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BOWHEAD HUNT CANADA

Interim report on observations of subsistence hunts of bowhead whales (*Balaena mysticetus*) by Nunavut communities, 2010-2014

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> "The reintroduction of whale hunts can not only be seen as empowerment of Inuit but also as a means of valorizing hunting and sharing practices as core elements of Inuit traditions." (Laugrand and Oosten 2015)

Introduction

Inuit were already accomplished whalers more than 1000 years ago (McCartney and Savelle 1993). In areas where large whales, more specifically bowhead whales (*Balaena mysticetus*), were abundant, their harvest provided great benefits as a source of food, fuel, and material for shelter. Whale hunting also came to represent one of the highest expressions of Inuit culture. In the late 19th and early 20th centuries, whaling became a cooperative venture between some Inuit communities and European and North American whalers, whereby Inuit hunters would get the meat and bones from the whales while the whalers would get the blubber and baleen.[1] Whaling activities ceased in the early 20th century as a result of overexploitation of populations of bowhead whales.

In the late 1970s, a 2-stock hypothesis for bowhead whales in eastern Canadian and western Greenland waters was adopted: Baffin Bay - Davis Strait or Baffin Bay stock, and Hudson Bay - Foxe Basin or Hudson Bay stock. In 2006, based on satellite tracking and genetic studies, this model was revised in favor of a single population, with sex-segregation between the two regions (mainly adult males and resting and pregnant females occupying Baffin Bay; and nursing females, calves and subadults in Hudson Bay) (Heide-Jørgensen et al. 2006, 2010). In 2006, the bowhead whale population in the eastern Canadian Arctic was estimated at 7309 (95% confidence interval: 3161-16900), from a few hundred at the end of commercial whaling (Cosens et al. 2006). This provided support for existing Inuit claims that numbers of bowhead whales have increased noticeably over the past decades.

Since 1994, Canada, under the Nunavut Land Claim Agreement, has sanctioned the taking of whales from the Baffin Bay and Hudson Bay stocks (Finley 2001). This is the only hunt for which Inuit hunters require a permit provided by Fisheries and Oceans Canada. It is also the only communal hunt in Nunavut. The current quota for this hunt for the whole of Nunavut is three animals, with a goal to extend this quota to five. Between 1996 and 2010, 13 bowhead whales were landed (and three more were struck but not landed). Nine Nunavut

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[1] Information obtained at Mirnguiqsirviit (Kekerten) Territorial Historic Park, Nunavut.

communities and one community in Nunavik (northern Québec) participated, the hunt occurring between late July and late September (Koski and Ferguson 2012).

Coastal people have an intrinsic right to utilize marine resources, including marine mammals, provided that it is done in a sustainable manner and that it respects basic principles of animal welfare while ensuring the safety of hunters (NAMMCO 2011). Under the Nunavut Land Claims Agreement, Inuit are legally entitled to a subsistence hunt for bowhead whales, subject to legitimate conservation concerns (Dueck et al. 2006). Traditional hunting methods may stand to benefit from scientific findings and technological developments, but proposed modifications to these methods must take users' knowledge into account. The harvesting of bowhead whales also gives science an opportunity to benefit from both access to the whales and the hunters' knowledge and observations.

Penthrite (pentaerythritol tetranitrate) has been used for many years as a substitute for black powder in grenades used for the commercial hunt of minke whales (*Balaenoptera acutorostrata*) in Norway. Since 1988, it has also been used in subsistence hunts for bowhead whales in Alaska, USA, and more recently for similar hunts in Nunavut, Canada (Øen 1995; Knudsen and Øen 2003; Anonymous 2009; Williams, personal observation). Penthrite is a supersonic explosive that detonates at a speed of 6500-8400 m/s (i.e., faster than the speed of sound), producing a gas volume of more than 6000 times the original mass. According to Knudsen (2005) in relation to the Norwegian hunt for minke whales, if the grenade detonates in an area ranging from the mid-chest and forward to the skull, nearly 100% of the whales lose sensibility immediately or very rapidly through acute traumatic brain injury (TBI) caused by the oscillating pressure waves generated by the grenade's explosion, in addition to direct damage this explosion inflicts on other organs such as heart, major blood vessels, and lungs. Pressure waves generated by the explosion travel via the blood to the spinal cord and brain, resulting in a severe increase in pressure within blood vessels of the brain and spinal cord and the meninges that cover them and causing rupture of these blood vessels (Knudsen and Øen 2003). However, this is more likely to occur with an explosion within body cavities than within relatively firm tissue like muscle, which may cushion the pressure waves. Penthrite is also non-toxic, and it does not affect the usefulness or taste of whale meat because it does not dissolve in water and upon detonation it breaks down into natural gases and water. It is also thermally the most stable and least reactive of its category of explosives (Anonymous 2009).

This document reports on close observations of bowhead whale hunts conducted by five different Inuit communities between 2010 and 2014. Each of these hunts was monitored closely from start to finish by independent observers, and subsequent dissection of the animal was also monitored closely by an experienced wildlife pathologist, with the objectives of better understanding the effects of the different tools used at the hunt and, where possible, make recommendations that will lead to a shorter time to death (TTD) of hunted whales. Time to death is an internationally accepted measure when discussing animal welfare issues pertaining to the killing of animals. By quantifying the time taken for an animal to die, it gives an indication of the efficacy of a killing method, which in the context of the hunt for large whales is important not only from the perspectives of conservation and animal welfare but also from that of hunter safety (NAMMCO 2011).

Methods

The bowhead whale hunts in Nunavut are licensed by the Government of Canada's Department of Fisheries and Oceans (DFO). The Nunavut Wildlife Management Board established an annual total allowable harvest of three landed whales or six strikes for the Inuit of Nunavut. Each of the three Regional Wildlife Organizations (RWO) (Qikiqtaaluk, Kivalliq, Kitikmeot) makes an allocation of one whale or two strikes to the Hunters and Trappers Organization (HTO) of individual hamlets that have made an application for a hunt in that region. Once the RWO has made the allocation, the community HTO begins planning and organization of the hunt. The bowhead whale hunts in Nunavut are a communal hunt, where the catch is shared and distributed to the whole community.

The community HTO is required to prepare a hunt plan and budget for the bowhead whale hunt. The hunt plan describes who is appointed from the community to participate in the hunt (Captain, crew, helpers, etc.), the location of the hunt, a list of required equipment, safety measures, and the process for flensing and dissecting the whale. The budget identifies cost estimates and funds available (from donations, fund raising, and contributions) and must be balanced. The hunt plan and budget are then reviewed and approved by the RWO prior to the license being issued by DFO. The HTO selects four to seven boats to participate in the hunt. Each boat has a driver, harpooner, linesman, and assistant, and it is required to have a harpoon (sometimes two) with line and float attached, at least one anguvigaq (lance with a wooden handle approximately 1.2 m long, and a metal portion with pointed head, between 1.5 and 2 m long), and a large calibre rifle. The 'designated' harpooner has the darting gun (modified harpoon; see below) and two penthrite grenades (Figure 1) on board in addition to the previously mentioned equipment. The hunt plan also identifies a supervisor for flensing and processing the whale once it is landed at the flensing site. The supervisor is responsible for the flensing crew and the required equipment.

Nunavut Tunngavik Incorporated (NTI) supplies the penthrite grenades and darting gun to the Captain and designated harpooner. Prior to the hunt, the Captain, designated harpooner, and crews are given instructions on the procedures for safe handling and deployment of the grenades. These training sessions include a review of bowhead whale anatomy with described "landmarks", sharing of observations and lessons learned from previous hunts, descriptions of recommended killing methods, and safety considerations.

A darting gun is used in order to deploy the penthrite grenade into the whale. Darting guns that are used in Alaska are of the same design as those used by American Whalers in the 1860s, which were made of brass. In order to safely deploy the new penthrite grenades, a modified steel barrel is required on the darting guns. In 2006, a few Nunavut Whaling Captains participating in a workshop with a gunsmith designed a new darting gun that uses a bolt and receiver from a Remington model 700 with a modern shear type trigger mechanism and a chamber and barrel that are made of weapons grade steel. The new darting gun is chambered for a .458 Winchester Magnum cartridge. This cartridge holds a black powder charge which pushes the grenade into the whale when fired. A shoulder gun cannot be used to deploy the new penthrite grenades as there is no fletching to stabilize the grenade in-flight. Therefore, deployment is limited to using a hand-held darting gun attached to a 3-m pole.

The penthrite grenade, containing 20 g of explosive, is equipped with a sequence-activated detonator with a 4-5 second delayed fuse. This safety feature is designed to ensure that the grenade is embedded in the whale before detonation. The grenade and detonator are two separate pieces that are threaded together just prior to being deployed (Figure 1). This allows for transportation, handling, and storage of the grenades and detonators in the safest possible way.

Initially the .458 'pusher' cartridge was loaded with 68 grains of black powder 'FFF'. Based on the observations made on bowhead whale hunts in 2005, 2006 and 2007, as well as information from Alaskan Whaling Captains, the pusher charges were increased to 72 grains. The depth of penetration of the grenade into soft tissue is determined by the size of the charge, provided that the grenade does not strike hard tissue (ribs or vertebrae). It has been determined that a 72-grain charge is optimal for large and medium sized whales. With smaller whales, there is a greater chance of the grenade passing through vital areas (see hunt #3) or passing right through the body and detonating outside the whale's body. As the pusher charges are prepared in advance of the hunt, it is not practical to load charges at or during hunts. The preparation of two or more different charges has been considered but not applied in order to avoid confusion on the harpooner's part. With placement of the grenade at the base of the skull/neck area, the probability of the grenade passing through a smaller whale is greatly reduced.

Results

Table 1 provides the locations and details of the hunts and observations on the harvested whales. The events surrounding each of the five hunts differed somewhat and therefore provided various opportunities to assess the efficacy of the tools used.

Description of hunt and behavioural responses

Striking the whale with the first harpoon and float represented the first important step of the hunt as it facilitated constant pursuit of the same whale by the boats, thus accelerating its oxygen debt. In all instances, the whale's reaction to the strike from the first and subsequent harpoons was relatively minor. These strikes did not elicit a sudden escape behaviour. On the contrary, the whale would typically slow down and remain on the water surface, occasionally slapping flippers or tail on the water. However, in two of the hunts the whale took evasive action with its tail in order to prevent the boats from approaching and striking with the harpoon gun. One whale positioned itself near shore with head and body close to shore and the tail at or above the water surface towards the boats. The other whale was swimming slowly on the surface near pieces of pack ice with the tail on the water surface, and as boats would approach the tail would be moved laterally across the surface in an attempt to strike the boat. This type of behaviour increased the TTD as the hunters in both situations had to reposition the boats in order to approach the whale in a safe manner, avoiding the tail.

A strike with the darting gun was the next step attempted in four of the five instances. During hunt #2, while one of the boats was attempting to avoid the animal's tail and reposition itself, a hunter on that boat was successful in striking the whale with an anguvigaq before the first grenade was deployed, but only one or at most three strikes could be applied. A total of nine grenades were deployed in the course of the five hunts. Subsequent to the deployment of one or the two grenades, several strikes of anguvigaq were delivered to each of the four animals. The metal portion of some anguvigaq was bent through forceful use by the hunters.

Time to death

In all instances but one, death was considered to have occurred when all movements by the animal had ceased. In hunt #4, the whale sank an estimated 122 m (400 feet) immediately after deployment of the second grenade and was successfully pulled back to the surface after 1.5 hr of hand hauling with 25 to 30 hunters by means of the rope attached to one of the harpoons lodged in the carcass. In that case, death was interpreted to have occurred immediately following deployment of the grenade, as indicated by the skull fracture identified during dissection. Overall, TTD from the first harpoon with float affixed to the animal varied between 38.5 and 90 min; that from the first grenade deployed varied between 14.5 and 61 min (not determined in one hunt).

Towing

In all five hunts, the duration of the tow between the site where the whale was killed and the site selected for dissecting the carcass was a few to several hours. All five captains intended to cut an opening in the ventral abdominal wall of the carcass shortly after death in order to allow seawater to get into the abdominal cavity and start cooling the carcass. For logistical reasons (including the unavailability of a sufficiently long flensing knife in one instance), this could be done properly in only two animals. In hunt #5, because of the gently sloping beach at the butchering site combined with the large size of the animal, the carcass ended up beaching fairly far from shore, thus interfering substantially with the start and efficiency of the butchering process.

Location of grenade in the carcass

Of the nine grenades that were deployed in the course of the five hunts, one was found lodged in the epaxial muscle mass (the large muscle mass on either side of the back) but for unknown reason did not explode, one penetrated only superficially and disintegrated (Figure 2) but caused no significant tissue damage (indicating that the energy of the explosion had been dissipated on the outside), four exploded in the epaxial muscle mass (one of them struck and fractured two ribs [hunt #2]; in two other instances, the grenade may have been delivered at too much an angle relative to the surface of the animal), one 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. Of these nine grenades, the only one to have caused immediate death was the latter. In that case, when ready to deploy the grenade, the hunter had aimed specifically for the indentation approximately 1 m behind the blow hole.

The whole grenade that did not explode and remnants of seven of the eight other grenades that were deployed were found, thus confirming these grenades' final resting site within the animal. Extensive damage was generally evident in association with the grenades that exploded within the epaxial muscle mass, consisting of a large area of destruction of muscle tissue, approximately 1 m in diameter, accompanied by an abundant amount of partly clotted blood (Figure 3). The grenade that exploded in the chest cavity of the whale killed in hunt #1 may have partly or completely destroyed one of the lungs as only one lung was located, although the observers left the site before being able to definitely confirm this on further dissection of the carcass. Interestingly, the presumed explosion of one of the grenades in the abdomen of the whale killed in hunt #3 was not associated with tears in the stomach and intestine; the liver, kidneys, and spleen of that whale were also intact except for some bleeding within one of the kidneys. A large portion of the rod part of the grenade was found in the muscle mass of the lower region of the abdominal wall of this whale, associated with some bleeding in the muscle. It is therefore possible that the explosion occurred partly within the abdominal wall, thus limiting the amount of damage within the abdomen. This was the only grenade that struck that whale. The grenade that exploded near the junction between the skull and vertebral column of the whale killed in hunt #4 was associated with a large fracture of the skull, a portion of which involved the brain cavity (Figure 4). Areas of bleeding could be found grossly on the surface of some portions of brain extracted by hand from the brain cavity of that whale, and many small areas of bleeding were found within the nervous tissue on microscopic examination.

Anguvigaq

Most strikes of anguvigaq seemed to be delivered into the chest cavity, but some were also delivered into the abdomen in at least one animal and in muscle near the back end in another. It was difficult to confirm the exact location of the sites struck by anguvigaq. Lacerations in some organs of two animals were strongly suggestive of strikes from anguvigaq, especially since in one case they were associated with pools of clotted blood (Figure 5). Others, however, may have been produced during the dissection process, either from the flensing knives or when the organs were pulled out of the carcass with hooks.

The whales killed in hunts #2, #3 and #5 were of particular interest in relation to the use of the anguvigaq as a killing tool. In hunt #2, the first grenade did not explode and the second grenade exploded in the epaxial muscle mass, yet lacerations from anguvigaq strikes were evident in the chest and abdomen, and the whale presumably died from severe bleeding within the chest cavity. In hunt #3, only one grenade was deployed and pieces of the grenade were located in the abdominal wall, yet an abundant amount of blood was present in the chest cavity. The anguvigaq strikes may therefore have contributed at least as much as the grenade to that whale's death. In that case, the TTD from the first harpoon affixed to the whale was 34 minutes, the shortest of the five hunts observed. In hunt #5, the first grenade exploded in the epaxial muscle mass, and the second grenade caused no significant tissue damage, yet this animal had bled profusely within its chest cavity.

Discussion

A number of factors in a hunt can influence its success: water depth in the area of the hunt, behaviour of the whale once it is harpooned, presence and density of ice floes in the hunting area, state of the sea, and experience of the Captain and crew members with bowhead whales. While based on only five hunts, the observations documented in this report led to some important conclusions. For example, observations of hunt #4 confirmed the value of affixing one or more harpoons with long lines and floats to a whale early in the hunt, before proceeding with either the grenade or the anguvigaq, in order to reduce the risk of losing it after it has been injured or killed. Such is the rational for hunting belugas, narwhals, and walruses in some regions of the Arctic (NAMMCO 2011). In addition, the use of the anguvigaq as a secondary killing tool likely reduced the TTD in some hunts.

Knudsen (2005) claimed that a vast proportion of minke whales hit with a penthrite M99 grenade in the mid region of the chest or further toward the head died immediately or very rapidly. Based on this observation, Inuit hunters were originally encouraged to also aim for the chest cavity of the bowhead whale when deploying the penthrite grenade. However, the whale's ribs obstructed the grenade's path in one instance. Increasing the charge of the pusher in the darting gun in order to increase the grenade's momentum and thus its capacity to break through ribs into the chest cavity would also increase the possibility for the grenade to pass right through a smaller animal if it does not strike hard tissue, as it seemed to have almost done in the whale killed in hunt #3. Moreover, in contrast to the hunt for minke whales, explosion of the grenade within a bowhead whale's chest cavity does not seem to carry with it as high a likelihood of immediate or rapid death. The fact that grenades used in the Norwegian commercial hunt for minke whales contain 30 g of penthrite as compared to 20 g in the subsistence hunt for bowhead whales may be a factor, due to the size difference between bowhead whales and minke whales. However, the Norwegian hunt for minke whales utilizes a deck-mounted cannon that fires a harpoon with a penthrite M99 grenade, the harpoon being deployed from the vessel 15-20 m away (Knudsen and Øen 2003). In contrast, the bowhead whale hunt utilizes a hand-held darting gun on a 3-m pole, and the penthrite grenade is deployed directly against the whale's back. Increasing the charge of penthrite for use on bowhead whales would carry with it an increased safety risk for the hunters.

Causes of death

Strikes from the anguvigaq are likely to cause severe internal bleeding if they are delivered in the upper region of the chest, between ribs (intercostal spaces). In all whales, small and large, intercostal muscles in this region contain a very extensive network of blood vessels called "rete mirabile" ("wonderful net") which extends into the spinal canal where it surrounds the spinal cord and from there continues to the brain where it forms its main blood supply (Figure 6) (Marshall 2002). Laceration of this extensive network of blood vessels in intercostal muscles may thus not only cause severe bleeding within the chest cavity but also directly interfere with the supply of oxygen and nutrients to the brain. Three of the five hunts observed (#2, #3 and #5) illustrated the efficiency of the anguvigaq as a killing tool, particularly when the chest region is struck. Despite extensive internal bleeding in the chest cavity observed in whales harvested in these three hunts, death was delayed. The apparent resistance of very large whales to death from blood loss may relate to their ability to contract blood vessels in their periphery and shift the contents of these blood vessels to vital organs such as brain and heart (as part of their normal diving adaptation), the large absolute oxygen store in their blood, and a low mass-specific metabolic rate (Noren and Williams 2000).

Hunt #4 showed that a bowhead whale of at least moderate size can be killed immediately if the hunter succeeds in striking the animal in a strategic location with the darting gun, namely the junction between the skull and vertebral column. Landmarks determined before and after dissection of this particular whale's head showed that striking the darting gun in the indentation located behind (caudal to) the blow hole should deliver the grenade to the appropriate location, provided that the strike is applied at right angle to the whale's surface. This, however, requires that the harpooner be positioned directly above the whale while standing on or in the boat. A similar process has been adopted during the Alaskan Inupiat subsistence hunt whereby the grenade delivered at close range with a darting gun is aimed near the base of the skull, approximately 1.5 m behind the blow hole (Anonymous 2009). In the experience of Knudsen and Øen (2003) with minke whales, in all cases where skull fractures were observed, the detonation had occurred less than 1 m from the brain. According to these authors, depending on the distance, damage to the brain varied from severe lacerations to only multiple areas of bleeding in the brain and meninges, shown with further evidence microscopically, and akin to the damage associated with acute TBI in humans following a direct blow to the head. The latter pattern was observed in the whale killed in hunt #4. That hunt also showed the importance of having an experienced boat driver who is familiar with the behavior of bowhead whales, can anticipate the animal's movements, and can thus get close to it at the safest possible time in order to allow the designated harpooner with grenade to strike the animal at the best possible location.

Conclusions

In view of the observations provided in this report, the penthrite grenade and anguvigaq can be considered complementary tools for hunting and killing bowhead whales. Both require close proximity to the whale, and thus a substantial amount of risk, for their application. However, it is probably quicker, and thus safer, to deploy the grenade than to deliver a deep strike of the anguvigaq into the whale's intercostal muscles and vital organs such as heart and large blood vessels. The explosion of the first grenade seems to be able to weaken the animal substantially, at least temporarily, whether it occurs in the epaxial muscle mass or in the body cavities, thus making it easier for the hunters to use the anguvigaq and/or the second grenade. However, it also appears that the explosion of a single grenade is sufficient to kill a bowhead whale instantly if the strike is applied in a specific location, at the base of the skull, although placement of the initial grenade in this location is also more difficult and an increased risk to the crew.

It is important that observations of the subsistence hunts of bowhead whales by Inuit-sanctioned observers be continued and expanded to all hunts in Nunavut. The observations and data collected will contribute to the continued improvements in techniques, equipment, and methods used to harvest bowhead whales.

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Table 1. Details of observations of subsistence hunts of bowhead whales (*Balaena mysticetus*) by five Nunavut communities between 2010 and 2014.

Details of the hunt	**Hunt #1, 2010**	**Hunt #2, 2011**	**Hunt #3, 2012**	**Hunt #4, 2013**	**Hunt #5, 2014**
Date (August)	5	15	11	6	2-3
Location	Eclipse Sound, south end of Navy Board Inlet	50 km southeast of Iqaluit, on west side of Frobisher Bay	western side of Admiralty Inlet	mouth of Kingnait fiord, 20 km north-east of Kekerten island	north of Cape Christian, near Clyde River
Captain	Charlie Inuarak	Solomon Awa	Tommy Tatatuapik	Simeonie Keenainak	David Iqaqrialu
Number of boats participating	5	6	7	4 to 6	7
Gender of whale	male	male	male	male	female
Body length (m)	12.8	14.3	8.8	11.9	16
Tail width (m)	not available	not available	2.87	4.57	5.5
Number of harpoons with floats deployed	3	3	2	4	4
Number of penthrite grenades deployed	2	2 (1 failed to detonate)	1	2	2
Time from first harpoon to death (min)	55	53	34	38.5	90

Time from first grenade to death (min)	not available	36	18	14.5	61
Site of first grenade application	left side of dorsal midline, near the body's midpoint	approximately 3 m behind blow hole, slightly on left side of dorsal midline	(fired underwater) slightly left of dorsal midline; went obliquely, from left to right and from back to front, through the whole abdomen; detonator found 10 cm from the skin surface ventrally	at an angle in cranial (forward) region of indentation behind the blowhole	approximately 1 m behind blow hole, on left side of dorsal midline
Site of first grenade explosion / associated gross lesions	right side of chest cavity[1] / right lung may have been largely, if not completely, destroyed	did not explode (lodged in muscle mass, some of it torn and filled with blood)	abdominal cavity, but also possibly ventral region of abdominal wall / abundant amount of blood in abdominal cavity (partly caused by anguvigaq strikes?); no evidence of ruptured stomach or intestine	cranial (forward) region of left epaxial muscle mass / large area of muscle very mushy and containing an abundant amount of blood	epaxial muscle mass on left side, approximately 1 m deep and 2m caudal to the entry wound; not possible to accurately assess gross lesions because of post-mortem decomposition

Site of second grenade application	right side of dorsal midline, less than 1 m cranial (forward) to the strike from the first grenade	approximately 3 m behind blow hole, slightly on right side of dorsal midline	not used	at right angle in caudal (back) region of indentation behind the blowhole (later measured as 1 m from back of blow hole)	on left side of the whale; large puff of smoke emerged from site of penetration as the grenade exploded
Site of second grenade explosion / associated gross lesions	right chest region of epaxial muscle mass (struck a rib?) / large cavity at this level	epaxial muscle mass / (large area torn and filled with blood); complete fracture of two right ribs (7th and 8th) in their mid region	not applicable	left side of junction between skull and spine / long fracture (approximately 0.5 m) of back part of skull on left side; several small areas of bleeding on surface of, but not within, some portions of brain and spinal cord examined [4]	near commissure of the mouth on left side, 1m ventral to blowhole and slightly caudal to it; one end of remnant of rod portion of grenade found only approximately 10 cm from skin surface; detonator found by palpation in what felt like a softball-size pocket roughly 30 cm from skin surface

Strikes from anguvigaq	after first and second grenades; in chest in both instances	before first grenade (only one or at most three strikes), presumably in lung[2]; many after second grenade	several by one hunter after first grenade, on right side, in two locations (one behind the other), presumably in lung[3]; then, several strikes from different hunters	after first grenade only; approximately 0.3 m behind caudal (back) edge of left flipper	many strikes after first grenade; many more strikes after second grenade
Injuries from anguvigaq strikes	numerous small lacerations in heart, most of them superficial (on outer surface); at least two lacerations in left lung	lacerations in dorso-lateral surface of left lung (right lung not examined); abundant amount of clotted blood in ventral region of chest cavity; several blood clots over sites of laceration of some intestinal loops	very large amount of mainly clotted blood in left side of chest cavity (right side could not be examined); several cuts in lungs (could also have been caused by flensing knives during dissection)	no lacerations observed, but abundant amount of blood in chest cavity	large area of hemorrhage and muscle destruction in left caudal hypaxial muscle mass; abundant amount of blood in thoracic cavity (some injuries identified in internal surface of thoracic wall); large amount of blood in first stomach compartment
Duration of tow to butchering site (hr)	3.5-4	not available	3.25	5.5-6	2.75 [6]

Interval between death and start of butchering process (hr)	7	not available	4	7-7.5 [5]	10.5 [7]

[1] The whale's blowhole sprayed an abundant amount of blood shortly afterwards.
[2] A fine mist of blood was ejected from the blowhole 6 min after the first grenade (which did not explode); some bloody foam was seen floating on the water surface 10 min later.
[3] Much blood came out of the blowhole as the whale exhaled after the first grenade exploded (in the abdomen or in the lower region of the abdominal wall, not in the chest cavity) and after several anguvigaq strikes were given; blood and also bubbles came out of one of the anguvigaq wounds.
[4] Small area of bleeding under the meninges on the surface of the spinal cord at its exit from the brain cavity. Small blood clots on the surface of some of the portions of brain (mainly cerebellum) extracted by hand from the brain cavity. No bleeding evident grossly within the nervous tissue itself; however, abundant amount of red blood cells around many small blood vessels in the nervous tissue throughout the brain on microscopic examination, indicating rupture of these blood vessels. There were also many large blood clots in the abdomen and extensive bruises on the external surface of some loops of intestine – result of some anguvigaq strikes and/or of severe pressure waves generated by explosion of the first grenade?
[5] The whale sank immediately after death, and it took 1.5 hr to pull it back to the surface.
[6] The carcass beached in shallow water approximately 300 m from shore.
[7] Several attempts were made by three bulldozers to bring the carcass closer to shore. Dissection was started when the carcass was still approximately 50 m from shore at low tide, but still in 1-2 m of water. There were subsequently many long interruptions because of high tide and of further attempts by the bulldozers to pull the carcass ashore.

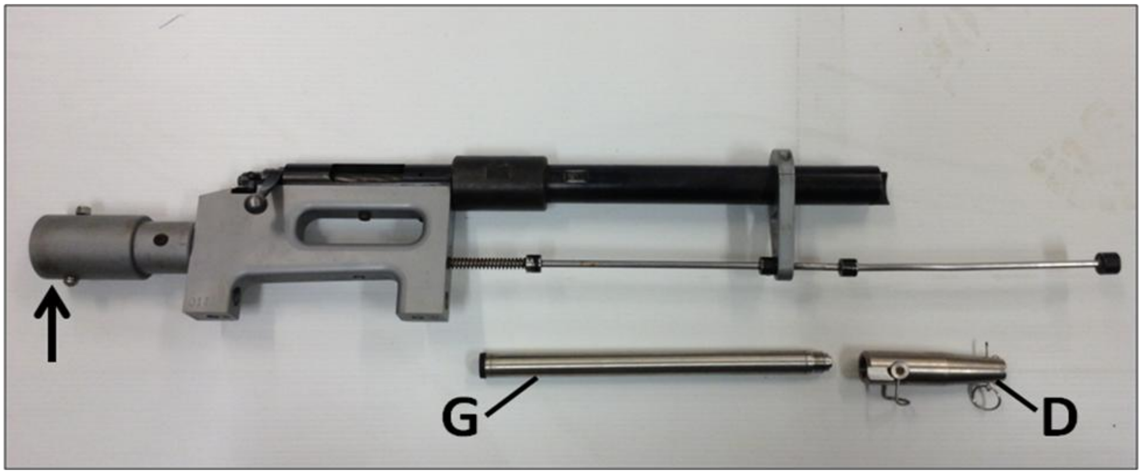

Figure 1. Darting gun (above), grenade (G) and its detonator (D). The arrow points to where the wooden pole is inserted into the darting gun.

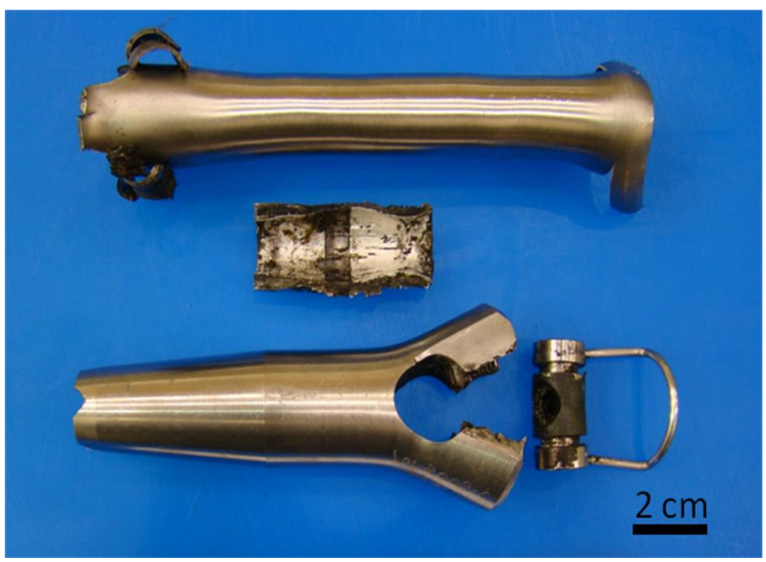

Figure 2. Remnants of the second grenade deployed in the whale harvested in hunt #5.

Figure 3. Large area (outlined by arrows) of destruction of, and bleeding within, the right epaxial muscle mass of a bowhead whale (hunt #2), caused by explosion of a penthrite grenade. The tip of the knife points to one of two fractured ribs.

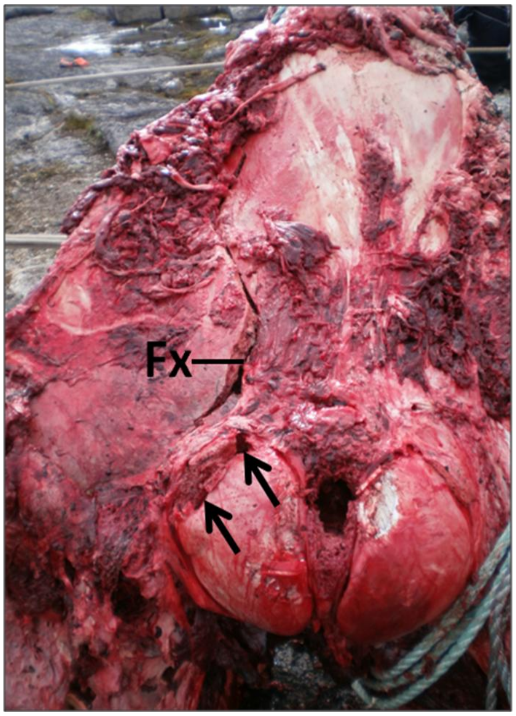

Figure 4. Fracture of left occipital condyle (arrows) extending along the left side of the skull (Fx) in a bowhead whale (hunt #4), caused by explosion of a penthrite grenade near the junction between skull and vertebral column. The gaping hole to the right of the arrows is where the spinal cord would extend from the brain into the vertebral canal.

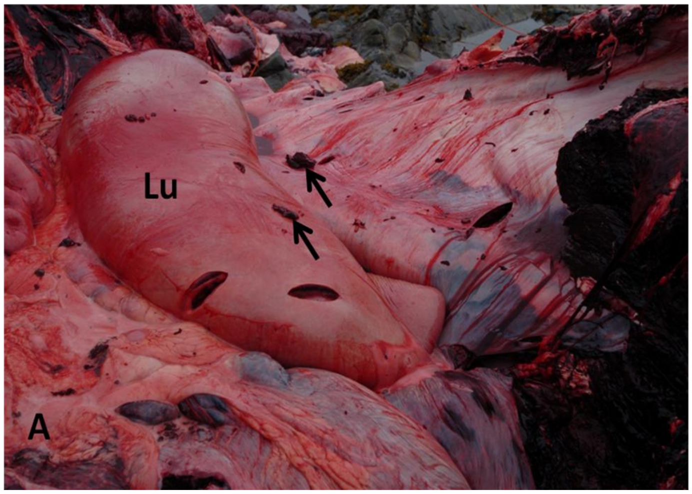

Figure 5. A) Lacerations on surface of left lung (Lu) of a bowhead whale (hunt #2) attributed to strikes of anguvigaq. Small pools of clotted blood (arrows) are free in the chest cavity.

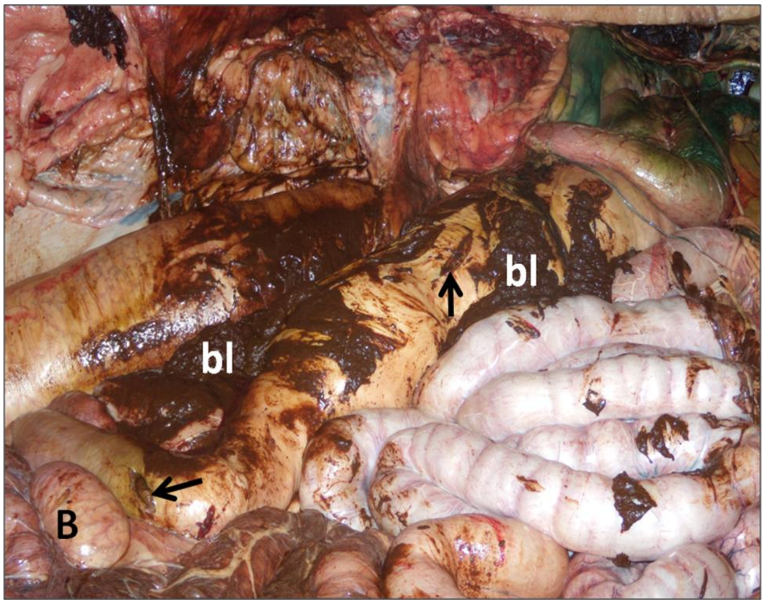

Figure 5. B) An abundant amount of blood (bl) also covers some intestinal loops in the abdomen of this whale. A few lacerations of the intestinal wall, likely caused by anguvigaq strikes, are visible (arrows).

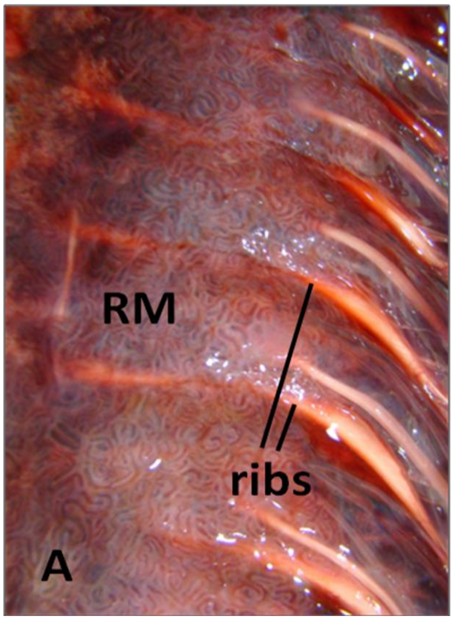

Figure 6. A) Rete mirabile (RM) (‘wonderful net’) of blood vessels on inner surface of the rib cage of a young harbour porpoise (*Phocoena phocoena*).

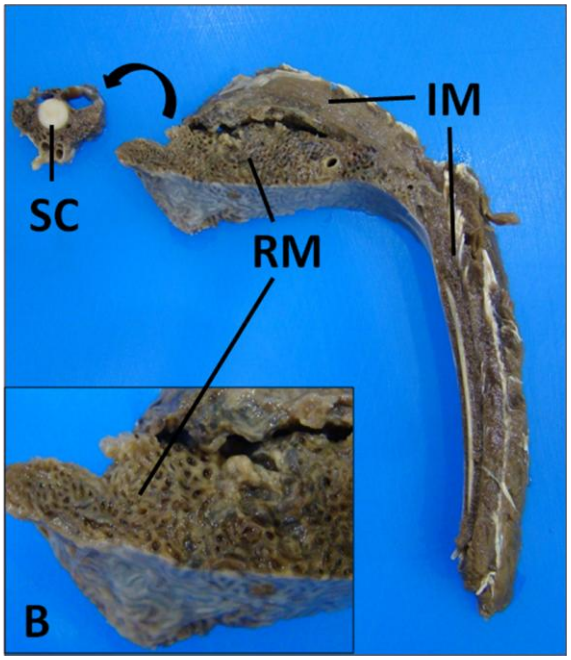

Figure 6. B) Section of one whole intercostal muscle mass (IM) from the same porpoise. The rete mirabile (RM), in the part of the muscle closest to the vertebral column and nearest to the chest cavity, sends blood vessels (curved arrow) to the meninges surrounding the spinal cord (SC, cross section). The inset (lower left corner) is a close-up of the many blood vessels forming the rete mirabile