The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK
www.ufaw.org.uk

Animal Welfare 2012, 21: 445-455
ISSN 0962-7286
doi: 10.7120/09627286.21.4.445

The Canadian harp seal hunt: observations on the effectiveness of procedures to avoid poor animal welfare outcomes

P-Y Daoust*† and C Caraguel‡

† Canadian Cooperative Wildlife Health Centre, Department of Pathology & Microbiology, Atlantic Veterinary College, University of Prince Edward Island, 550 University Avenue, Charlottetown PE C1A 4P3, Canada
‡ School of Animal & Veterinary Sciences, Roseworthy Campus, The University of Adelaide, SA, Australia 5371
* Contact for correspondence and requests for reprints: daoust@upei.ca

Abstract

*The Canadian harp seal (*Pagophilus groenlandicus*) hunt has, for several decades, raised public concerns related to animal welfare. The field conditions under which this hunt is carried out do not lend themselves easily to detailed observations and analyses of its killing practices. This article reports observations carried out over several seasons that aimed at obtaining more specific information about the conditions under which seals are killed, in order to assess potential welfare issues and explore avenues for possible improvements in its practice. A standardised three-step process for killing seals (ie stunning, checking by palpation of the skull, and bleeding) was recently implemented to maximise the proportion of animals that are killed rapidly with minimum pain. Based on field observations, the rifle and the hakapik, when used properly, appeared to be efficient tools for stunning and/or killing young harp seals. All carcases of seals observed to be killed with a rifle, either on the ice or in the water, could be recovered. However, shooting seals in water rather than on ice carried a higher risk of poor welfare outcome because of the limited opportunities to shoot the animals again if not stunned with the first shot. Based on current practices, there is no reliable evidence that the Canadian harp seal hunt differs from other forms of exploitation of wildlife resources from the perspective of animal welfare. Although opportunistic field observations may be less amenable to generalisation than structured studies, we believe that they reflect the reality of the hunt and provide valuable information to direct the evolution of its practice.*

Keywords: *animal welfare, Canada, hakapik, harp seal, hunt, killing methods*

Introduction

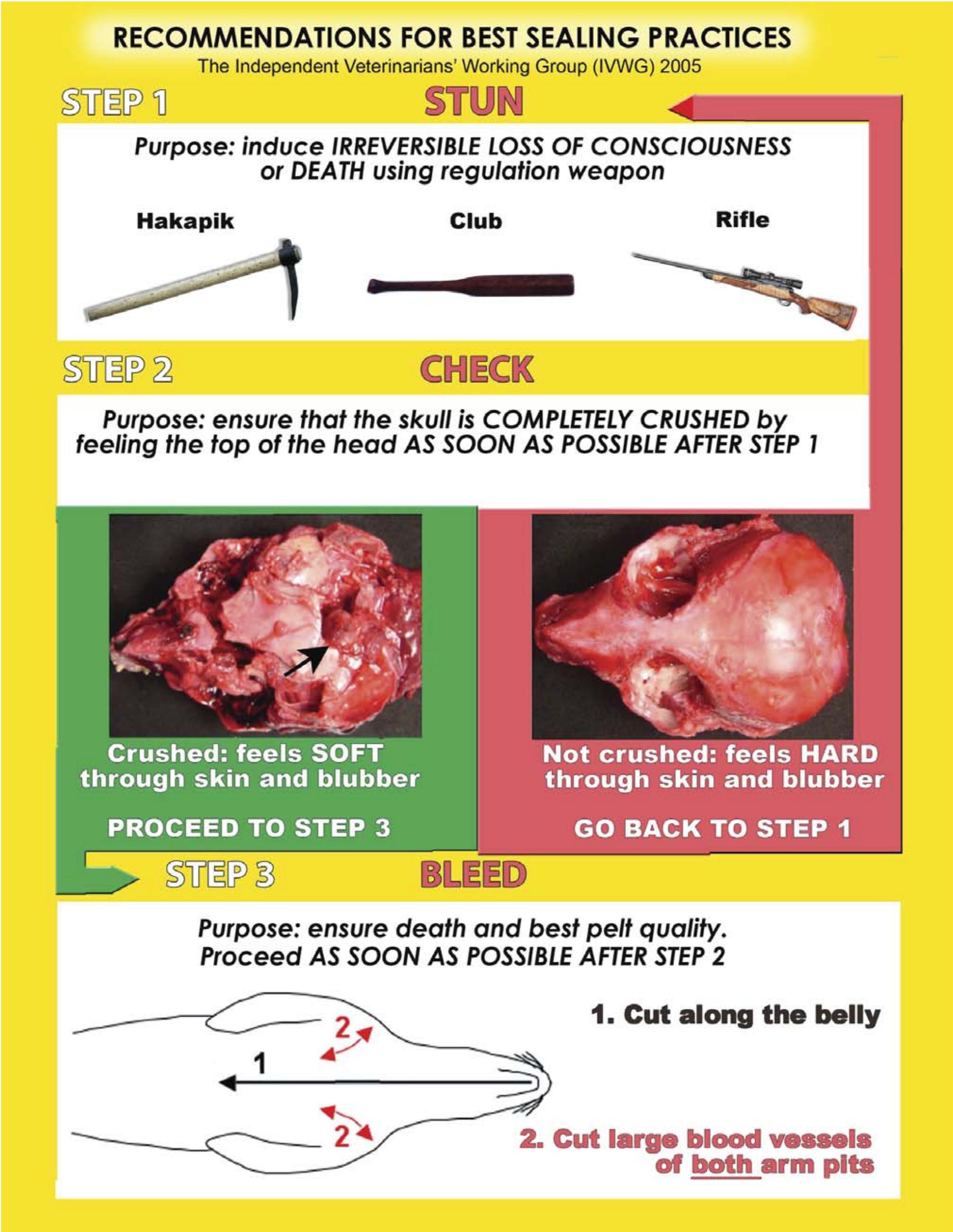
The Canadian harp seal (*Pagophilus groenlandicus*) hunt has been the subject of much controversy for several decades. 'Beaters' (young harp seals, approximately one to three months old, that have been weaned and left by their mother at approximately 10 days of age and have completely shed their white coat) are the main target of this hunt; over 95% of the seals taken during the hunt since 2000 were one-year old or less (Stenson 2009).

Depending on ice conditions, these seals are hunted mainly with one of two regulation tools (Anonymous 2010): the hakapik, a long wooden club with a metal ferrule at the striking end (the blunt part, rather than the spike, being used to strike the animal on the top of its head) (Figure 1), which is used mainly in the Gulf of St Lawrence (hereafter referred to as the Gulf) (~47°-49°N; ~59°-62°W) in years of good ice, when the sealers can get down on the ice and approach the animals; or a rifle with ammunition of specified minimum velocity (1,800 ft s^{-1} [549 m s^{-1}]) and energy (1,100 ft-lb [1,500 J]), with the animal's head as the target, which almost exclusively is the tool used at the Front, east of the province of Newfoundland and Labrador (~°49-52°N; ~53°-56°W), where ice floes are typically much smaller and more spread out.

Efforts to assess animal welfare (hereafter referred to as welfare) concerns related to this hunt were reviewed by Daoust *et al* (2002). The debate on the ethics of this hunt has nonetheless continued between opponents who argue that it fails on many levels of welfare standards (Burdon *et al* 2001; HSUS 2010; IFAW 2010), and those claiming it to be a well-monitored and regulated hunt that is commercially important for coastal communities (DFO 2010; FIC 2010).

A number of reports were produced in recent years by independent groups of veterinarians and marine biologists that intended to assess objectively the different killing methods used during seal hunts in Canada and other countries (Smith *et al* 2005; EFSA 2007; NAMMCO 2009). These reports generally concluded that the tools used in most hunts can kill the majority of animals quickly when used properly, but that improvement may be needed in the implementation of their use in order to ensure consistent positive welfare outcomes.

Figure 1



Poster provided to Canadian sealers illustrating a three-step process for killing young harp seals, with the purpose of inflicting minimal or no pain to the animal.

https://doi.org/10.7120/09627286.21.4.445 Published online by Cambridge University Press

Smith *et al* (2005) recommended standard killing practices based on a three-step process that, if and when systematically used, should result in minimal or no pain on the part of the animal, provided that the three steps are carried out in sequence as rapidly as possible (Figure 1). Step one refers to stunning (with regulation tools, ie hakapik, club [shorter than a hakapik, and without a metal ferrule (Figure 1)], or rifle [Anonymous 2010]) and aims to cause irreversible loss of consciousness or death of the seal by severely damaging its skull and brain, the hakapik and club being allowed only for seals less than one-year old. Step two refers to checking and aims to verify the proper completion of step one by external palpation of the skull, more specifically the calvarium (dome-shaped superior portion of the cranium), through skin and blubber in order to confirm that it is completely crushed and, therefore, that the integrity of the underlying cerebral cortex (centre of pain perception) has been lost (AVMA 2007). If the calvarium is only partially crushed, the sealer is required to strike it with a hakapik or a club in order to ensure its complete destruction before proceeding to step three. Step three refers to bleeding and aims to stop blood supply to all regions of the brain and thus ensure death. It is done by sectioning both axillary arteries, following incision of the skin and blubber along the ventral midline from the mandibular symphysis to the umbilicus or to the pelvis (this incision being the first step of the skinning process).

The three-step process was included in the 'Conditions of License' for the Canadian harp seal hunt in spring 2009, and the Canadian Marine Mammal Regulations were subsequently amended to this effect, with the additional regulation that the bleeding proceed for at least 1 min before the seal could be skinned (Anonymous 2010). When using a hakapik, it should be possible for the sealer to carry out step two immediately after step one in all instances. Conversely, because the use of a rifle implies a long distance between the hunter and the seal and thus precludes immediate access to the animal, it is currently required by the Conditions of License to observe the animal for 'directed movements' (ie any co-ordinated movement of the head and/or flippers, including escape behaviour) after the first shot and, if such movements are observed, to immediately shoot the animal again before shooting another seal (Commercial Seal Conditions #7388, L Yetman, DFO, personal communication 2010).

In 2009, motivated by animal welfare concerns, the European Union passed a regulation to ban the trading of seal products within its territory, with the aim of ensuring that products derived from seals hunted for commercial purposes are no longer found on the European market (Europa 2009). However, this will probably not lead to cessation of seal-hunting activities as parallel markets, such as those in Asia, will likely be targeted more earnestly than in the past. Continuous effort to monitor and study the conduct of seal-hunting practices is therefore important in order to further enhance their performance from a welfare perspective. So far, there has been very limited detailed information on the practice of seal hunts anywhere in the world. In particular, EFSA (2007) pointed out the lack of continuity of evidence (uninterrupted observation of an animal from the time that it is first struck to the time that it is confirmed to be irreversibly unconscious or dead) in observations included in all recent studies that have purported to provide objective documentation of these hunts. This article reports the results of observations by the authors carried out since 2005 during the Canadian harp seal hunt both in the Gulf and at the Front that provide further information on various critical elements of the practice of the Canadian harp seal hunt.

Materials and methods

Field studies

Information was collected during four seasons of observations by one or both authors, focusing on different parameters related to hunting practices during the hunt (Table 1).

Gulf of St Lawrence (2005)

Observations were made from a sealing vessel when more than 200 seals were killed over a period of 6 h, all of them with hakapiks and most of them within 20 m of the vessel. These included observations of the terminal behaviour of 63 seals selected opportunistically and sequentially as they became available to the observers during the course of the hunt. Information collected for each of these 63 seals included: number of blows from the hakapik, presence or absence of post mortem reflex movements (which, in seals, are characterised by lateral movements of the caudal portion of the body referred to as 'swimming reflex', and which may vary in amplitude anywhere from slight motions of the hind flippers to strong movements involving the entire caudal half of the body), and duration of these movements recorded with a stopwatch. The degree of damage to the skull was also determined by palpation of the calvarium through skin and blubber for most of the more than 200 seals brought onboard, although the exact number of skulls examined was not recorded; the calvarium was thus considered to be completely, partially or not crushed. Death, or at least deep unconsciousness, in these seals, was determined by the authors on the basis of cessation of respiration and either on verification by palpation through skin and blubber that the calvarium was completely crushed or on the absence of corneal (blinking) reflex. Twelve heads with an incompletely crushed calvarium based on palpation through skin and blubber were subsequently examined in detail at the Atlantic Veterinary College, University of Prince Edward Island, to evaluate the degree of fracture and displacement of the bones and the presence of lesions in the brain.

Front (2006)

During enforcement patrols by a vessel of the Canadian Coast Guard, a total of 22 sealing vessels were boarded by Fisheries' officers to verify their conformity to the Conditions of License and Marine Mammal Regulations. During one of these patrols, one of two outboard motorboats associated with a sealing vessel was found to only carry a rifle with ammunition of lower calibre (.22-long [5.6 mm] rimfire soft-point; 29 gr [1.9 g]; muzzle velocity, 1,038 ft s^{-1} [316 m s^{-1}]; muzzle energy, 67 ft-lb [91 J]) than allowed by the Marine Mammal Regulations. Out of the 13 seal

doi: 10.7120/09627286.21.4.445

Table 1 Parameters recorded during four seasons of observations of the harp seal hunt in the Gulf of St Lawrence (Gulf) and east of the province of Newfoundland and Labrador (Front).

Location and year	Number of animals observed	Parameters
Gulf (2005)	63	Number of blows from a hakapik
		Presence or absence of post mortem reflex movements, and their duration if present
	~200	Degree of damage to the skull (completely, partially, or not crushed)
Front (2006)	9	Extent of skull damage in seals killed with prohibited ammunition
Gulf (2008)	13	Difference in bleeding time (from severance of first axillary artery to cessation of steady bloodflow) between sections of one versus both axillary arteries
Front (2009)	280*	Stunning instrument used (.222-calibre ammunition, .223-calibre ammunition, hakapik)
		Location of seal when first struck (ice floe, water)
		Method of retrieval of the seal (on the ice by a sealer, from the vessel with a gaff)
		Time interval between steps one (stunning) and two (checking by skull palpation) of the three-step killing process
		Location of rifle shot in the body (head, neck, head/neck, trunk)
		Time from start of skin and blubber incision to severance of axillary arteries for bleeding
		Bleeding time (based on same criteria as in Gulf, 2008)
		Presence of blood in stomach

* Not all parameters could be recorded in all 280 seals.

carcases seized from this motorboat, the heads of nine seals whose skull did not appear severely damaged externally were collected for further examination at the Atlantic Veterinary College.

Gulf (2008)

A pilot trial to estimate bleeding time was conducted onboard a sealing vessel when seals were hunted using the hakapik. After steps one and two of the killing process had been completed, 13 seals were brought onboard where each was bled by severance of the axillary arteries, alternating systematically between only one and both arteries. Bleeding time was measured from the time that the first axillary artery was cut to the cessation of a steady flow of blood from one or both arteries. This bloodflow was typically pulsatile from the start, indicating a heart beat, and would stop to a trickle almost abruptly.

Front (2009)

Over a period of eight days, a total of 768 seals were killed by the crew of a sealing vessel, the great majority of them with a rifle and most often within a distance of less than 40 m. During that period, detailed observations of the terminal behaviour of 280 seals were made from the vessel. As in the Gulf in 2005, these 280 seals were selected opportunistically and sequentially as they became available to the observer during the course of the hunt.

The killing process could be followed completely in all of these seals from step one to step three (ie continuity of evidence in observations). Detailed information was collected on several parameters associated with this process, although this information could not be recorded for all parameters in all 280 seals: stunning instrument used (.222-calibre [5.7 mm] ammunition [centrefire soft-point; 50 gr (3.2 g); muzzle velocity, 3,476 ft s^{-1} (1,059 m s^{-1}); muzzle energy, 1,342 ft-lb (1,820 J)], .223-calibre [5.7 mm] ammunition [centrefire soft-point; 55 gr (3.6 g); muzzle velocity, 3,240 ft s^{-1} (990 m s^{-1}); muzzle energy, 1,282 ft-lb (1,738 J)], or hakapik), location of seal when first struck (ice floe or water), whether the animal was retrieved manually on the ice by a sealer or from the vessel with a gaff (a wooden pole with an iron hook) (either from an ice floe or from the water), time interval between steps one and two, location of shot in the body when a rifle was used (head [including snout and brain case], neck, head/neck [when both sites were damaged], body [trunk]), time to access the axillary arteries (from start of skin and blubber incision, which in most cases extended caudally to the pelvis, to first axillary artery cut), bleeding time (based on the same criteria as in the Gulf in 2008), and presence of blood in the stomach.

The exact interval between steps two and three was not measured. When a seal was retrieved from the vessel with a gaff and step two was performed on deck, step three followed immediately afterwards. However, when a seal was retrieved on the ice by a sealer, step two was performed immediately on the ice, but for safety considerations for the sealer the seal was brought on to the vessel's deck where step three was then performed immediately, and this interval was not measured.

https://doi.org/10.7120/09627286.21.4.445 Published online by Cambridge University Press

In addition, each seal was allowed to bleed for at least 1 min according to the Conditions of License, but the subsequent interval to the skinning process was not measured.

Because the sealers were required to crush the skull with a hakapik or club if they palpated an intact calvarium after the seal had been shot, it was not always possible to determine the original damage caused by the shot when the animal was retrieved on the ice. However, for seals that were retrieved onto the vessel with a gaff, it was possible for the observer to ascertain whether the animal was dead or at least deeply unconscious (by verifying cessation of respiration and absence of corneal reflex) and, if it was, to request the sealers to proceed immediately with the bleeding process; otherwise, the sealer was requested to crush the skull immediately with a hakapik or a club. For subsequent analysis, a 'poor welfare outcome' was identified when a seal showed some evidence of consciousness between steps one and two that would have required further action to complete step one but the latter was not carried out immediately.

Statistical analysis

Basic descriptive statistics (eg mean, 95% confidence interval [CI]) were obtained using the statistical package Stata IC 11.0 (StataCorp, College Station, TX, USA, 2009). For the 2008 study in the Gulf, the comparison between average bleeding times for one versus two severed arteries was tested using an exact permutation approach to account for the limited number of observations and on a log-scale to assume equal variance (Good 2006). This particular test was run using the open-source statistical software R project 2.11 (R Foundation for Statistical Computing, Vienna, Austria, www.R-project.org, 2010). For the 2009 study at the Front, a multivariable logistic regression was conducted to estimate the association between poor welfare outcome and factors associated with the killing process, and between bleeding time and these factors. The regressions were built and run into Stata IC 11.0. Datasets and commands are available for consultation upon request to the corresponding author.

Results

Gulf of St Lawrence (2005)

Among the 63 seals that were monitored closely of the more than 200 seals observed (all of which were killed by hakapik), the number of blows received varied between one and four (single blow: 11.1%; two blows: 38.1%; three blows: 38.1%; four blows: 12.7%). A swimming reflex was observed in 36 of 58 seals (62.1%) (5 missing observations); it lasted a mean of 9.1 s (CI: 6.8–11.5; range: 2-35) and was not considered strong in any of the carcases. Besides lateral movements of the caudal portion of the body, this reflex was also observed to include: tonic lateral contraction of the caudal portion of the body maintained for several (10–15) seconds, and flexion of the front flippers and of their phalanges (especially when soft tissues along the axillae were cut during the bleeding/skinning process). Often, the carcases tended to contract as they were handled.

All of the more than 200 seals collected (including the 63 seals that were monitored closely) were dead or at least deeply unconscious when brought onboard where they were bled. Examination of most of these animals (exact number not recorded) revealed a completely crushed skull in all but 12. Detailed examination at the Atlantic Veterinary College revealed that nine of these 12 skulls had multiple and severe fractures with displacement of the bony fragments and invariably including the floor of the cranial cavity. Two of the three remaining skulls had linear fractures, ie without displacement of the bony fragments, which were nonetheless considered severe and, in one case, involved the floor of the cranial cavity. The last skull had a crushed snout and a small bone fragment detached from the rostral (cranial) portion of the right frontal bone. The brain in these three seals had multiple meningeal haemorrhages, but little haemorrhage evident within the nervous parenchyma.

Front (2006)

Out of the 22 sealing vessels boarded by Fisheries' officers, three (13.6%) had onboard rifles with ammunition of lower calibre (.22-long) than allowed for killing seals according to the Marine Mammal Regulations. Of the nine skulls examined from seals that had been shot from an outboard motorboat with .22-long ammunition, seven had multiple fractures which, in five, involved the floor of the cranial cavity; in two of these skulls, the fractures affected mainly the frontal bones. One skull had a single depressed fracture confined to the right frontal bone, with no involvement of the floor of the cranial cavity. Moderate to marked meningeal haemorrhages were noted in these eight skulls. The last skull had no fracture and no meningeal haemorrhage; the rest of the carcase of this animal was not examined for evidence of traumatic injury.

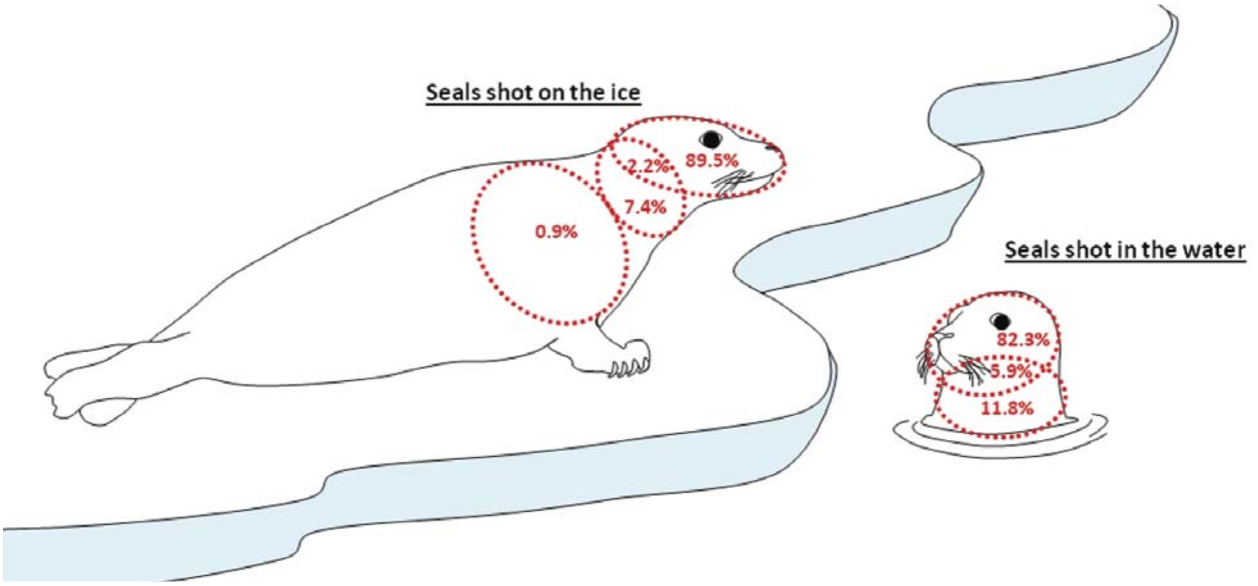
Gulf (2008)

Seven of 13 seals were bled by cutting both axillary arteries, and six by cutting only one of them. The mean bleeding time was 21.3 s (CI: 14.7–27.9; range: 14–35) when the two arteries were cut and 50.3 s (CI: 26.7–74.0; range: 12–75) when one artery was cut. The difference between these two means was significant according to the non-parametric permutation approach test ($P = 0.027$).

Front (2009)

None of the seals observed from the vessel was shot and subsequently lost (ie not brought onboard the vessel) during the eight days of the hunt. Of the 280 seals from which detailed information was collected, only two were killed with a hakapik. A .223-calibre ammunition was used for 186 seals, a .222-calibre ammunition for 88 seals, and the calibre was not recorded in four seals; no difference in the severity of trauma caused by these two types of ammunition was apparent. A total of 254 seals (91.4%) were shot on the ice while 24 (8.6%) were shot in the water; all seals shot in the water floated. A total of 120 seals were retrieved by a sealer on the ice (including the two animals killed with a hakapik) (52.6%), and 108 seals were retrieved with a gaff from the vessel (47.4%); the manner of retrieval was not recorded in the remaining 52 seals. Among the 278 seals shot with a rifle, single seals were shot and retrieved indi-

Figure 2



Percentage of entry wounds in the head, neck, and chest of harp seals shot from a vessel either on the ice or in the water at the Front, east of the province of Newfoundland and Labrador, in 2009. A total of 228 and 17 observations were recorded for ice and water, respectively. The overlap between the head and neck areas refers to damage involving both sites.

vidually on 254 occasions (91.4%), two seals were shot consecutively before being retrieved on nine occasions, and three seals were shot consecutively before being retrieved on two occasions. According to the two gunners onboard, a maximum of five seals were shot consecutively on one occasion. Seals shot consecutively before being retrieved were often, but not always, on the same ice floe. Twelve of the 278 seals were shot twice (4.32%), and one seal was shot three times (0.36%).

The original site of injury could be determined in a total of 245 seals, including 228 shot on the ice and 17 shot in the water. The head was hit in 218 seals (89%); this included at least 14 animals (6.4% of the 218 seals) in which the bullet had destroyed the base of the skull, leaving the calvarium more or less intact. The neck was hit in 25 seals (10.2%), including six in which the occipital region of the skull was also fractured. The cranial thoracic region of the body was hit in two seals (0.8%). Although the number of observations for seals shot in the water was small as compared to those for seals shot on the ice, no substantial difference was detected between these two groups in terms of the original site of injury caused by the bullet (Figure 2).

Only qualitative observations were made of what was interpreted as swimming reflex. This was considered strong in only three seals shot on the ice and in four seals shot in the water. The skull was severely damaged in four of these seven seals, thus indicating immediate death or loss of consciousness; one of these seals, shot in the water, kept turning in circles. The skull damage was not severe in at least two of the remaining three seals, and it is therefore possible that some of the early movements interpreted as swimming reflex in these seals were voluntary.

The time intervals between step one and step two of the killing process for different categories of seals and the time taken to complete step three, including bleeding time, are given in Table 2. Retrieval of seals from the vessel with a gaff was necessary when the animals had been shot in the water. Retrieval of seals on the ice with a gaff was also done if the ice floe appeared too unstable for the sealer to get on it or if the animal was near the edge of the ice floe when the vessel moved by. Retrieving seals with a gaff significantly increased the interval between step one (stunning) and step two (checking) by, on average, 26.5 s (Table 2).

Fourteen (5.0%) out of the 278 seals that were shot were considered to have had a poor welfare outcome; these animals were not killed immediately with the first shot and were not shot again before being retrieved, in at least 12 of these cases with a gaff from the vessel. Seven of these seals were shot on the ice, and seven in the water. The head was hit in 11 seals; the shot had hit the seal's snout in several of them while, in others, the mandible, one of the orbits, or the throat had been hit. The original site of injury caused by the bullet was not determined in the remaining three seals. Most of the seven seals shot on the ice did not move at first, having presumably been stunned by the shot. By the time they showed some evidence of consciousness, mainly through head movements, the vessel was already close to the ice floe, thus preventing the hunter from taking another shot for safety reasons. In one case, however, the seal's head movements may not have been seen by the gunner as he was

https://doi.org/10.7120/09627286.21.4.445 Published online by Cambridge University Press

Table 2 Parameters recorded during the harp seal hunt at the Front, east of the province of Newfoundland and Labrador, in 2009.

Parameters	Mean (± SD)	95% CI	Range	N
Interval between steps one and two				
All measures	63.5 (± 36.7)	58.9–68.0	16–307	254
Shot in the water	91.95 (± 54.1)[a]	66.6–117.3	43–244	20
Shot on the ice	61.0 (± 33.9)[a]	56.7–65.4	16–307	234
Poor welfare outcome	114.4 (± 54.8)[b]	79.6–149.2	58–244	12
Acceptable welfare outcome	60.9 (± 33.8)[b]	56.7–65.2	16–307	242
Retrieved using gaff	76.5 (± 43.9)[c]	69.2–83.8	28–307	90
Retrieved manually by sealer	50.0 (± 26.3)[c]	40.3–59.7	16–163	116
First part of step three (time from first soft tissue cut to first axillary artery cut)	10.9 (± 4.2)	10.1–11.8	5–26	90
Second part of step three (time from first axillary artery cut to end of steady bloodflow, ie bleeding time)	11.0 (± 4.1)	10.4–11.7	5–32	141

Steps one, two and three refer, respectively, to stunning (with regulation tools, in this case a rifle), palpation of the skull (in order to ensure that the brain is destroyed), and bleeding (done by sectioning both axillary arteries, following a skin incision along the ventral midline from the mandibular symphysis to the pelvis). All times are in seconds.
Superscripts differ significantly from each other at $P < 0.05$

also steering the vessel. In another case, the seal fell into the water after the first shot. In cases where seals were shot in the water but not killed immediately, it was not possible for the gunner to take another shot at the animal unless it lifted its head out of the water, since otherwise a bullet aimed at the head would have fragmented on impact with water.

A logistic regression was built to model the probability of a poor welfare outcome and identified seal location when first shot and time interval between steps one and two as the only significant explanatory factors. Shooting a seal in the water significantly increased the risk of getting a poor welfare outcome to 30% compared to 2.6% when shooting a seal on the ice ($P = 0.001$). This was associated with an increase in time interval between steps one and two when seals were shot in the water (extra 30.9 s on average), because it took longer to retrieve these animals. For any additional 10 s spent between stunning and checking, the risk of getting a poor welfare outcome significantly increased by 18% ($P = 0.003$). Although retrieving a seal from the vessel with a gaff was unconditionally associated with increasing the odds of getting a poor welfare outcome compared to retrieving the seal manually on the ice ($P = 0.025$), this association was confounded by the fact that all seals shot in the water were gaffed from the vessel.

The average bleeding time was 11.0 s (CI: 10.4–11.7; range: 5–32; n = 141) (Table 2). None of the factors studied (calibre of ammunition, location of seal when first struck, location of shot in the body, etc) had a significant unconditional association with bleeding time ($P > 0.05$).

A small quantity of blood, either fluid or clotted, was found in the stomach of seven (7.9%) of 88 seals examined specifically for this purpose, this blood having presumably been swallowed from the head injury. Two of these seals were among the 14 considered to have had a poor welfare outcome and thus could have swallowed blood when conscious or semi-conscious. Three seals were not seen moving on the ice after having been shot once; their skull was palpated when reached by the sealer who then proceeded to hit them with his hakapik, thus suggesting an incompletely crushed skull but not necessarily consciousness; the vertebral column of one of these seals was almost severed in the mid-cervical region. One seal shot once on the ice was gaffed from the vessel; its skull was crushed. The remaining seal was one of two killed with a hakapik; the sealer hit the animal twice, palpated its skull, and hit it immediately a third time.

Discussion

Approximately 70% of the Canadian harp seal hunt occurs at the Front (DFO 2010), where the rifle is the main hunting tool used. A major concern with the use of rifles is the potential loss of struck animals. In their study of seals hunted in Canadian and Greenland waters, Sjare and Stenson (2002) estimated the proportion of struck-and-lost at 0–1.9% in young harp seals killed on the ice and at 0–10% in those killed in the water during the commercial seal hunt and a substantially higher risk (0–4.9% on the ice, but 13.8–50% in the water) when animals older than one year were targeted after the breeding period. No seals were shot and lost during observations at the Front in 2009. This aspect of the hunt was not monitored during observations in the Gulf. At the time of year that they are shot, beaters typically have a thick blubber layer and are thus buoyant, as was observed repeatedly at the Front in 2009, whereas older animals in the spring have used a considerable proportion of their blubber and will readily sink in water when shot.

When used properly, the rifle and the hakapik appear to be efficient tools for completion of step one. During the 2005 study in the Gulf, the use of the hakapik had resulted in severe fractures of the skull in all but one of approximately 200 seals killed, with one to four blows being delivered to each seal. The calvarium of young harp seals has a homogeneous thickness averaging 2.6 mm (Caraguel, unpublished data). Thus, a single strong blow, properly placed to the centre of the calvarium, should be sufficient to cause severe fracture with loss of the integrity of the underlying cerebral cortex. However, sealers commonly gave a few more blows as only a few more seconds were needed to do so and thus ensure that the skull was completely fractured.

In the 2009 study, most of the rifle shots (approximately 90%) had struck the head, regardless of the seal's location (ice or water). The Marine Mammal Regulations (Anonymous 2010) specify the minimum velocity and energy of ammunition that can be used during the harp seal hunt; this is a means of increasing the probability of efficiently stunning or killing a seal through a process of tissue cavitation even if the bullet does not strike the brain case directly (Fackler 1996). Ammunition of lower calibre than the required minimum, such as the .22 long or the .22 magnum, may be sufficiently powerful to kill a harp seal beater instantly when the animal is hit in the brain case. However, as compared to ammunition of higher velocity and energy, it may be more likely to injure an animal than to kill it instantly when the brain case is not hit directly (Daoust & Cattet 2004). At the Front in 2006, some of the vessels boarded by Fisheries' officers (13.6%) carried such illegal ammunition onboard; in at least one of 13 seals killed with this ammunition, the skull damage was minimal.

Post mortem reflex movements occur commonly in animals following acute trauma to the head or neck and consist of a short period of tonic or clonic muscular contractions (see Grandin 2002). They likely result from the loss of normal inhibitory signals from the higher control centres of the brain, as seen in decerebrate animals (Guyton & Hall 2006). In seals, such movements are characterised by lateral motions, variable in amplitude, of the caudal portion of the body, referred to as 'swimming reflex' which can be misinterpreted as voluntary movements by inexperienced observers (EFSA 2007). Close observation of post mortem reflex movements during the 2005 study in the Gulf showed that they were frequent and could also involve the front flippers. This parallels the observations by Grandin (2002) of cattle stunned in slaughter plants; the author advised that "kicking of the limbs are often present and are not considered a sign of sensibility" and considered an animal to be insensible when its head was completely limp. We believe that this applies equally to seals and that the gunner should watch carefully for the occurrence of directed movements, including co-ordinated movements of the head, in a seal that has just been shot and, as is currently required by the Conditions of License, shoot the animal again immediately if such movements are seen.

The three-step process recommended by Smith *et al* (2005) for killing seals provides a simple set of standard guidelines, easily understandable by sealers and that can be easily incorporated into their normal hunting practices, for ensuring rapid death of the animals with minimum pain. According to Smith *et al* (2005), this methodology is consistent with the recommendations of the report of the American Veterinary Medical Association on euthanasia (AVMA 2007) and accepted abattoir practice. We believe that step two (checking — palpation of the calvarium through skin and blubber to ensure that it is crushed) is critical as a means of ensuring irreversible unconsciousness or death of the animal as quickly as possible after step one (stunning). Compared to verification of the absence of corneal reflex, which was previously required by the Marine Mammal Regulations to confirm death of the seal, palpation of the calvarium is easier to perform and interpret under field conditions.

Palpation of the skull was not done consistently by sealers in the Gulf in 2005. At that time it was a relatively new procedure and was not a requirement dictated by Conditions of License or Marine Mammal Regulations, but the corneal reflex was not practiced consistently either. Incorporation of palpation of the calvarium into the Marine Mammal Regulations (Anonymous 2010) should also help Fisheries' officers boarding sealing vessels to verify compliance with step two, through palpation of the skulls of seal carcases onboard, thus facilitating its enforcement.

Although a completely crushed calvarium ensures the absence of sensibility (through death or irreversible unconsciousness), an intact or only partially crushed calvarium on palpation through skin and blubber does not imply persistence of consciousness because it cannot rule out the possibility of other lesions that could have caused loss of consciousness or death by themselves, such as linear fractures of the calvarium (implying, at a minimum, severe concussion), multiple fractures of the base of the skull, brain contusion with meningeal and/or cerebral haemorrhage from the process of tissue cavitation following the impact of a bullet (Fackler 1996), or severance of the cervical portion of the vertebral column. These different types of lesions were observed in this study and by Daoust *et al* (2002), although the possibility that some of the animals involved may have been conscious or semi-conscious for a few seconds after step one could not be ruled out. Regardless, these observations do not diminish the importance of ensuring complete destruction of the calvarium as rapidly as possible after step one.

The purpose of step three (bleeding by severance of the axillary arteries) is to stop the supply of oxygen and glucose to brain tissue that may still be viable. This step cannot be compared directly with the exsanguination process used on livestock in slaughter plants. The latter is the method relied upon to kill the animal, whereas at the seal hunt step two is the method used to confirm that the animal is dead, whereas step three is used only as a precautionary measure. In this study, bleeding time was measured from the time that the first axillary artery was cut, to the cessation of a steady flow of blood from these arteries. This was considered to provide a good measure of the arrest of bloodflow at a pressure physiologically sufficient to supply oxygen and glucose to the brain, and it was the only practical method that could be used in the field. Severing the two axillary arteries instead of one significantly decreased the average bleeding time by more than half (21 versus 50 s) in seals killed with a hakapik in 2008. By comparison, the average bleeding time of seals killed with a rifle at the Front in 2009, following severance of the two axillary arteries, was half as long (11 s). By the time they were brought on to the vessel, most seals that had been shot had probably already lost a substantial amount of blood through their wound, which may explain their shorter average bleeding time. Subjectivity in assessing the end point of the bleeding time may also partly explain this difference. In adult sheep, severing the two carotid arteries and two jugular veins took, on average, 14 s to induce a loss of flash-evoked responsiveness in the electrocorticogram, whereas severing only one carotid artery plus one jugular vein took 70 s (Gregory & Wotton 1984). In domestic animals, the reported time to loss of brain function following exsanguination by severance of the carotid arteries and jugular veins at slaughter is influenced by the parameters used to determine loss of brain function and can vary considerably among species and between individual animals of the same species. The ranges published are narrower in goats (3–7 s) and sheep (5–22 s) than in cattle and poultry (5–60 s or more) (Anonymous 1995; Mellor *et al* 2009). The ballooning process or formation of false aneurysm in the severed end of carotid arteries observed in calves, but not in sheep, that might slow the rate of blood loss (Gregory *et al* 2006) was not observed in the axillary arteries of seals in this study. Regardless of its duration, step three of the recommended killing process remains essential to perform as an added precautionary measure to ensure death.

Blood was found in the stomach of a small proportion (8%) of seals examined, having presumably been swallowed from head wounds. The swallowing process becomes involuntary once liquid or a bolus of food enters the pharynx, and this reflex includes delivery of liquid or food along the oesophagus from the pharynx to the stomach (Guyton & Hall 2006). It is therefore conceivable that, in an animal that is irreversibly unconscious but not dead, blood accumulating in the mouth from fractures of the skull and/or snout would reach the pharynx and thus trigger a swallowing reflex, as was observed in some seals in the 2009 study at the Front. This indicates that the presence of blood in the stomach of a dead seal does not necessarily represent evidence of poor welfare.

Because the rifle is a tool commonly used to kill wild animals, it may be more readily acceptable to the public than the hakapik, which is most often the tool shown in photographs of the Canadian harp seal hunt by its opponents. Yet, neither tool offers a complete guarantee of instant death, and the hakapik offers the distinct advantage over the rifle that the sealer stands beside the animal and can perform step two of the three-step process immediately after step one. Because of the variable ice conditions at the hunt, seals killed with a rifle shot may be in the water or on ice floes too small to allow a sealer to stand on. In such cases, a gaff must be used to retrieve the animal, and this may raise welfare concerns since verification of the animal's death or state of irreversible unconsciousness has not yet been performed with step two of the three-step process and, therefore, conscious or partly conscious animals may be gaffed. Whereas shooting seals in the water can be avoided, it is not always evident to a gunner shooting a seal on the ice from a long distance whether the ice floe on which the seal rests is thick enough to support the weight of a sealer and thus allow him to retrieve the animal manually.

During the 2009 observations at the Front, 5% of the 280 seals observed closely were considered to have had a poor welfare outcome, based on the fact that they still appeared to be conscious after step one but that further action to complete this step was not carried out immediately. The average interval between step one and step two in these seals was significantly longer than in the remaining seals (Table 2). These animals may or may not have been fully conscious throughout this interval, depending in part on the amount of blood lost after the rifle shot and on whether or not the impact of the bullet had been sufficient to cause brain concussion. This proportion of seals considered to have had a poor welfare outcome is comparable to, or lower than, that in other types of hunt. For instance, Nixon *et al* (2001) estimated that 12.5% of white-tailed deer (*Odocoileus virginianus*) were lost to wounding by shotgun hunters in the state of Illinois, USA. In North America, 16–44% of the 10–11 million waterfowl harvested annually by sportsmen are estimated to be injured or crippled, although many injured birds are thought to recover from their wounds (Hicklin & Barrow 2004). In Scotland, Urquhart and McKendrick (2003) examined the wound location in 943 carcases of wild red deer (*Cervus elaphus*) killed by hunters and estimated that 14.3% of these animals had required two or more shots to be killed. In South Africa, Lewis *et al* (1997) reported that 6.3% of impala (*Aepyceros melampus*) shot in the head at night (with the help of spotlights) were wounded prior to being killed with a subsequent shot; for these animals, the mean time between wounding and death was 30 s (range: 4.8–117 s). By comparison, the success rate (ie no return to sensibility) for stunning cattle in the best slaughter plants under the best conditions averages 97–98%, but in one study conducted in the United Kingdom unsuccessful stunning varied from 1.7% of 628 cows to 6.6% of 1,284 steer and heifers up to 53.1% of 32 bulls (reviewed in: Appelt & Sperry 2007).

The proportion of seals with a poor welfare outcome significantly increased by 11-fold for seals that were shot in the water because opportunities to shoot the animal again were limited unless it raised its head out of the water. Moreover, the only means of bringing the animal onboard was with a gaff, and use of this tool on a potentially conscious or semi-conscious animal represents an additional poor welfare outcome. Less than 10% of the seals observed at the Front in 2009 were shot in the water, but this proportion may vary according to the age of the beaters (the older ones spending more time in water) and the ice conditions and thus the time of year and location of the hunt. These observations should raise questions about the potential welfare impact of shooting seals in water. Interestingly, hunting seals that are in the water is prohibited in the commercial hunt of harp seals in Norway (EFSA 2007).

Promoting acceptance and implementation of good welfare practices should be done through information to user groups based on objective research, delivered in a respectful manner, and supported by relevant legislation. There are approximately 12,500 commercial sealers (and up to 2,200 sealing vessels) spread among the provinces of Newfoundland and Labrador, Québec, and Nova Scotia, with the majority residing in Newfoundland and Labrador, although the number of sealers participating in the hunt varies annually according to weather conditions and the pelt value (DFO 2010). Between 2009 and 2011, several information workshops were offered to members of the sealing industry in these three provinces, during which the anatomical and physiological bases behind the three-step process and the associated Marine Mammal Regulations were explained. Approximately 4,000 (32%) sealers attended these workshops, which are not yet mandatory, and more than 12,000 posters of the three-step process (Figure 1) were distributed to these participants and by mail to other sealers (Mark Dolomount [Professional Fish Harvesters Certification Board, Newfoundland and Labrador], Sylvette Leblanc [Fisheries and Oceans Canada, Îles-de-la-Madeleine, Québec] and Robert Courtney [North of Smokey Fishermen's Association, Nova Scotia], personal communications 2011).

Animal welfare implications and conclusion

This article does not purport to provide a full representative picture of the Canadian harp seal hunt, since the results of the observations reported here were subject to a number of logistical constraints and could have been confounded by many factors that were difficult to control, such as the knowledge and attitude of the crew onboard, weather conditions, the relative abundance of seals and thus the rapidity with which the hunt was conducted, and the presence of observers.

Instead, the purpose of this study was to obtain a better practical knowledge of the different aspects of the hunt in order to identify its strengths and weaknesses, better understand its challenges, and promote continued improvements in its practice through ongoing monitoring. First-hand experience of the hunt by veterinarians interested in promoting welfare allows them to design pragmatic recommendations and to better guide government-managing authorities in developing appropriate regulations. Ultimately, however, progress is best achieved through improvement in the attitude of those exploiting wildlife resources.

Acknowledgements

We are very grateful to Eldred Woodford, Henri-Fred Poirier and Denis Éloquin, captains of the Harbour Mist '96, the Bel Espoir and the Jean Mathieu, respectively, for their hospitality and their trust, without which this work would have been impossible. We also wish to thank the managers and officers of Fisheries and Oceans Canada in Newfoundland and les Îles-de-la-Madeleine who provided the necessary permits and logistical support. We are indebted to Dr Michael Cockram for his many useful comments on an earlier draft of this manuscript and to Dr Raphael Vanderstichel for his analytical advice.

References

American Veterinary Medical Association (AVMA) 2007 *AVMA Guidelines on Euthanasia* pp 36. http://www.avma.org/issues/animal_welfare/euthanasia.pdf

Anonymous 1995 The Welfare of Animals (Slaughter or Killing) Regulations 1995. *Statutory Instrument 1995 No 731. Great Britain.* http://www.opsi.gov.uk/si/si1995/Uksi_19950731_en_13.htm#sdiv6. Schedule 6

Anonymous 2010 Marine Mammal Regulations SOR/93-56. *Minister of Justice, Canada* pp 29. http://laws.justice.gc.ca/en/F-14/SOR-93-56/index.html

Appelt M and Sperry J 2007 Stunning and killing cattle humanely and reliably in emergency situations. A comparison between a stunning-only and a stunning and pithing protocol. *Canadian Veterinary Journal 48*: 529-534

Burdon RL, Gripper J, Longair JA, Robinson I, Ruehlmann D and Fielder J 2001 *Veterinary Report Canadian commercial seal hunt Prince Edward Island, March 2001* pp 36. http://www.ifaw.org/Publications/Program_Publications/Seals/asset_upload_file693_12090.pdf

Daoust P-Y and Cattet M 2004 Consideration of the use of the .22 caliber rimfire Winchester magnum cartridge for instant killing of young harp seals (*Pagophilus groenlandicus*). *Department of Fisheries and Oceans Canadian Science Advisory Secretariat Research Document* 2004/072 p 37. http://www.dfo-mpo.gc.ca/ CSAS/Csas/DocREC/2004/RES2004_072_B.pdf

Daoust P-Y, Crook A, Bollinger TK, Campbell KG and Wong J 2002 Animal welfare and the harp seal hunt in Atlantic Canada. *Canadian Veterinary Journal 43*: 687-694

Department of Fisheries and Oceans Canada (DFO) 2010 *Seals and sealing in Canada.* http://www.dfo-mpo.gc.ca/fm-gp/seal-phoque/index-eng.htm

Europa 2009 *Environment: Commission welcomes the agreement reached on seal product ban.* http://europa.eu/rapid/pressReleasesAction.do?reference=IP/09/698&format=HTML&aged=0&language=EN&guiLanguage=en

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. http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178671319178.htm

Fackler ML 1996 Gunshot wound review. *Annals of Emergency Medicine 28*: 194-203. http://dx.doi.org/10.1016/S0196-0644(96)70062-8

Fur Institute of Canada (FIC) 2010 *Fact sheet on seals and sealing.* http://www.fur.ca/index-e/news/news.asp?action=sealing&newsitem=fact-sheet

Good PI 2006 Comparing two populations. In: Good PI (ed) *Resampling Methods: A Practical Guide to Data Analysis* pp 31-60. Birkhäuser: Boston, USA

Grandin T 2002 Return-to-sensibility problems after penetrating captive bolt stunning of cattle in commercial beef slaughter plants. *Journal of the American Veterinary Medical Association 221*: 1258-1261. http://dx.doi.org/10.2460/javma.2002.221.1258

Gregory NG and Wotton SB 1984 Sheep slaughtering procedures. 2. Time to loss of brain responsiveness after exsanguination or cardiac-arrest. *British Veterinary Journal 140*: 354-360. http://dx.doi.org/10.1016/0007-1935(84)90126-X

Gregory NG, Shaw FD, Whitford JC and Patterson-Kane JC 2006 Prevalence of ballooning of the severed carotid arteries at slaughter in cattle, calves and sheep. *Meat Science 74*: 655-657. http://dx.doi.org/10.1016/j.meatsci.2006.05.021

Guyton AC and Hall JE 2006 *Textbook of Medical Physiology, Eleventh Edition*. Elsevier Inc: Philadelphia, USA

Hicklin PW and Barrow WR 2004 The incidence of embedded shot in waterfowl in Atlantic Canada and Hudson Strait. *Waterbirds 27*: 41-45. http://dx.doi.org/10.1675/1524-4695(2004)027[0041:TIOESI]2.0.CO;2

Humane Society of the United States (HSUS) 2010 *About the Canadian seal hunt*. http://www.hsus.org/marine_mammals/protect_seals/about_the_canadian_seal_hunt/

International Fund for Animal Welfare (IFAW) 2010 *Seal hunt update*. http://www.ifaw.org/ifaw_canada_english/

Lewis AR, Pinchin AM and Kestin SC 1997 Welfare implications of the night shooting of wild impala (*Aepyceros melampus*). *Animal Welfare 6*: 123-131

Mellor DJ, Gibson TJ and Johnson CB 2009 A re-evaluation of the need to stun calves prior to slaughter by ventral-neck incision: an introductory review. *New Zealand Veterinary Journal 57*: 74-76. http://dx.doi.org/10.1080/00480169.2009.36881

Nixon CM, Hansen LP, Brewer PA, Chelsvig JE, Esker TL, Etter D, Sullivan JB, Koerkenmeier RG and Mankin PC 2001 Survival of white-tailed deer in intensively farmed areas of Illinois. *Canadian Journal of Zoology 79*: 581-588. http://dx.doi.org/10.1139/z01-010

North Atlantic Marine Mammal Commission (NAMMCO) 2009 *Report of the NAMMCO expert Group on best practices in the hunting and killing of seals. Copenhagen, Denmark* pp 30. http://www.nammco.no/webcronize/images/Nammco/930.pdf

Sjare B and Stenson GB 2002 Estimating struck and loss rates for harp seals (*Pagophilus groenlandicus*) in the northwest Atlantic. *Marine Mammal Science 18*: 710-720. http://dx.doi.org/10.1111/j.1748-7692.2002.tb01068.x

Smith B, Caraguel C, Crook A, Daoust P-Y, Dunn JL, Lair S, Longair A, Philippa J, Routh A and Tuttle A 2005 Improving humane practice in the Canadian harp seal hunt. *A report of the Independent Veterinarians' Working Group on the Canadian harp seal hunt. BL Smith Groupwork* pp 26. http://www.ccwhc.ca/ivwg.php

Stenson GB 2009 Total removals of Northwest Atlantic Harp Seals (*Pagophilus groenlandicus*) 1952-2009. *Department of Fisheries and Oceans Canadian Science Advisory Secretariat Research Document 2009/112* p 34. http://www.dfo-mpo.gc.ca/CSAS/Csas/publications/resdocs-docrech/2009/2009_112_e.pdf

Urquhart KA and McKendrick IJ 2003 Survey of permanent wound tracts in the carcases of culled wild red deer in Scotland. *The Veterinary Record 152*: 497-501. http://dx.doi.org/10.1136/vr.152.16.497