that it is made available on board and that all hunters familiarise themselves with the manual prior to the actual hunting.

Iceland

Training courses

Traditionally, education and training of minke whalers took place informally by transfer of knowledge from one generation to the next. Formal courses in the use of harpoon guns and grenades were first held in 1983 and the most recent course to teach hunters to use Whale Grenade-99 was held for minke whalers in 2003.

In order to get a licence for minke whaling, Icelandic regulations require that the gunner undertake a course on handling of harpoons and grenades as well as holding a general licence for firearms. No training requirements exist on an annual basis.

In the fin whale hunt the gunners have been trained in separate courses in 2009 and 2010. Annual courses have been held in 2013, 2014 and 2015.

Greenland

Training courses

In Greenland, only full-time hunters can apply for a licence to hunt large whales. There are no regulatory training courses or tests on how to shoot and where to aim at the animal. Knowledge is passed down from generation to generation and between captain and crew. However when hunting of new whale species starts up, pilot projects including shooting practice and theoretical courses are held by the responsible Ministry (Ministry of Fisheries, Hunting and Agriculture) with mandatory participation of the relevant hunters and vessel crew.

As in Iceland, there are obligatory special courses in how to handle the grenades in order to buy, handle and use harpoon grenades. The use of penthrite grenades became mandatory for boats equipped with harpoon cannons in 1991. The grenades may only be bought after presenting the certificate from this course together with the licence for whaling.

Licences for whaling with harpoons are only given to captains who have taken the course or have at least one crew member who has passed the course. It is special technical staff at the Hunters Organisation KONFIFA-KNAPK who organise the courses in cooperation with the Ministry of Fisheries, Hunting and Agriculture. The courses are held one or more times a year depending on demand. The programme of the course includes the mechanics of the Whale grenade 99, security aspects, mounting of the harpoon, storage and handling of the grenade, as well as operations of the harpoon cannon.

KONFIFA and the Ministry also organise courses in mounting and renovating of the harpoon guns. These courses are taken by people who have a technical education on welding and who are working with metal and are employed in a shipyard approved for the mounting and checking of harpoon cannons. The harpoon cannons are, by regulation, examined and approved every other year by a person certified through the above-mentioned course.

Japan

Gunners, crew members and the persons concerned always have a meeting before the start of a research cruise to discuss experiences and results of data analysis from the previous season with respect to improving TTD. During the season, necropsy records obtained by a researcher on the mother ship are also sent to the gunners on the sampling vessels as soon as possible so that the gunners may review the results of their shots while their memories are still fresh. Gunners are responsible for handling any equipment problems that arise during the offshore hunt and are therefore also trained in harpoon maintenance.

Alaska
AEWC has put strong emphasis on training programmes related to the introduction of the penthrite grenade and also to ensure that hunters understand the importance of the hitting point or target areas. Already in 2004 they produced the first user's manual for the penthrite projectile and the darting gun. This manual has recently been updated. The meeting was presented with the latest video produced that showed the assembly and disassembly of the darting gun with the penthrite projectile. The AEWC also organises training sessions on dissection to teach hunters about the whale anatomy with focus on target areas.

Canada
The hunting takes place in communities that are located far away from each other. Probably as a consequence of the geographical spread of whaling communities, formal training or possibility of learning from each other are limited for Inuit Hunters. Prior to each hunt, training by a representative from NTI and potential transfer of knowledge by hunters from other communities are given during a half-day or whole-day introduction to hunting and flensing methods.

Makah training programme
The Makah Tribe provided their draft training programme to the EG for review. The training programme includes training requirements and certifications specified for each team member of the hunt. The training programme will be implemented through lectures, hands-on training, and certification tests for key personnel. The emphasis of the training is to ensure that the hunt is safe for the whaling team and bystanders and to ensure that the hunt is as effective and humane as possible.

Discussion
The EG recognizes that whaling takes place under very different circumstances in different places and that this will have an impact on education and training. However regular training and exchange of information are very important to achieve more efficient hunts and to improve animal welfare.

The EG emphasizes the importance of combining theoretical information with actual meetings in order to exchange information and experiences, including sampling and recording of data.

The EG emphasizes the importance of the angle of the shot relative to the animal's long axis in the harpoon cannon hunts. The recommended angle, based on the Norwegian data, is from 45 to 135 degrees relative to the animal's long axis and aiming the shot at the thorax. This information should be included in training programmes for gunners.

The EG thanked AEWC for the training material presented on the darting gun. The EG would appreciate a future presentation on other aspects of training in the AEWC hunt.

The EG thanked the Makah Tribe for sharing their whale training programme and description of their planned hunt methodology.

The EG noted that the whale training programme educates Makah whalers on the general biology of gray whales, aspects of gray whale behaviour relevant to a hunt, gray whale anatomy, and hunt safety. One strength of the training programme is that it helps hunters learn key landmarks to locate the brain of gray whales.

The EG endorsed the Makah training programme noting that with the portion of the training programme presented to the EG, and the other planned training activities, future Makah whale hunts should be safe and efficient.

The EG encourages the Makah to benefit from the expertise and experience from other hunts.

MONITORING

NAMMCO has an international observation scheme hunting whereby activities in the member countries are monitored on an annual, random basis. The scheme is a mechanism to monitor the hunting activities and control that hunting activities follow national law and regulations and also that national inspections are carried out according to their intentions. Provisions and more information can be found at www.nammco.no.

Norway

Responsible authority
The responsibility for whaling lies with the Ministry of Trade, Industry and Fisheries and is regulated, administrated and supervised by the Directorate of Fisheries.

Monitoring system
Norway has since 2006 an automated monitoring system that verifies when and where a shot has been fired and when a whale has been taken on board. Consequently, struck and lost whales are also recorded. All licensed whaling boats are equipped with an Electronic Trip Recorder (the Blue Box). The system cannot be manipulated and consists of a control and data logger box (Blue Box) designed to independently monitor and log hunting activity data. An independent GPS and different sensors deployed in certain areas and structures of the boat collect the data, and the programmes are designed for continuous operation and logging of data for at least 4 months. It is equipped with back-up batteries and automatic restart functions if system interruption occurs.

After the hunting season, the encrypted data from the Blue Box are decrypted and analysed by authorised personnel in the Directorate of Fisheries. For more reading see document Øen, E.O.: electronic monitoring of Norwegian minke whaling, IWC 2005

Inspection
There are also random inspections occurring carried out by inspectors from the Directorate of Fisheries. These inspectors have attended the same training courses.

Reporting system
There is no mandatory reporting of TTD or IDR.

The reporting system in Norway is a combination of a self-reporting system and the automated blue box. The automatic monitoring system is a supplement to the electronic catch reporting system. The hunters are obliged to electronically report the catch (or no catch) on a daily basis. This report includes information on catch, position of catch, sex, length, circumference, blubber dimension, foetus/size of foetus and number of grenades used in the catch.

Iceland

Responsible authority
The responsibility for whaling lies with the Ministry of Trade, Industry and Fisheries and is regulated, administrated and supervised by the Directorate of Fisheries.

Monitoring and inspection system
There are random inspections carried out by inspectors from the Directorate of Fisheries.

Reporting system
In Iceland there is a self-reporting system where all catches are reported to the Directorate of Fisheries. Hunters are obliged to report the position, sex and length, presence and size of foetus, for caught animals.

Greenland
Responsible authority
The responsibility for whaling lies with the Ministry of Fisheries, Hunting and Agriculture. They regulate and administer the hunt, while the Fisheries Licence Control Authority, through their wildlife officers, supervises and controls the activities.

Monitoring and inspection system
The wildlife officers work in close cooperation with the municipality authority, the police, Arctic Command and the Government of Greenland. The wildlife officers monitor the whaling activity itself by inspections of some of the hunts at sea and / or by controlling permits, licenses and equipment used on-board the vessels and skiffs and at the open markets where the hunters can sell their products. In 2015, 8 wildlife officers and 4 assisting wildlife officers were employed nationally.

Reporting system
The reporting system in Greenland is a self-reporting system where all catches are reported to the Ministry of Fisheries, Hunting and Agriculture. For every large whale taken, the responsible person (captain of the harpoon boat or the chosen leader in the collective hunt) is required to fill out a reporting form that is submitted to the Ministry shortly after the hunt.

The information given includes information about the hunter, his licence and boat, description of the weapon used to kill the animal, serial number of the grenade, etc. Furthermore it gives information on species, catch area and flensing place, body length, sex, reproductive state of females, stomach contents, weight of edible products and estimated time to death (TTD). Cases of "struck and lost" are also reported.

No edible products from a whale may be sold before the catch is reported to the municipality. Through this reporting the hunter will obtain a stamp on their licence. To get a stamp it is required that a filled out reporting scheme is handed in; and for whalers with a harpoon boat licence, the receipt for the purchase of the whale grenade as well as the used grenade with serial number must also be presented.

For more information see document Greenland: White paper on management and utilisation of large whales in Greenland, 2012.

Japan
The hunting is monitored closely mainly for research reasons. A researcher(s) is/are allocated to all whaling vessels and also a national inspector(s) is present at a mother ship (offshore operation) or a land base (coastal operation).

Alaska
There are regular reporting requirements initiated by the federal government. The whaling captains are obliged to report on sex, location of strike and damage to the animal and take certain biological samples that are reported to NOAA. The biomonitoring sampling programme respond to food health and safety concerns.

Canada
Permits for each of the bowhead whale hunts by Inuit communities are issued by Fisheries and Oceans

Canada (DFO). DFO officers and, on occasions, officers of the Nunavut Department of Environment attend some, but not all, of the hunts. Catches and struck-and-lost are reported to DFO by Hunters and Trappers Organizations of individual communities.

Makah
There are presently no monitoring programmes in place. In the 1999 hunt NOAA monitored and it is anticipated that NOAA will continue to do so when the hunt resumes.

Discussion:
The EG recommends that all hunts are monitored with regard to TTD and IDR at 10-year intervals unless other important issues arises that require more frequent monitoring.

The EG recommends a workshop to look into alternative, and if possible, more economical methods for collecting standard TTD data that may also facilitate more frequent collection of data.

CONCLUSIONS AND RECOMMENDATIONS

Norway
The EG acknowledges the completion of data gathering that has been done since 2010 and also the improvement in the quality of the hunt over the past few decades.

The EG recommends that Norway repeat monitoring of the hunt with regard to TTD and IDR at 10-year intervals unless important issues arise that require more frequent monitoring.

Iceland
Minke whale
The EG acknowledges the work that has been done since 2010.

The EG encourages Iceland to try again to gather data on TTD and IDR and increase the sample size in order to obtain more robust information. A sample size of 25-30 animals should be adequate to obtain statistically reliable data for some types of comparisons.

There has been no training course arranged since 2003. A new course for the hunters should be arranged.

Fin whale
Recommendations from 2010 are fully completed and the EG acknowledges this.

The EG recommends that Iceland repeat monitoring of the hunt with regard to TTD and IDR at 10-year intervals unless important issues arise that require more frequent monitoring.

Greenland
Minke whale
Harpoon cannon hunt
There has been an improvement of the grenade hunt of minke whales. The EG acknowledges this, and also the low struck and lost rate. The IDR is lower, and the TTD greater than in Norway, and the aim should be to improve the hunt efficiency. The recommendations from 2010 to present the data and analysis in a statistically more informative way will be fulfilled in the near future. Analysis of strike location should be informative of why Greenlandic hunts have lower IDR than Norwegian hunts and the EG recommends that the result of this analysis be presented to hunters in future trainings.

It was furthermore recommended to organise a practical training course for gunners. There should, as stated by the hunters, be a debriefing at the end of the season in order to exchange information and experiences from the season.

Minke whale

Rifle hunt

Data show that there is a longer TTD and higher struck and lost rate in the rifle hunt than in the harpoon hunt.

The EG learned that the proportion of minke whales hunted in the collective hunt has been increasing in recent years as compared to the number of whales hunted with deck-mounted harpoon cannon. Noting that rifle hunts are increasing, the EG encourages Greenland to evaluate the current sequence of the use of rifle and harpoon to catch the animals and also the efficiency of the harpoon in this sequence. It also encourages review of other types of harpoons.

The Greenlandic hunters stated that there is a clear difference in efficiency of killing between different geographical regions in Greenland. The EG reiterates the recommendations that experienced hunters should meet with less experienced hunters to exchange information.

The EG acknowledges that Greenland has gathered data pertaining to the body position where the whale is hit and TTD, and looks forward to analysis and interpretation of these data to be made available.

Fin whale

The EG acknowledges Greenland for the change in the charge of the grenade that has resulted in a higher IDR for the fin whale hunt. The IDR is lower and the TTD greater than in the Icelandic fin whale hunt and the aim should be to improve the efficiency bearing in mind the differences in equipment used.

Data are needed with reference to the body position where the whale is hit in relation to TTD, and the EG looks forward to analysis and interpretation of these data to be made available.

Bowhead

The EG acknowledges that shooting trials to study the trajectory of the harpoon through the water have been performed.

Data are needed with reference to the body position where the whale is hit in relation to TTD, and the EG looks forward to analysis and interpretation of these data to be made available.

Fin, humpback and bowhead

The EG recommends that hunters be trained to measure and report on strike location, detonation location and distance between the two in order to evaluate the efficiency of the hunts.

Japan

The use of sonar during the hunt has effects on the behaviour of whales. It also appears to be counterproductive in relation to TTD since the animal will need to be chased and will be shot at too narrow an angle from behind. These two factors have important implications in terms of animal welfare since they are bound to increase TTD and decrease IDR.

Minke whale

The EG acknowledges the work that has been done since 2010 in relation to statistical analysis of the

data, in particular the number of parameters that have been considered.

Based on survival analysis it is clear that the lance is not as effective for the coastal hunt as the rifle used in the offshore hunt. The EG recommends that Japan develops and uses a more effective back up weapon for the coastal hunt.

The EG notes that the 2010 recommendations included a study of the efficiency of the back up (secondary) killing methods but that this does not appear to have been addressed.

Acknowledging that a rifle shot through the brain kills an animal instantaneously and faster than bleeding out caused by the use of the lance, the actual efficiency of the lance as a killing method should be evaluated.

Alaska
The EG encourages the Alaska Eskimo Whaling Commission (AEWC) to collect and present TTD and IDR data on their hunts at the next EG meeting to allow comparison of bowhead hunt effectiveness with other nations. The EG thanks AEWC for the training material presented on the darting gun. The EG would appreciate a future presentation on other aspects of training in the AEWC hunt.

Canada
The EG acknowledges the effort that has been made in recent years to gather data on the bowhead whale hunt by Canadian Inuit. Observations of the hunt have been few but detailed, and have offered a welcomed veterinary aspect. The EG encourages continuation of these observations.

The EG noted long TTD values in the hunts observed. It believes that these values could be substantially reduced through further training of hunters, including exchange of information with other bowhead-hunting nations in order to benefit from their expertise and experience with other hunting techniques.

The EG encourages research on the efficiency of the lance (anguvigaq) as a back up weapon to kill bowhead whales.

Makah
The EG thanked the Makah Tribe for sharing their whale training programme and description of their planned hunt methodology.

The EG noted that the whale training programme educates Makah whalers on the general biology of gray whales, aspects of gray whale behaviour relevant to a hunt, gray whale anatomy, and hunt safety. One strength of the training programme is that it helps hunters learn key landmarks to locate the brain of gray whales.

The EG endorsed the training programme noting that with the portion of the training programme presented to the EG, and the other planned training activities, future Makah whale hunts should be safe and efficient.

The EG encourages the Makah to benefit from the expertise and experience from other hunts.

GENERAL
Accepting that struck and lost is an inevitable part of all whaling operations the EG recommends that there be a review of the underlying reasons for struck and lost with the aim of decreasing it.

The EG recommends that the data be analysed by the statistical methods recommended in 2010. These analyses should include analysis of the efficiency of the backup (secondary) killing methods.

Monitoring
The EG recommends that all hunts be monitored with regard to TTD and IDR at 10-year intervals unless other important issues arises that require more frequent monitoring.

The EG recommends a workshop to look into alternative, and if possible, more economical methods for collecting standard TTD data that may also facilitate more frequent collection of data.

Education and training
The EG emphasizes the importance of the angle of the shot relative to the animal's long axis in the harpoon cannon hunts. The recommended angle, based on the Norwegian data, is from 45 to 135 degrees relative to the animal's long axis and aiming the shot at the thorax. This information should be considered in training programmes for gunners.

Regular training and exchange of information is very important to achieve more efficient hunts and to improve animal welfare.

The EG emphasizes the importance of combining theoretical information with actual meetings in order to exchange information and experiences, including sampling and recording of data.

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Appendix 2: Agenda

1. INTRODUCTORY ITEMS
2. TERMS OF REFERENCE AND BACKGROUND TO THE WORKSHOP
3. ADOPTION OF THE AGENDA
4. PRINCIPLES OF COLLECTION, QUALITY CONTROL, ANALYSING AND PRESENTATION OF TTD DATA
5. DESCRIPTION OF KILLING METHODS IN USE AND/OR UNDER DEVELOPMENT, CRITERIA FOR DEATH AND REVIEW OF TTD DATA
    - 5.1 Norway
        - 5.1.1 Minke whales
    - 5.2 Iceland
        - 5.2.1 Minke whales
        - 5.2.2 Fin whales
    - 5.3 Japan
        - 5.3.1 Minke whales in Antarctic and N. Pacific
        - 5.3.2 Minke whales, coastal
        - 5.3.3 Fin whales
        - 5.3.4 Sei whales
        - 5.3.5 Bryde's whales
        - 5.3.6 Other species
    - 5.4 Greenland
        - 5.4.1 Minke whales
        - 5.4.2 Fin whales
        - 5.4.3 Bowhead whales
        - 5.4.4 Humpback whales
    - 5.5 Canada
        - 5.5.1 Bowhead whales
    - 5.6 The US
        - 5.6.1 Bowhead whales
        - 5.6.2 Gray whales
6. FOLLOW UP ON THE RECOMMENDATIONS FROM THE NAMMCO EXPERT GROUP MEETING ON ASSESSMENT OF LARGE WHALE KILLING DATA IN 2010
7. COMPARISON OF METHODS AND EFFICACY
8. EDUCATION AND TRAINING OF HUNTERS
9. MONITORING SCHEMES
10. CONCLUSIONS AND RECOMMENDATIONS
11. OTHER MATTERS
12. ADOPTION OF CONCLUSION AND RECOMMENDATIONS

Appendix 3: Protocol for TTD data collection and analyses

PROTOCOL FOR COLLECTION OF TTD DATA IN WHALE HUNTS WITH DECK MOUNTED HARPOON GUN

Dr Egil Ole Øen, Wildlife Management Service-Sweden

Collecting TTD data in whaling

Background

Time to death (TTD) or Survival time (ST) and the Instantaneous death rate (IDR) are terms that are used to measure and to quantify the killing efficiency and the state of art of current killing methods and practices used in whaling operations. Collection and analysis of TTD/ST and IDR data in a standardised manner with covariates that may influence TTD/ST and IDR make it possible to compare how rapidly whales are killed using different techniques and gears. Standardised collection methods and analyses of TTD make it possible to calculate impacts on TTD and IDR of new developments, modifications or changes in hunting practices and the impact also on efficiency of systematic training of hunters.

In Norway (1981-2012) TTD of more than 5000 minke whales killed using different types of hunting gears were collected and analysed with the covariates animal size, shooting distance and angle of harpoon gun shot, hit region and detonation area. The results were used to document the need for innovations like development of new and improved weapons, consecutive modifications and testing of gears and hunting techniques and practices, training of hunters etc. During these 21 years IDR increased by 65% from 17% to 82% and the average TTD was reduced from 11.5 min to 1 min.

The NAMMCO Expert Group Meeting on Assessment of Large Whale Killing Data in 2010 underscored the importance of recording TTD/ST/IDR and recommended the use of the Norwegian way of collecting and analysing for all hunts to identify needs for improvements.

Why record TTD

To document killing efficiency
To discover potential ways to improve the killing
To follow improvements or other issues relevant for killing over time

How to sample TTD data – "the Norwegian Way"

It is very important that the personnel collecting data are independent and are able to concentrate on data collection and not have other tasks to attend to in the killing and flensing (butchering) phase.

<u>Who should sample/collect – required qualifications prioritised</u>

1. Veterinarians
2. Large mammal biologist and large whale physiologist
3. Hunt- and fisheries inspectors

The profession of the veterinarians makes them able to better understand and assess the behaviour of the animal when hit, and relate the animal's reaction to the death criteria. Large mammal biologists and physiologist may also have this understanding. Anatomical and pathological knowledge is important when assessing damage to organs and gross (macroscopic) changes in vital organs, which can be studied during flensing.

If it is not possible to have dedicated personnel that only collect TTD data, scientists/hunt-fisheries inspectors (preferably with biological background) carrying out research/inspection on board but with necessary time off from his/her own research/inspection during killing and flensing may be used.

Generally, all personnel should receive special training PRIOR to collecting TTD data for whales – category 3 above will generally need more training than categories 1 and 2. Such training course should cover *inter alia*:

A general introduction on whales, whaling and management of whales (abundance estimates, quota setting, national and international management systems)

National laws and regulations – implications for the hunting practise with respect to

- equipment (review of gear and equipment – functions and correct use and maintenance)
- the hunt itself (searching for whales, shot, hauling, flensing and correct treatment of edible products)
- criteria of death

Description of why data is collected and how it is collected
Utensils: watch for measuring TTD

- anatomy and physiology relevant for estimating TTD
- examination of detonation area
- reporting: how to fill out the forms and how to deliver them

Reporting form
The attached form with guidelines is the one used in the Norwegian minke whale hunt.

For practical reasons the form should be limited to one page. To the extent possible the form should be designed with only "yes/no/unknown" options to tick off.

Comments or circumstances not covered by the form and which the inspector wants to inform about may be written either on the back of the form or on a separate sheet.

It is a prerequisite to fill out the report immediately after the kill has taken place and observations of organ damages have been identified. It is very easy to forget details after a short while.

The form shall cover information on I. Primary observations/findings and II. Secondary observations/findings.

I. Primary observations/finding are factors that are used directly to determine or that upon review may be used to support, nuance or disprove the given TTD estimate in the report.

Important primary observations are (but not excluding other):

a. Reaction patterns in whales in connection when struck/hit (whale dives, sinks, turns over on its back, swims, etc.)
b. Slackening or movements in mouth, flipper or tail
c. Hit area (harpoon)
d. Detonation site (grenade)
e. Gross organ damages - bleedings
f. Estimated TTD

II. Secondary observations/findings are related to aspects of the hunt that may impact the TTD (like but not excluding other):

g. Animal size
h. Weapon type
i. Shooting distance
j. Shooting angle

Criteria of death
The International Whaling Commission in 1980 recognized that it is difficult to decide exactly the moment of death of a whale as it is more or less under water when it happens. It therefore recommended the use of behavioural cues as indicators of death. These diagnostic criteria of death in whales, known as the "IWC criteria", were set to "…the time taken for the mouth to slacken, the flipper to slacken or all movements to cease". These signs, which can be observed during practical whaling, are to be used in conjunctions with pathological findings made during necropsy. It has been recognized that when TTD are solely determined on the basis of IWC criteria, a significant portion of animals will be recorded as being sensible or alive when they are actually unconscious or dead.

Quality control of data
The importance of filling out the form *immediately* during the hunt cannot be stressed enough. The likelihood of remembering details and circumstances correctly after time has passed is low and may normally result in invalid and incorrect information.

Before statistically analysing the data each separate reporting form must be examined closely with respect to errors and possible falsifications of facts.

When in doubt it may be necessary to acquire additional information through interviewing the inspector and hunters, or checking catch data from the existing reporting systems.

To be able to carry out this kind of quality control satisfactorily it is a prerequisite to have the necessary biological knowledge in addition to detailed knowledge of, and experience from, whaling.

GUIDELINES FOR THE COMPLETION OF THE CATCH FORM

Fill out all questions as thoroughly as possible.

If uncertain what to write or if information is missing, note this down. Likewise, give additional comments of any kind.

Death criteria are slackened mouth, flippers slackened (along the sides) and that whales are at rest. It is not always that all of these criteria are present even though the whale is dead. For example, the jaw will not be open when the animal is on its back. Currents and waves can provide movements of the tail. Flippers will not immediately lie completely along the side when the whale dies.

If the whale is conscious or waking up again, it will try to straighten up, move the flippers outwards, close the jaw and give blow and try to dive. Movements in the tail will be clear and coordinated with the other signs of consciousness.

Survival time/ TTD: The time it takes from firing the shot to the whale's death. Instantaneous kill is specified as 0 or instantaneous in the form. If one is unsure of the time, for example if not all criteria are fulfilled, indicate why and what kind of uncertainty in the form.

In order to verify stated survival time in retrospect, it is very important that the following information is noted as accurately as possible:

- did the grenade work normally?,
- place for recoveries of any grenade remnants,
- shot reactions,
- organ damages,
- mark the harpoon hit area in the figure
- shot angle information.

Shot direction indicates the direction where the harpoon comes from in relation to the whale's long axis. The direction is indicated by the numbers 1-5:

1 = directly from the front (0°)
2 = diagonally from the front (above 0° to 45°)
3 = sideways (45° to 135°)
4 = diagonally from the back (135° to 180°)
5 = directly from the back (180°)

Shot Distance is estimated without any technical aid.

Grenade detonated: It is very rare that the grenade does not detonate due to technical error. If the grenade did not detonate this may be because the harpoon has not penetrated far enough into the whale body (65-70 cm in minke whale) or because the trigger line is cut off. In the case of malfunctioning, indicate probable cause for the malfunction, grenade production number and year.

Loss notes loss of struck and dead or hurt whale. The cause(s) are described under comments. If possible note where the harpoon hit the whale and if the grenade detonated or not.

Reaction harpoon hit/detonation: This information is important for the assessment of the effects of shot/detonation, and is used when evaluating the survival time.

Visible organ damages after the detonation
This is important information when assessing final survival time.

The grenade detonates approximately 65-70 cm inside the whale (minke whale). Often there will be remains of the grenade on the detonation site such as residual from the aluminium capsule and one or more pieces of black polyethylene. Damages to organs are observed during flensing or when organs are removed. In the area where the grenade exploded, the tissues and organs will be torn up and there is substantial accumulation of blood in the area. Detonation in the musculature causes massive injuries to muscle tissue and transforms it into a jellylike mass without normal tissue structure up to 20 – 30 cm from the detonation site.

REPORTING FORM NORWEGIAN MINKE WHALING (YEAR)

Date: Vessel: Whale no in hunting logbook:

Survival time:

Harpoon in (Figure 1-9): Harpoon out (Figure 1-9): Shot through: Yes/No

Shot direction (1-5): Shot distance: Grenade detonated: Yes/No

Lost animal: Yes/No

Reshot canon: Yes/No Gunshot: Yes/No Alongside of boat (time):

Reaction from harpoon shot (mark X):

Turned over/ sank Dived and sank Swimming movements in tail: Yes/No

Mouth: open/closed Flippers: laying by the side/stood partly out/completely out

Visible grenade damages to organs taken when flensing :

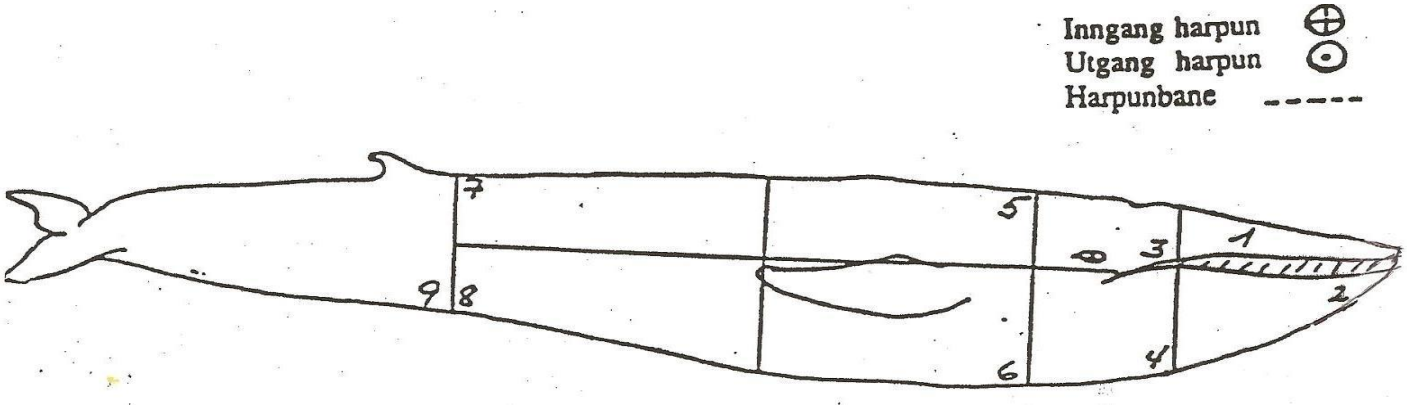
Hearth: Yes/No Lung(s): One lung Yes/No /both lungs: Yes/No
Large veins in chest cavity: Yes/No Large veins in abdominal cavity: Yes/No

Spine/neck/skull: Yes/No Indicate damage area:

Organs in abdominal cavity: Yes/No Indicate organ(s) damaged:

Blubber/muscles: Yes/No Indicate damaged area (Figure 1-9):

Remains of grenade: Yes/No Indicate area of discovery:



Comments (use back of form or separate sheet)

PROTOCOL FOR STATISTICAL ANALYSES OF TTD IN WHALING OPERATIONS

Professor Lars Walløe, University of Oslo, Norway

Which and how many killings should be recorded?

1. The ideal is to record TTD for all animals killed.
2. Nearly equally good is to record TTD for a random (in the statistical sense) sample of the killings (or boats or hunters).
3. A non-random sample may provide valuable information, especially if explanatory variables are recorded, but a small random sample is better than a large non-random sample.
4. If the sample has to be non-random, try to include all possible types of boats or hunters.
5. If the sample has to be non-random, try to include the same boats or hunters (or similar boats and hunters) in the following years.
6. Even a very small sample (less than 10) is better than no sample.

Advice on the organisation of the data matrix

a) Each whale should be represented by one line (row) in the matrix
b) The first column should contain a whale identifier (e.g. a number)
c) An early column should contain a binary value indicating instantaneous death (e.g. 1: instantaneous dead, 0: alive after the first hit)
d) One column should contain time to event
e) The next column should contain a variable indicating type of event (1: death, 2: censoring)
f) The next columns should contain covariates which could be binary, categorical or scale, one column for each variable
g) If a secondary weapon is used, the columns c), d), e) and f) should be repeated for the secondary weapon. If there are alternative secondary weapons, one column should indicate which secondary weapon is used.

A) Instantaneous death

a) binomial p with confidence interval
b) comparing two binomial p's with chi-square (n-1) or Fisher-Irwin test
c) logistic regression with covariates

B) Time to death for whales that are not instantaneous dead

a) Kaplan-Meier plots
b) Cox-regression with covariates
c) survival analysis with censoring
d) survival with use of secondary weapon

Appendix 4: Overview TTD data and IDR.

Note that comparisons can only be made between years within each hunt due to differences in sampling, analysing and hunting methods

TTD: time to death, **IDR**: instant death rate **ST**: Survival time

Species Minke whales	Country Year	Hunting methods Primary weapon	 Secondary weapon	TTD in minutes Mean	 Median of survivors	Max ST in minutes	IDR %	Sample size *1*2
	Norway							
	1981-83	cold harpoon	rifle 30.06	11	11	62	17	353
	1984-86	grenade 22 g penthrite	rifle 9.3	6	8	57	45	257
	1993-99	grenade 22 g penthrite	rifle .375 and .458	4	7	90	60	2687
	2000-02	grenade 30 g penthrite	rifle .375 and .458	2	10	90	80	1667
	2011-12	grenade 30 g penthrite	rifle .375 and .458	1	6	20	82	271
	Iceland							
	2014-15	grenade 30 g penethrite	rifle .458	1	4	13	69	13
					Median all inc. survivors			
	Greenland							
	2007	grenade 30 g penthrite	rifle 30.06 and .375 or larger	7	3	45	31	123
	2008	grenade 30 g penthrite	rifle 30.06 and .375 or larger	6	5	25	27	77
	2009	grenade 30 g penthrite	rifle 30.06 and .375 or larger	5	2	30	41	68
	2010	grenade 30 g penthrite	rifle 30.06 and .375 or larger	5	2	30	44	95
	2011	grenade 30 g penthrite	rifle 30.06 and .375 or larger	4	1	60	34	108
	2012	grenade 30 g penthrite	rifle 30.06 and .375 or larger	4	2	40	48	89
	2013	grenade 30 g penthrite	rifle 30.06 and .375 or larger	4	2	20	51	79
	2014	grenade 30 g penthrite	rifle 30.06 and .375 or larger	4	1	25	53	78
	2007	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	24	20	120	3	29
	2008	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	23	20	120	8	38
	2009	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	29	20	120	0	59
	2010	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	25	25	90	0	57
	2011	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	26	21	120	0	56
	2012	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	27	20	120	0	50

	2013	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	34	20	720	0	91
	2014	rifle 30.06 and .375 or larger	rifle 30.06 and .375 or larger	27	20	210	3	70
	Japan*3				**Median all inc. survivors**			
C.minke whale	2010	grenade 30 g penthrite	grenade/ rifle .375 or .458	2	1		50	14
offshore	2011	grenade 30 g penthrite	grenade/ rifle .375 or .458	2	0		59	49
	2012	grenade 30 g penthrite	grenade/ rifle .375 or .458	1	0		62	74
	2013	grenade 30 g penthrite	grenade/ rifle .375 or .458	3	3		33	3
C.minke whale	2009	grenade 27 g penthrite	cold harpoon/lance	4	1		48	119
coastal	2010	grenade 27 g penthrite	cold harpoon/lance	4	0		57	105
	2011	grenade 27 g penthrite	cold harpoon/lance	7	4		35	77
	2012	grenade 27 g penthrite	cold harpoon/lance	4	2		44	108
	2013	grenade 27 g penthrite	cold harpoon/lance	5	2		47	92
	2014	grenade 27 g penthrite	cold harpoon/lance	6	2		40	81
	2015	grenade 27 g penthrite	cold harpoon/lance	6	3		37	19*4
A.minke whale	2009	grenade 30 g penthrite	grenade/ cold harpoon/rifle .375/.458	2	0		57	506
	2010	grenade 30 g penthrite	grenade/ rifle	2	0		62	170
	2011	grenade 30 g penthrite	grenade/ rifle	2	0		59	266
	2012	grenade 30 g penthrite	grenade/ rifle	1	0		63	103
	2013	grenade 30 g penthrite	grenade/ rifle	2	0		57	251

Notes:

***1**: In the Greenlandic and Japanese hunts TTD is calculated from the whole sample size not only the survivors.

***2:** In the Greenland data sample size and catch size is different, i.e. in 2007 grenade hunt sample size is 123 animals which represent 95% of total catch.

***3:** The grenade is a cast iron grenade unlike the aluminium Whalegranade 99.

***4:** In 2015 Japan sampled 70 common minke whales; 19 (Sanriku) and 51(Kushiro). Only the Sanriku survey was analysed at the time of meeting.

Note that comparisons can only be made between years within each hunt due to differences in sampling, analysing and hunting methods.
TTD: time to death, IDR: instant death rate ST: Survival time

Species Fin whales	Country Year	Hunting method Primary weapon	 Secondary weapon	TTD in minutes Mean	 Median of survivors	Max ST in minutes	IDR %	Sample size
	Iceland							
	2014-15	grenade 100 g penthrite	grenade 100 g penthrite	1.5	8	15	84	50
	Greenland*1*2				**Median all inc. survivors**			
	2007	grenade 30 g penthrite	grenade 30 g penthrite	15	13	60	30	10
	2008	grenade 30 g penthrite	grenade 30 g penthrite	11	10	25	20	10
	2009	grenade 30 g penthrite	grenade 30 g penthrite	23	25	45	14	7
	2010	grenade 30 g penthrite	grenade 30 g penthrite	22	4	60	33	3
	2011	grenade 30 g penthrite	grenade 30 g penthrite	21	15	60	20	5
	2012	grenade 30 g penthrite	grenade 30 g penthrite	8	8	15	25	4
	2013	grenade 45 g penthrite	grenade 45 g penthrite	12	10	25	44	9
	2014	grenade 45 g penthrite	grenade 45 g penthrite	22	10	120	36	11
	Japan*2				**Median all inc. survivors**			
	2009	grenade 60 g penthrite	grenade 60 g penthrite		0		100	1
	2010	grenade 60 g penthrite	grenade 60 g penthrite	12	12		50	2
	2012	grenade 60 g penthrite	grenade 60 g penthrite		0		100	1

Notes:

***1:** For the Greenland data sample size and catch size is different, i.e. in 2008 hunt sample size is 10 animals which represent 71% of total catch.

***2** In the Greenlandic and Japanese hunts TTD is calculated from the whole sample size not only the survivors

Note that comparisons can only be made between years within each hunt due to differences in sampling, analysing and hunting methods.

TTD: time to death, **IDR:** instant death rate. In the Japanese hunt TTD is calculated from the whole sample size not only the survivors

Species	Country	Hunting method		TTD in minutes		IDR %	Sample size
Sei whales	Year	Primary weapon *1	Secondary weapon	Mean	Median		
	Japan						
	2010	grenade 60g/50g penthrite	grenade/cold harpoon/ rifle .458	3	0	52	100
	2011	grenade 60g/50g penthrite	grenade/cold harpoon/ rifle .458	4	3	41	95
	2012	grenade 60g/50g penthrite	grenade/cold harpoon/ rifle .458	3	0	52	100
	2013	grenade 60g/50g penthrite	grenade/cold harpoon/ rifle .458	2	0	60	100
	2014	grenade 60g/50g penthrite	grenade/cold harpoon/ rifle .458	3	2	48	90
	2015	grenade 60g/50g penthrite	grenade/cold harpoon/ rifle .458	3	0	53	90

Species	Country	Hunting method		TTD in minutes			Sample size
Bryde's whale	Year	Primary weapon *1	Secondary weapon	Mean	Median		
	Japan						
	2010	grenade 50g/30g penthrite	grenade/cold harpoon/ rifle .375/.458	3	0	58	50
	2011	grenade 50g/30g penthrite	grenade/cold harpoon/ rifle .375/.458	2	1	50	50
	2012	grenade 50g/30g penthrite	grenade/cold harpoon/ rifle .375/.458	2	0	71	34
	2013	grenade 50g/30g penthrite	grenade/cold harpoon/ rifle .375/.458	5	3	47	28
	2014	grenade 50g/30g penthrite	grenade/cold harpoon/ rifle .375/.458	3	0	60	25
	2015	grenade 50g/30g penthrite	grenade/cold harpoon/ rifle .375/.458	3	0	52	25

Species	Country	Hunting method		TTD in minutes			Sample size
Sperm whale	Year	Primary weapon *1	Secondary weapon	Mean	Median		
	Japan						
	2010	grenade 60g/50g penthrite	grenade 60g/50g penthrite	0	0	100	3
	2011	grenade 60g/50g penthrite	grenade 60g/50g penthrite		6	0	1
	2012	grenade 60g/50g penthrite	grenade 60g/50g penthrite	4	3	33	3
	2013	grenade 60g/50g penthrite	grenade 60g/50g penthrite		11	0	1

***1: Penthrite charge depend on body length**

Note that comparisons can only be made between years within each hunt due to differences in sampling, analysing and hunting methods.
TTD: time to death, **IDR**: instant death rate, **ST**: Survival time

Species	Country	Hunting method		TTD in minutes		Max ST in minutes	IDR %	Sample size
Humpback whales	**Year**	**Primary weapon**	**Secondary weapon**	**Mean**	**Median**			
	Greenland							
	2010	grenade 30 g penthrite	grenade 30 g penthrite	23	7	90	17	6
	2011	grenade 30 g penthrite	grenade 30 g penthrite	9	3	30	50	6
	2012	grenade 45 g penthrite	grenade 45 g penthrite	12	13	25	25	8
	2013	grenade 45 g penthrite	grenade 45 g penthrite	30	15	120	17	6
	2014	grenade 45 g penthrite	grenade 45 g penthrite	21	10	75	17	6

Note humpback whales:
Sample size and catch size is different, i.e. in 2010 hunt sample size is 6 animals which represent 67% of total catch.
TTD is calculated from the whole sample size not only the survivors.

Species	Country	Hunting method		TTD in minutes		Max ST in minutes	IDR %	Sample size
Bowhead whales	**Year**	**Primary weapon**	**Secondary weapon**	**Mean**	**Median**			
	Canada							
	1996-2010	n/a*1	n/a	n/a	n/a	n/a	n/a	16
	2010-2014	grenade 20 g penthrite	lance	54.1*2	62	90	0	5
				32.4*3	37.75	61		4

Notes bowhead whales:
***1:** 13 whales landed, 3 struck and lost, no information on TTD
***2:** time from first harpoon to death
***3**: time from first grenade to death