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Canadian Science Advisory Secretariat
Science Advisory Report 2013/010

EFFECTIVENESS OF METHODS USED TO KILL SEALS IN CANADA'S COMMERCIAL SEAL HUNT, WITH PARTICULAR EMPHASIS ON GREY SEALS (*HALICHOERUS GRYPUS*)

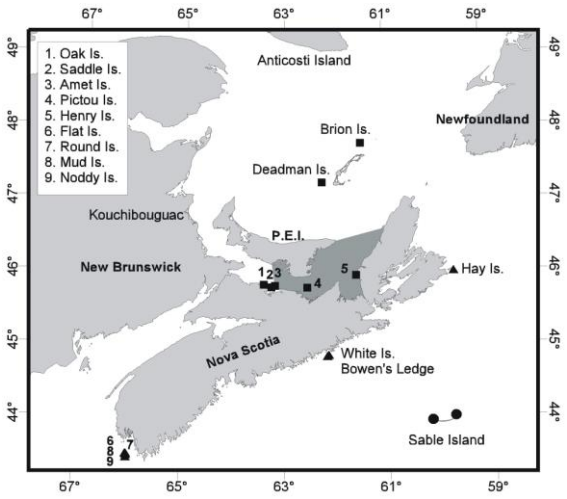

Figure 1. Southern Gulf of St Lawrence and Scotian Shelf showing location of Sable Island (●), coast of Nova Scotia (▲), and Gulf (■) grey seal colonies, and general location of ice-breeding animals (dark grey area).

Context

Beginning in 1996 there was renewed demand for products from the Canadian seal hunt. In 2005, the Independent Veterinarians' Working Group (IVWG) provided recommendations to ensure that the harvest was conducted in a manner that respected animal welfare concerns. In 2009 the Department incorporated the IVWG recommendation to adopt the 3-step process in the killing of seals as a condition of licence and in 2010 the 3-step process for killing seals was incorporated into the Marine Mammal Regulations. The continued increase in the North Atlantic Grey Seal population has resulted in an increasing interest in hunting activities. Due to field observations that the skull of young grey seals is thicker than that of similarly-aged harp seals, questions have been raised regarding whether hunting tools currently allowed under the Marine Mammal Regulations meet Canada's hunting requirements from an animal welfare perspective when used on grey seals.

Science was requested to evaluate the differences in skull thickness and force required to crush young harp seal and grey seal skulls, to assess current methods used during the hunt for young grey seals, and to review the effectiveness of the .17 HMR rifle cartridge to kill young grey seals in a manner appropriate from an animal welfare perspective.

SUMMARY

- The NW Atlantic grey seal population has increased markedly over the last few decades and there is interest in developing a commercial harvest for this species.
- The skull of grey seal beaters is almost twice as thick as that of harp seal beaters, primarily along its top.
- Using a hakapik under controlled conditions, the effective force required to crush the skull was lower for harp seal than for grey seal beaters, but this difference was not significant, likely because of the small number of skulls tested.
- Under field conditions, both the club and the hakapik were considered effective tools to cause rapid, if not immediate, death of grey seal beaters.
- Time to bleed out grey seal beaters was less than the legal requirement. When both axillary arteries were severed, grey seals bled out in an average time of 18 seconds, and all seals bled out in less than 1 minute.
- Owing to the greater thickness of grey seal beater skulls, fragmentation was not as evident as in harp seal beater skulls. This was because the skulls of grey seals tended to break into fewer larger pieces that were more difficult to detect by palpation through skin and blubber. The damage resulted in death in a way that respects animal welfare concerns, but grey seals may require more blows than harp seals to ensure that legal requirements that the skull be crushed, as indicated by palpation, are met.
- The .17 HMR rifle cartridge was tested as an alternative to the club and the hakapik for killing grey seal beaters and proved to be effective at tested distances of up to 2 m.
- The presence of numerous metal fragments in radiographs of several skulls showed that the bullets used with a .17 HMR rifle cartridge fragment easily, thus minimizing the risk of ricochets.

INTRODUCTION

Regulations governing the commercial harvesting of marine mammals take into account animal welfare concerns related to how the harvest is conducted. Initial animal welfare concerns in the prosecution of the seal hunt were reviewed in the Royal Commission on Seals and Sealing during the 1980s (Malouf 1986). However, the harvest at that time focused on whitecoats, whereas the current harvest targets weaned animals (beaters), four weeks old and older. In 2005, the Independent Veterinarians' Working Group outlined proposals that if adopted would meet animal welfare concerns regarding the Canadian commercial harvest (IVWG 2005). These proposals were adopted initially as conditions of licence in 2009 and formally incorporated into the Marine Mammal Regulations in 2010. The European Food Safety Authority reviewed the methods used in the Canadian commercial seal hunt and concluded that the legal methods used in the harvest did respect animal welfare concerns, but that little empirical information is available on the use of different hunting methods at different times of the year; the efficacy of each of these methods in the different environments; and their respective advantages and disadvantages in relation to animal welfare (EFSA 2007).

Species biology

The grey seal is a member of the family Phocidae. In Canada, they are sometimes referred to as horse-head seals owing to the elongated snout of adult males. Males may reach a length of

231 cm, and weigh as much as 350 kg. Females are smaller, reaching 201 cm in length and weigh up to 227 kg. Breeding occurs on islands, on isolated beaches or on the pack ice. Females nurse a single pup for about 16 days. The pup is born with a white lanugo which is completely shed by 3-4 weeks of age. Grey seals are a coastal or continental shelf species. Prior to the 1950s, the grey seal was considered uncommon or rare, but the population has increased since the 1970s and currently numbers around 350,000 animals.

The Northwest Atlantic population of harp seals summers in the Canadian Arctic and Greenland. In the fall, most of these seals migrate southward to the Gulf of St. Lawrence ("Gulf"), or to the area off southern Labrador and northern Newfoundland ("Front") where they give birth in late February or March on medium to thick first year pack ice. Male and female harp seals are similar in size with body length and mass of adults averaging 1.6 m and 130 kg, respectively. Females nurse a single pup for about 12-14 days. The pup is born with a white lanugo which is completely shed by 3-4 weeks of age. Currently the population numbers around 7 million animals.

ASSESSMENT

A comparison between the skulls of grey seals and harp seals approximately 4-6 weeks old (beaters) showed that the skull of young grey seals was almost twice as thick as that of young harp seals, when measured at the top (4.88 mm, SD= 2.12, and 2.64 mm, SD= 0.76, respectively) ($P < 0.001$)(Caraguel et al. 2013). Overall, harp seal beaters have a thinner skull with a uniform inner surface, whereas the mid-dorsal region of the grey seal beater skull is almost twice as thick with a more complex, irregular inner surface that becomes thinner laterally (Figure 2).

Using a hakapik, the force required to fracture the skull of 3 adult harp seal, 9 beater harp seal and 6 beater grey seal intact heads (including skin and blubber) was tested by two researchers under controlled conditions. In the case of the adult harp seal skulls, the force from one researcher's strike resulted in an effective blow with skin puncture, multiple displaced bone fragments, and a 2-3 cm indentation in the cranium, whereas that of the second researcher did not (Table 1).

Table 1. Velocity and force using a Canadian hakapik generated by two researchers to determine the range of forces required to effectively crush the skull of adult harp seals.

Researcher Number	Effective Mass (kg)	Velocity (m/s)	Force (Newtons)
3	0.571	23.66	1266
3	0.571	25.31	1032
4	0.606	31.74	2509

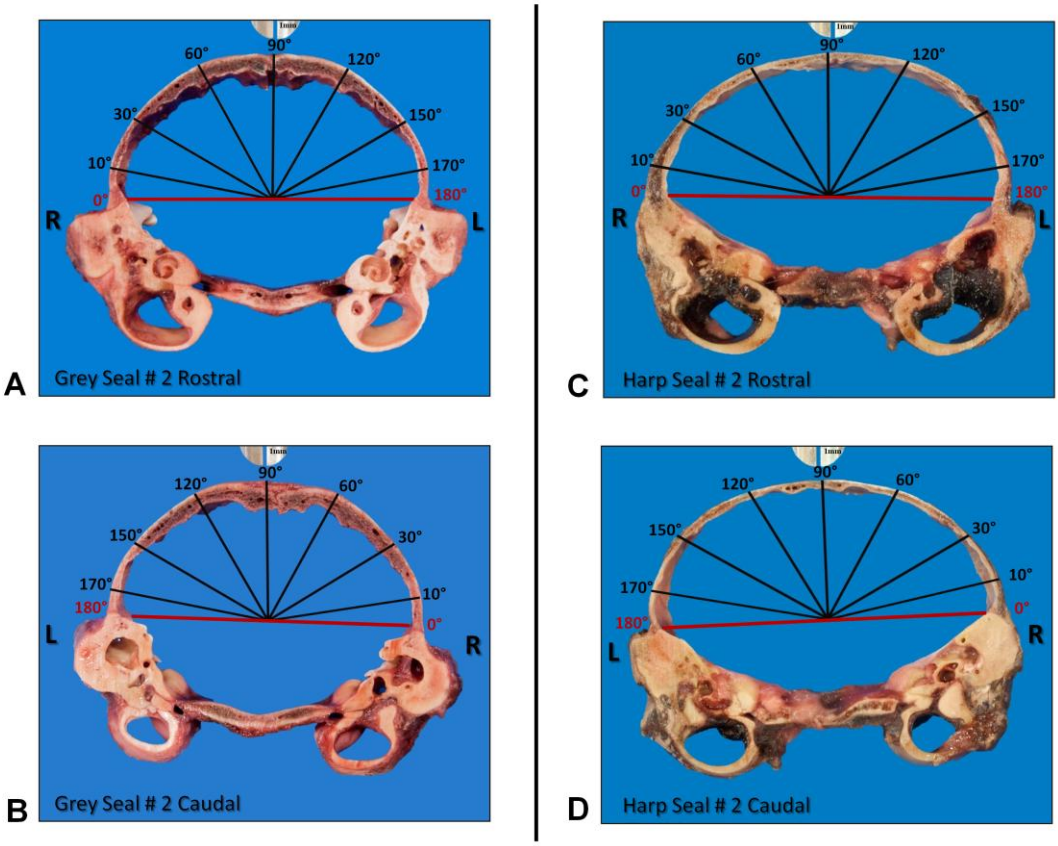

Figure 2. Forward (A,C) and back (B,D) views of a cross section of a grey seal skull (left) and of a harp seal skull (right). The thickness of the skull was measured in mm at seven set angles: 10°, 30°, 60°, 90°, 120°, 150° and 170°. The caliper used as a reference scale at the top of each photo is opened to a width of 1 mm.

It was concluded that a strong man of moderate size can produce enough force to effectively crush the skull of adult harp seals. The required force was near the maximum the researcher was able to produce, making it unlikely that he would be able to sustain that level of force over many blows during several hours.

The mean velocity resulting in effective blows to crush the skull was lower for harp seal beaters (21.44 m/s, n=4) than for grey seal beaters (27.04 m/s, n=3). The differences were not statistically significant owing to small sample sizes. The effectiveness of the strikes was affected by technique and exact location of the strike on the skull by the hakapik (Roy et al. 2012).

Field assessment of stunning and killing methods, using a club or a hakapik, was done during the commercial harvest on Hay Island, Nova Scotia, in February 2009 (Daoust et al. 2012). Since the goal of a proper killing method is to achieve irreversible unconsciousness or death as quickly as possible, the required outcome was identified as the number of blows used to completely crush the skull and thus destroy the brain. Twenty grey seal beaters were killed with a club, and 20 with a hakapik. On average, the hakapik required more blows (4.55; range, 3-10) than the club (3.7; range, 2-7) to crush the skull, but this difference was not statistically significant.

Time required for animals to bleed out was also examined. The average bleeding time was 21.3 sec (range, 9-70) when severance of one and both axillary arteries was combined. If both axillary arteries were severed, as required by the Marine Mammal Regulations, the average bleeding time was 18 sec (SD=2.4), and all seals bled out in less than 1 min. If only one axillary

artery was severed, the average bleeding time was longer (25 sec, SD=4.5). The average bleeding time for grey seal beaters was shorter than that for harp seal beaters killed with a hakapik: 21.3 sec (CI,14.7-27.9; range, 14-35) when both axillary arteries were cut, and 50.3 sec (CI, 26.7-74.0; range, 12-75) when only one axillary artery was cut (Daoust and Caraguel, 2012). These times are less than the time of 1 min that animals are required to bleed before being skinned as required by the Marine Mammal Regulations.

The thick mid-dorsal region, but relatively thinner sides, of the grey seal skull mean that blows delivered to the top of the skull would likely produce thicker and larger skull fragments as compared to those that are created when an overall thinner harp seal skull is struck. These fragments would indicate that the animal was irreversibly unconscious or dead, but they could be more difficult to detect by palpation through skin and blubber than those in a harp seal skull. Skull fractures in four grey seal beaters resulting from strikes from a hakapik or a club were examined in the laboratory. In addition to fragments in the top of the skull, fractures were found consistently in the floor of the braincase of the four seals, as has also been observed in harp seal skulls struck with a hakapik. Fractures in this location imply severe functional, if not structural, damage to the brain stem, which rests on the floor of the braincase. Because this part of the brain contains respiratory and cardiovascular control centres that are essential for life, such damage would indicate rapid, if not immediate death, although it would not be possible to feel by palpation the fractures in this deep location.

Both the club and the hakapik were considered effective tools to quickly and completely crush the skull of young grey seals under field conditions, thus resulting in their rapid, if not immediate, death. However, in view of the thicker skull of grey seal beaters, the efficacy of a rifle fired at close range to destroy the brain of these animals was examined.

The .17 HMR is a high-velocity rimfire cartridge often used to hunt varmint. Its small bullet is designed to disintegrate quickly on impact and thus cause considerable damage while minimizing the possibility of ricochets. In a controlled study, 12 young grey seals were shot at distances of 15 cm (n=3), 30 cm (n=3), 1 m (n=5) and 2 m (n=1). Death was judged to be immediate in 11 animals, based on the sudden relaxation of the body and on the absence of corneal reflex. One animal, shot on the right side from a distance of 30 cm, may have turned its head toward the rifle just as the shot was fired and did not demonstrate complete obliteration of central neurologic function immediately after being shot. Its body contracted, and its eyes were closed tight, which prevented evaluation of the corneal reflex. This body contraction was maintained for approximately 30 sec, after which a slight relaxation occurred. The animal was then bled out to ensure death. This and five other animals showed no evidence of swimming reflex; the other six animals showed only a very mild swimming reflex. In all animals, the external wound created by the bullet's entry was very small; another small external wound also appeared in two animals, possibly created by the exit of a small bullet fragment or of a piece of bone from the skull. Slight to moderate fragmentation of the skull could be felt on palpation in 10 animals; the skull of two animals was intact on palpation. On radiography, numerous small and a few large metal fragments could be seen in the skull and/or surrounding soft tissues of all 12 animals, indicating extensive fragmentation of the bullet. Skull fractures were evident in all radiographs.

In 10 animals, macroscopic examination revealed severe multiple fractures of the skull involving especially its caudal region and accompanied by extensive hemorrhage around and within the brain and extensive laceration of the brain. In one of the two seals with an intact skull on palpation, fracture of the skull was confined to the lower, typically very hard, region of the right temporal bone. This was accompanied by severe hemorrhage and laceration of the adjacent region of the brain. In the other seal with an intact skull on palpation, the animal that did not demonstrate evidence of immediate death after being shot, fracture of the skull was also confined to the lower

region of the temporal bone. This was accompanied by extensive subdural hemorrhage over the right cerebral hemisphere, over the cerebellum, and on the floor of the cranial cavity, including the ventral surface of the brainstem. This amount of hemorrhage would presumably have resulted in irreversible unconsciousness or death within a few seconds.

Field testing of the .17 HMR rifle cartridge was conducted on 45 seals during the commercial harvest on Hay Island, Nova Scotia, in February 2011. Seals were shot at distances of <0.5 m (n=33), 0.5 m (n=7), and 1 m (n=5). No effect of distance on the efficacy of the shot or the degree of damage to the skull was detected. A single shot resulted in immediate death or death within a few seconds in 40 instances (88.9%). Based on palpation through skin and blubber, the skull was considered to be completely crushed in 22 seals, partly crushed in 10 seals, and not crushed in two seals; no description of skull palpation was available for six seals. In five of the seals with a skull that was only partly crushed or not crushed on palpation, the animal was shot a second time to complete destruction of the skull.

In 30 seals killed with a single shot, the body relaxed immediately, and there were no corneal reflex or respiratory movements; a mild to moderate swimming reflex was observed in 15 of these seals, although in four of them this reflex occurred while or shortly after the skull was palpated to assess its destruction. In 10 seals killed with a single shot, the body contracted and the eyes closed immediately after the shot. This lasted for a few to several seconds before the body relaxed. Three of these 10 seals showed some swimming reflex. In three of these 10 seals, the skull was subsequently examined in details and had multiple severe fractures; in three others, the skull was determined to be completely crushed on palpation; and in the remaining four seals, the skull was determined to be only partly crushed on palpation.

In six seals that had been killed with a single shot, detailed macroscopic examination of the skull revealed multiple severe fractures of bones of the brain case in all instances. Radiographic examination of five of these six skulls showed only a very few small metal fragments, while several metal fragments, including some large ones, were present in the sixth skull. Five (11.1%) seals were not killed with the first shot. In four of these seals, a second shot to the head was fired shortly afterwards, whereas a hakapik was used to crush the skull of the fifth seal.

It was not possible to make accurate observations about the occurrence of exit wounds by bullet fragments or lack thereof. Small gaps in the skin of the head, from which blood and/or brain tissue easily came out, were common, but these could also have been caused by bone fragments from the skull. An exit wound was clearly observed in one seal only, which was shot in front of the head at an angle almost parallel with the body.

Sources of uncertainty

For the field assessment of the club and hakapik, there is some uncertainty associated with the results outlined above because only one sealer was involved. Different sealers would vary in strength, fitness, ability, and experience to deliver a blow to the best location on the skull in order to crush it after only one or a very few strikes. Repeated strikes from the hakapik or club would ensure that the skull is crushed. A wider cross-section of sealers may provide further insights into which tool is most effective. Similar comments apply to the field testing of the .17 HMR rifle cartridge, as a single sealer was involved in this test. Other sealers could have differed in their shooting skills and their degree of maintenance and use of the rifle.

Harp seals are monomorphic and it is unlikely that there are differences between the sexes in the amount of force required to crush the skull. Grey seals are sexually dimorphic, and some differences are observed at weaning between the two sexes, but the differences are not large. Male and female grey seals were included in the tests, but their sex was not recorded. There may

be some differences between sexes in skull thickness and this should be considered in future tests.

There was considerable uncertainty associated with the engineering tests, which was largely due to the small number of skulls that were available for these tests.

ADDITIONAL STAKEHOLDER PERSPECTIVES

The use of a small caliber rifle facilitates killing large numbers of grey seals at close range. Owing to the light bullet, which disintegrates on impact, there appears to be little additional risk to other hunters from ricochets. However, this does not eliminate the need for safe handling of firearms.

CONCLUSIONS AND RECOMMENDATIONS

The hakapik and club were effective in killing harp seal and grey seal beaters under field conditions.

A greater force is required to crush the skulls of grey seal beaters than those of harp seal beaters owing to the fact that the top of the skull of grey seal beaters is almost twice as thick as that of harp seal beaters. Because of the greater thickness of grey seal skulls, fragmentation may be more difficult to detect by palpation. This does not necessarily indicate a poor animal welfare outcome, but may require additional blows from a hakapik or club to confirm that the skull is crushed.

The current Marine Mammal Regulations require that animals be bled for 1 min after both axillary arteries have been severed and prior to skinning. All seals bled out in less than 1 min when both axillary arteries were severed.

From an animal welfare perspective, the use of a .17 HMR rifle cartridge was effective in killing grey seals when animals were shot at tested distances of 2 m or less. From a safety perspective, the bullet showed few signs of ricochet. Additional input from stakeholders is needed regarding their interest in using the .17 HMR rifle cartridge as an alternative method for killing young grey seals.

It is likely that more than one type of ammunition can fulfill the criteria required for use at the hunt for grey seal beaters. However, as with any hunt, the most important element remains the professionalism of the sealer.

SOURCES OF INFORMATION

This Science Advisory Report is from the October 29 to November 2, 2012 Annual meeting of the National Marine Mammal Peer Review Committee. Additional publications from this meeting will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule.

Caraguel, C., Daoust, P-Y. and de Bie, F. 2013. Comparison of the thickness of the calvarium between young grey (*Halichoerus grypus*) and harp (*Pagophilus groenlandicus*) seals. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/172. ii + 6 p.

Daoust, P-Y and Caraguel, C. 2012. The Canadian harp seal hunt: observations on the effectiveness of procedures to avoid poor animal welfare outcomes. Animal Welfare 21: 445-455.

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European Food Safety Authority (EFSA). 2007. Animal welfare aspects of the killing and skinning of seals. Scientific Opinion of the Panel on Animal Health and Welfare. The EFSA Journal 610: 1-122.

Independent Veterinarians' Working Group (IVWG). 2005. Improving humane practice in the Canadian harp seal hunt. A report of the Independent Veterinarians' Working Group on the Canadian harp seal hunt. 26 pp.

Malouf A. 1986. Seals and Sealing in Canada. Report of the Royal Commission on Seals and the Sealing Industry in Canada. Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, 3 volumes.

Roy, L.D., Jenson, E. and Hiltz, M. 2013. Force needed to effectively fracture skulls of grey and harp seal beaters using a hakapik. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/134. ii + 11 p.

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