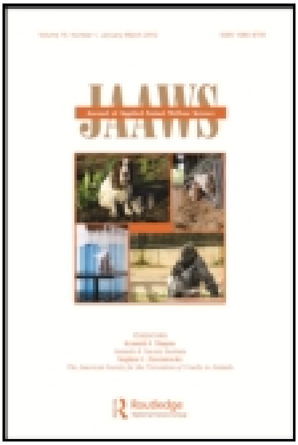

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A Veterinary and Behavioral Analysis of Dolphin Killing Methods Currently Used in the "Drive Hunt" in Taiji, Japan

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Annually in Japanese waters, small cetaceans are killed in "drive hunts" with quotas set by the government of Japan. The Taiji Fishing Cooperative in Japan has published the details of a new killing method that involves cutting (transecting) the spinal cord and purports to reduce time to death. The method involves the repeated insertion of a metal rod followed by the plugging of the wound to prevent blood loss into the water. To date, a paucity of data exists regarding these methods utilized in the drive hunts. Our veterinary and behavioral analysis of video documentation of this method indicates that it does not immediately lead to death and that the time to death data provided in the description of the method, based on termination of breathing and movement, is not supported by the available video data. The method employed causes damage to the vertebral blood vessels and the vascular rete from insertion of the rod that will lead to significant hemorrhage, but this alone would not produce a rapid death in a large mammal of this type. The method induces

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paraplegia (paralysis of the body) and death through trauma and gradual blood loss. This killing method does not conform to the recognized requirement for "immediate insensibility" and would not be tolerated or permitted in any regulated slaughterhouse process in the developed world.

Keywords: *Taiji, Japan, dolphin, killing methods*

It is estimated that each year within Japanese waters up to 22,000 small whales, dolphins, and porpoises (known collectively as "small cetaceans") are killed in hunts that involve a range of techniques. Most of these small cetaceans are killed in a direct hunt for Dall's porpoises, but others are taken in a particular category of hunt known as "drive hunts" or the drive fishery (Kasuya, 2007; National Research Institute of Far Seas Fisheries, 2009). The main species taken in the drive hunts include common bottlenose dolphins (*Tursiops truncatus*), striped dolphins (*Stenella coeruleoalba*), Risso's dolphins (*Grampus griseus*), or short-finned pilot whales (*Globicephala macrorhynchus*). These small cetaceans are herded at sea—using small fishing vessels, with underwater noise (this is referred to as the Oikomi method; Brownell, Nowacek, & Ralls, 2008; Ohsumi, 1972)—and driven into harbors or shallow coves that have been netted off and where they are then killed.

The Government of Japan sets yearly quotas that allow for more than 2,000 dolphins and small whales to be killed in the drive hunts (Kasuya, 2007). These hunts are conducted for several reasons: as a means of pest control resulting from the perception that dolphins compete with local fisheries (Brownell et al., 2008; Morisette, Christensen, & Pauly, 2012), to obtain meat for local human consumption, and to procure live dolphins for marine parks and swim-with-the-dolphin programs in Japan and internationally. After the captured dolphins are rounded up and some selected for marine parks, the remaining individuals are then killed or occasionally released (Vail & Risch, 2006).

To date, little data on the animal welfare aspects of these drive hunts have been made available by the Government of Japan and thus, an independent assessment of whether the killing techniques used during these hunts are humane has not been possible. In 2000, fishermen began using a new killing method that Iwasaki and Kai (2010) reported is an improved and more humane method of killing. Until the introduction of this new method, the primary tools used for killing were knives and spears, targeted at various parts of the dolphin or whale body. According to data published on the website of the Taiji Fishing Cooperative (Iwasaki & Kai, 2010) this new killing method—which is intended to sever the spinal cord at the junction between the occiput and first cervical vertebra—was tested from December 2000 to February 2001. When the hunt was carried out in 2008, the technique was applied comprehensively to the killing of striped dolphins, and from December 2009, a wooden wedge was driven into the wound to control bleeding and to prevent blood from polluting the water (Iwasaki & Kai, 2010).

The drive hunts have drawn a great deal of professional and public interest and concern internationally, particularly in relation to the killing methods used (Hemmi, 2011; Reiss, 2010). (A Scientists' Statement was initiated in 2005 and signed by hundreds of international marine mammal scientists, veterinarians, and conservation biologists imploring the Government of Japan to put an end to the brutal treatment and slaughter of dolphins [including small-toothed whales] in the Japanese drive hunts.) Similar killing methods in development over the past 10 years have also been utilized within the Faroe Island pilot whale drive hunts (Faroese Ministry of Foreign Affairs, Uttanrikisradid, 2012; Olsen, 1999) known as the grindadrap (or grinds), and they have informed the methods utilized in the Japanese dolphin drive hunts (Iwasaki & Kai, 2010).

Reports that the new technique could reduce the time to death (TTD; Iwasaki & Kai, 2010) in these hunts warrant independent examination, and this claim is examined in this article. However, because TTD data and other statistics associated with the welfare of the individuals killed are not readily available, we examined film footage collected independently during a recent hunt. Here, a veterinary and behavioral analysis of data are presented that were collected during drive hunts conducted in January 2011 in the Japanese coastal town of Taiji, Japan. We compared our data and analysis with previously published data by Iwasaki and Kai (2010) describing the current killing method and the claim of improved efficacy and a more humane method based on TTD of the animals. Independent observers in Taiji documented this killing method as early as the fall of 2008.

Excerpts from an English translation of Iwasaki and Kai's (2010) original *Improved Method of Killing Dolphins in the Drive Fishery in Taiji, Wakayama Prefecture* are presented here. (The English translation of the original document was provided by Chisa Hidaka, MD.) Iwasaki and Kai stated the following:

> Purpose: In the "drive hunt" (Oikomi) in Taiji, dolphins were killed using a spear-type instrument (the conventional method, see below) and were harvested for food. However, in the Faroe Islands, methods to cut around the blood vessel plexus and cervical spine have been developed [the spinal transaction method (Olsen, 1999)]. This method results in a shorter harvest time, and is thought to improve worker safety. We report the results of the implementation of this method.

In their Material and Methods section, Iwasaki and Kai (2010) stated the following:

> From December 2000 to February 2001, the spinal cord cutting method was applied to nine Risso's dolphins, four striped dolphins, and two spotted dolphins and one pilot whale. Harvest times were recorded, using the conventional method of killing

> for a striped dolphin as a control. The criterion for the time of death was the termination of movement and breathing as observed by the worker (fisherman). In December 2008, the technique was applied comprehensively to the killing of striped dolphins. In December 2009, control of bleeding was attempted by driving a wooden wedge into the wound.

In their Results section, Iwasaki and Kai (2010) claimed, “The spinal transection method reduced the time to death.” They presented data in a table (Table 1) that provides the TTD (in seconds) for different species utilizing different killing methods, including conventional (spear) and newer transection technique. Iwasaki and Kai also presented images showing the use of the rod and “the control of bleeding by using the wedge” (Figure 1). They described the appropriate cutting location as follows:

> Taking the width of a fist to be approximately 10 cm, and based on photographs of the events, the appropriate cutting guide was considered to be behind the blowhole by one fist width for striped and spotted dolphins (10 cm), one and a half fist widths for Risso’s dolphins (15 cm), and 2 fist widths for the larger pilot whale (20 cm).

Iwasaki and Kai (2010) also reported that other methods are employed in the killing:

FIGURE 1 The use of the wooden plug in the killing process. This image shows the use of the wooden plug inserted in the wound after the metal rod is removed. This is done to prevent the blood from escaping the body. This technique will actually prolong time to death (color figure available online).

TABLE 1
Video Analysis of the Timing of Events During a Dolphin Drive Hunt Using the New Killing Device and Procedure

Video Time Code(s)	*Duration(s)*	*Event*	*Comment*
—	Prolonged (video does not capture start and end of this event)	Dolphins are secured by their tail flukes and dragged by boat	These animals are unable to swim effectively and so are being repeatedly pushed under the water by the action of dragging and by pressure of other animals tied up with them. The inability to control the timing of breathing (and enforced submersion) is causing profound distress and restricted escape movements in these animals. Some will be experiencing aspects of "forced asphyxiation" due to their inability to reach to the surface to breathe.
02:37	Start	Dolphin 1—first forceful insertion of metal rod	The rod pushes into tissues rapidly. It appears unlikely that this first "push" penetrates bone. Severing the spinal cord at the first attempt (as claimed in the description of the method) is not achieved at this first insertion.
02:40 to 02:44	3 to 7	Animal moves strongly and operative redirects and reforces the rod at multiple angles repeatedly pushing it into the animal	The animal responds strongly to the first insertion of the rod and the operatives have to hold the animal while the operative with the rod redirects the rod and repeatedly pushes it into the animal.
02:44 to 02:48	7 to 11	The rod appears to hit hard (bony) obstruction and the operative pushes the rod in at different angles but does not achieve deep insertion of the rod	At this point it appears likely that the rod makes first contact with the vertebral bones of the cervical (neck) vertebrae. The rod clearly requires very significant force to push further into the tissues at this time. At the end of a period of pushing, it is possible that the cervical vertebrae have now been damaged sufficiently to allow the spinal cord to also be damaged by the rod.
02:50	13	Insertion of the wooden peg	The rod is withdrawn and a wooden peg inserted. This is intended to "reduce pollution of the sea" with blood. If "rapid bleed-out" (as is required in animals slaughtered and killed in a slaughterhouse) is part of the killing process, then blocking the bleed-out passage may slow down bleed-out and prolong the time to death.* [11,12]
03:17	40	Animal with wooden peg in puncture site visible	The animal is stationary at this time, but the wooden peg is clearly visible.

(*continued*)

TABLE 1
(*Continued*)

Video Time Code(s)	*Duration(s)*	*Event*	*Comment*
03:48	71	Small vertical head movements	The animal starts to make regular rhythmic vertical head movements.
04:10	93	Animal stationary	The animal stops moving.
04:30	113	Slow rotational movements of the body seen	The animal now makes slow regular rotational movements.
04:33	116	Vertical head movements	The animal makes regular rhythmic vertical head movements.
04:39	122	Vertical head tremor	The head movements become rapid and repetitive.
05:07	150	Major body movements start	The entire body now makes large-scale regular repetitive movements.
05:24	167	Major body movements continue with thrashing fluke causing splashing	The repetitive movements now include the whole body and the tail fluke and this thrashing throws up considerable spray. Because this spray is interfering with the operative (who is now using the rod on another animal), another operative puts a rope around the thrashing animal's tail fluke. Both operatives are not showing attention to the movements of the animal other than to remove the animal from the "work area."
05:25	168	Operative secures thrashing fluke and drags animal away from other operative	The powerfully moving animal is dragged out of the "work area"—but the tail fluke movements bring the animal back toward the operative, who is using the rod on another animal.*
05:29	172	Vigorous thrashing of the flukes	
06:02	205	Animal motionless	The animal now becomes motionless.
06:36	239	Mouth visible and making small regular and coordinated opening and closing movements	Regular small movements of the mouth are visible.*
06:51	254 s (4 min 14 s)	Opening and closing movements of mouth continue—end of available video material	Regular small movements of the mouth are visible.[a]

[a]If the stated criteria for establishing time to death (termination of movement and breathing) are applied, then this animal has not yet achieved death.

> Placing a vinyl sheet over the rocks facilitated the transport of the striped dolphins to the killing area and also the full application of the spinal transection technique. In addition, by driving a wedge into the cut, bleeding was controlled. Exsanguination occurred 10 to 30 minutes later at the time of gutting, and this did not affect the quality of the meat (for consumption).

Iwasaki and Kai (2010) concluded,

> Harvest time was shortened, improving worker safety. Bleeding was controlled by the wedge, and this opens up the possibility of commercial utilization of the blood and prevents pollution of the sea with blood. The individual who developed the spinal cord transection technique has pointed out that prevention of bleeding and internal retention of blood using the wedge risks prolongation of the time to death. An additional review to compare time to death with the Faroe Islands is required.

Based on this minimal data, Iwasaki and Kai (2010) claimed that the new method is more humane. This claim is based on a shorter TTD recorded in four species where the spinal transection technique was utilized, compared with only one instance where the conventional spear method of killing was used on a striped dolphin. TTD was defined by Iwasaki and Kai as the termination of movement and breathing.

METHOD

We analyzed videotape footage of a dolphin drive hunt involving striped dolphins (*Stenella coeruleoalba*) conducted in Taiji, Japan, in January 2011 (for the video, see http://youtu.be/dzOw5IBmqWk). The video material was systematically analyzed by one of the authors (A. B.), a veterinarian. The video footage used in this analysis was recorded covertly and provided by an independent video journalist. Events and event intervals were documented, tabulated, and timed using the time base available on the video material. We also compared their observations and analysis with the data and assessment reported in Iwasaki and Kai (2010).

RESULTS

The results of our veterinary and behavioral analysis of the video documentation of the killing method used are presented in the table (Table 1). The timing of events and the method of killing are described in detail in relation to dolphin anatomy and the physiological and behavioral responses during this process.

For illustration and clarification purposes, still images derived from the video material were used to overlay outlines of cetacean anatomical structures in relation to use of the rod and wooden plug (Figure 1, Figure 2). The images are still photographs taken from the video footage of the drive hunt that we analyzed and referenced to the written description of the killing method described in Iwasaki and Kai (2010).

Using external landmarks (rostrum, mouth, eye, blowhole, dorsal, and pectoral fins) it was possible to locate with some accuracy the path and track of the insertion of the rod (Figure 2). The rod appears to enter the skin in the midline of the animal and about 10 cm caudal to (behind) the blowhole. The ease with which the rod penetrates the tissues on the first push suggests that it passes through only soft tissues at this time. The soft tissues in this location, which is immediately caudal to the skull, would be the skin, blubber, musculature of the dorsum, and the suspension of the skull, some of which are associated with the cervical vertebrae and some of which are the very large and powerful (swimming) muscles of the dorsal region including the longissimus and multifidus muscles (Rommel & Lowenstein, 2001). The tissues in this area will contain a large amount of collagen, as the muscles that attach to the skull convert from muscle to tendon to allow attachment to the bone.

In this region immediately caudal to the skull will be portions of the rete mirabile—a specific adaptation of the vascular system of marine mammals that

FIGURE 2 Dolphin skeletal and soft tissue and point of insertion of the metal rod. This image shows the overlay of skeletal and soft tissues on a striped dolphin (*Stenella coeruleoalba*). This overlay shows the relationship between the skeletal and soft tissues compared with the external anatomical features (eye, mouth, blowhole, dorsal fin, and pectoral fin) and with the course and positioning of the metal rod (color figure available online).

appears to function to buffer pressure (and perhaps pH and oxygenation levels) in blood circulation to the brain (Lin, Lin, & Chou, 1998; Melnikov, 1986; Nagel, Morgane, McFarlan, & Galliano, 1968). Damage to the vertebral blood vessel and the vascular rete will lead to significant hemorrhage, but this alone would not produce a rapid death in a large mammal (American Veterinary Medical Association [AVMA], 2007; Anil, McKinstry, Gregory, Wotton, & Symonds, 1995; Daly, Kalweit, & Ellendorf, 1988). In the case of the use of the rod, after the operative has used the rod to cause tissue damage, a wooden peg is inserted into the hole created by the rod (see Figure 1). It is likely that this will impede bleeding, so it is also possible that this process prolongs the time for the animal to die.

The bony structures in the area that are likely to be penetrated by the rod will be the spinous neural dorsal (upward pointing) processes of the cervical vertebra and the bony bodies of the first and second cervical vertebrae (C1, C2). Cetaceans have well-developed neural processes on their vertebrae as attachments for the powerful epaxial muscles that form part of the swimming musculature. The cervical vertebrae join the skull with a bony junction at the occipital bone via the occipital condyle (the joint with the vertebrae), and in this area the spinal nerves and spinal cord emerge from the skull and enter the spinal canal. The spinal cord is well protected within the bony bodies of the cervical vertebrae and runs in a bony tunnel with the dorsal and lateral processes of the vertebrae protecting it on the upper (dorsal) side and the vertebral body protecting it on the lower (ventral) surface.

To penetrate the spinal canal, the rod would have to accurately enter the space between vertebrae (which provide overlapping bony protections) or damage the cervical vertebral bone sufficiently to allow spinal cord severance. Either of these processes, if carried out with a rod after passage through muscle and other tissues, is unlikely to be applied with a high degree of precision. It appears from the video available and from a consideration of the anatomy that the approach is to push the rod hard and repeatedly and eventually there will be very significant damage and trauma and this will (eventually but not immediately) lead to the death of the animal.

DISCUSSION

The results of the analysis of the killing methods utilized in the Taiji dolphin drive hunt are in sharp contrast with and contradictory to the descriptions and conclusions presented in Iwasaki and Kai (2010). The following points are raised to indicate the significant concerns with this killing method:

1. After being driven into a restricted area and confined, the animals are sometimes tethered to boats by their tail flukes and pulled to the killing

area. The video shows animals who are unable to swim effectively and who are being repeatedly pushed under the water by the action of dragging and by pressure of other animals tied up alongside the boat. The inability to control the timing of breathing (due to forced submersion) may cause distress, and escape movements are evident in these animals. It is likely that some dolphins will be experiencing aspects of *forced asphyxiation* due to their inability to control whether they are at the surface or forced underwater. Dolphins do have the capacity to breath hold during planned diving activity and have specific physiological adaptations: storage of oxygen in blood and muscle, bradycardia (heart slowing), and redistribution of oxygenated blood within organs to conserve use of oxygen (Williams, Haun, & Friedl, 1999).

However, with repeated forced shallow immersion (each submersion of unknown duration and not in the control of the animal) it is unlikely that the dolphins would initiate (or be able to initiate) true deep diving responses, and so it is surmised that treatment of this type (dragging and forced submersion) is likely to be very aversive. The video material available does not allow calculation of the duration of submersion, but it is clear from the behavioral responses that the animals resist this procedure and that some are already unconscious with their heads submerged or already dead (assumed drowned or suffocated by the process). This type of treatment would not be tolerated or accepted for commercially farmed animals being prepared for slaughter in the United States or Europe.

2. The dolphins are positioned in close proximity to each other during the killing process and struggling and whistling, which is audible on the video material despite its remote filming origins, occurs throughout the process. Dolphins are highly social mammals who have long-term relationships and live in complex social groups (Connor, 2007). Individuals produce and respond to individually distinctive stereotypic whistles to locate, contact, and identify conspecifics (Janik & Slater, 1998). They show advanced cognition (Herman, 2006; Marino et al., 2007) including complex social awareness as demonstrated by their understanding of the identity and behavior of others (reviewed in Herman, 2006), self-knowledge as demonstrated by an understanding of their own behavior and body parts (reviewed in Herman, 2006), and self-awareness as evidenced by their capacity for mirror self-recognition (Reiss & Marino, 2001). These socially and self-aware mammals undergo a prolonged process involving not only the herding offshore but also confinement, holding, and eventual corralling to the shoreline, followed by killing in close proximity to conspecifics and other members of their social and family groups. The entire process can last many hours or even days.

The AVMA recommendations state, "Euthanasia should be carried out in a manner that avoids animal distress. In some cases, vocalization and release of pheromones occur during induction of unconsciousness. For that reason, other animals should not be present when euthanasia is performed" (AVMA, 2007). The regulations and guidelines governing the humane treatment and slaughter of animals in the United States and the United Kingdom prohibit the killing of an animal in the presence of other animals (Humane Slaughter Act, 2003; Welfare of Animals [Slaughter or Killing] Regulations, 1995). From a scientific, humane, and ethical perspective, the treatment of dolphins in the drive hunts sharply contradicts current animal welfare standards employed in most modern and technologically advanced societies.

3. The use of termination of movement (Iwasaki & Kai, 2010) as the determinant time of death in an animal with a transected spinal cord is not a credible measure of death for a mammal (International Whaling Commission, 2003, 2004). Immobility (termination of movement) will be the natural final consequence of severance of the spinal cord; however, in any mammal (including humans) incomplete severing of the spinal cord does not immediately lead to death, and this is apparent in the continued life of many human and animal patients following spinal injury. Evaluation of death when livestock are slaughtered is based on the cessation of central neurological function and respiratory activity or that the animal has been effectively exsanguinated (bled out; AVMA, 2007; Commission of the European Communities COM, 2006; Food and Agriculture Organization [FAO] Animal Production and Health, 2004; Humane Slaughter Association, 2001).
4. Termination of breathing (Iwasaki & Kai, 2010) is not (in the short term and certainly in the periods described in the aforementioned translation) an appropriate indicator of death in marine mammals, who have enormous capacity for breath holding (Joulia, Lemaitre, Fontanari, Mille, & Barthelemy, 2009), with dives of up to 40 min recorded in some of the dolphin species (Kooyman, Ponganis, & Howard, 1999; Miller, Daniels, Schurch, Schoel, & Orgeig, 2006; Noren & Williams, 2000; Snyder, 1983). The striped dolphin does not usually breath hold for periods of longer than 15 min, and Iwasaki and Kai (2010) claimed that death can be assessed after breathing has stopped for as short a period as 5 (Risso's dolphin), 8 (spotted dolphin), or 25 (pilot whale) s. These periods are well within the breath-holding capacity of many mammals and a very short breath hold for a marine mammal.
5. The sample size for the control animal (one striped dolphin) described in the paper proposing the method (Iwasaki & Kai, 2010) is unlikely to be sufficient to draw any meaningful conclusions, particularly in light

of the availability of a large number of animals to study for these authors.

6. The method describes the times taken for an animal to die (as defined using termination of movement and breathing) to be as short a period as 5 (Risso's dolphin), 8 (spotted dolphin), or 25 (pilot whale) s—with average times of 13.7 (Risso's dolphin), 9 (spotted dolphin), or 25 s (pilot whale). The data derived from the analysis of a striped dolphin killed using the rod (Table 1) indicates that the animal was still moving after 254 s (4 min 14 s). The disparity between the published results (Iwasaki & Kai, 2010) and those from this independent observation-based assessment is considerable and calls into question the confidence that can be attributed to the data provided in the Iwasaki and Kai (2010) report.
7. Damage to the vertebral blood vessel and the vascular rete from insertion of the rod will lead to significant hemorrhage, but this alone would not produce a rapid death in a large mammal. After the operative has used the rod to cause tissue damage a wooden peg is inserted into the hole created by the rod (Iwasaki & Kai, 2010). It is likely that this would impede bleeding and so it is also possible that this process prolongs the time for the animal to die (Katsura, Kristian, & Siesjo, 1994). This risk is acknowledged by Iwasaki and Kai (2010), who stated, "The person who developed the spinal cord transection technique has pointed out that prevention of bleeding and internal retention of blood using the wedge risks prolongation of the time to death." This calls into question the contention that this new killing method results in reduced TTD.
8. Analysis of the video evidence suggest that the operator must make repeated pushes of the rod into the tissues close to the back of the skull. The video shows the animal making vigorous movements during the insertion of the rod and subsequently making powerful muscular movements at times after the rod has been withdrawn. This evidence strongly suggests that the method is immediately invasive and distressing and does not bring about immediate insensibility, as the brain itself remains unaffected. Complete and rapid (immediate) cord transection could result in destruction of sensory (pain) pathways, but what is observed in the animals studied is neither immediate nor appears to induce effective and assured cord transection, and so there can be no assurance that pain elimination is achieved.

After a period of violent insertion of a rod into sensitive tissues, the animal becomes paraplegic (paralysis of the body) and dies through trauma and gradual blood loss. This method of killing does not conform to the recognized requirement for "immediate insensibility" and would not be tolerated or permitted in any regulated slaughterhouse process in the developed world (AVMA, 2007; Commission of the European Communities COM, 2006; FAO Animal Production and Health, 2004; Humane Slaughter Association, 2001).

9. Rapid exsanguination is usually required after stunning for either humane slaughter or euthanasia. The method described in this paper is not designed primarily for bleed-out—in fact, the use of the wooden plug will, to a degree, reduce the capacity for bleeding from damaged blood vessels. This method appears to be primarily focused on causing gross neural tissue damage to the spinal cord and potentially the brain stem. This will cause, initially, immobilization and eventually death due to lack of coordination of respiratory and motor function. The method described does not conform to any recognized mechanism for bringing about death in accepted humane slaughter or euthanasia practice in large mammals.
10. The results presented in this article provide strong evidence that the claims regarding the improved killing method described in Iwasaki and Kai (2010) are not substantiated. Also, this killing method cannot be considered humane as it does not fulfill the recognized requirement for immediacy and in fact may result in a prolonged aversive application of a violent and traumatic physical process followed by slow death by spinal paralysis and blood loss. This method would not be recognized or approved as a humane or acceptable method of killing for mammals in any setting.

It should be noted that it is extremely difficult to obtain clear video footage from the drive hunts that is conducive to analysis. The sample presented here from January 2011 is the clearest available video record of the drive hunt and is representative of other footage taken from the hunts depicting this method since October 2008. Because the hunts are extremely controversial and hidden beneath tarpaulins that are pulled over the shoreline of the killing cove, independent video footage documenting the killing method can be obtained only through remote surveillance from public spaces. New tarpaulins and other visual obstacles have been constructed during the 2011 hunting season, further limiting access to viewing points around the killing cove.

The source of the video independently documenting the killing method used for this analysis was procured from an investigative journalist representing Atlantic Blue, a German organization. We were provided with two video accounts of the killing method being utilized in December 2009 and January 2011. Because the video footage from January 2011 was of higher quality, and represents the most current methods in use, it was utilized for this analysis.

The absolute paucity of this kind of material makes multiple analyses impossible, and so this analysis focuses on one good quality video example where the entire process from instigation to apparent end point is visible in a continuous frame without obstruction. We are not familiar with any other wildlife hunts that are specifically shielded from view in this manner.

As Iwasaki and Kai (2010) referenced the development and testing of this method since 2000, we are confident that the video sample is representative of current methods being utilized in the dolphin drive hunts in Taiji. Additionally, from the available video material it is apparent that the same process is applied to multiple animals and this analysis is representative of the approach being used on many small cetacean species in these hunts.

The range of social attitudes toward the killing of species in the wild around the world raises a number of important ethical questions. If we acknowledge that suffering is undesirable and that humans should do all that is practical to ensure that suffering is minimized at the time of death for domesticated animals whom humans farm, use, or consume, then it appears logical and consistent to also acknowledge that suffering should also be avoided for wild mammalian species (Commission of the European Communities COM, 2006; Mellor & Littin, 2004).

The application of double standards for these two groups of animals (domesticated and wild) appears to be largely based on arguments related to the practical difficulties of ensuring a swift death in the wild setting. The challenges presented in achieving the same standards for killing wild animals as exist for domesticated animals have, unfortunately, led to a systematic dilution or reduction in the standards permitted for the killing of wild species.

There are precedents for applying scientific knowledge and concern for animal welfare to policy decisions regarding commercial fishing and hunting practices. In the mid 1980s, increased scientific and public concern in the United States about the welfare of dolphins caught as bycatch during tuna purse seine fishing operations led to U.S. Senate subcommittee hearings and the ultimate decision to ban the use of purse seine procedures in the eastern tropical Pacific. Studies were conducted as part of a larger research program mandated under the 1997 International Dolphin Conservation Program Act (IDCPA), which investigated whether the eastern tropical Pacific tuna fishery was having a significant adverse impact on these dolphin stocks, known collectively as the Chase Encirclement Stress Studies (CHESS; see Forney, St. Aubin, & Chivers, 2002).

Stress-response protein profiles and various other health parameters in offshore spotted and spinner dolphins revealed acute stress-response in chased and captured dolphins, including heart lesions and other tissue damage (Forney et al., 2002). Resultant policy changes were adopted within the Marine Mammal Protection Act (MMPA) recognizing the desire of Congress, the public, and corporate interests to incorporate dolphin protection and welfare into practice through regulations addressing the tuna fishery and product labeling standards (U.S. Marine Mammal Protection Act, 1972). Policy changes included a ban on the use of purse seine fishing in the eastern tropical Pacific, which reduced the number of dolphins being encircled, trapped, and crushed in fishing gear. Policy changes occurred at the corporate level in the tuna industry responding to consumers' desire and right to know about the fishing practices used in this commercial fishery.

Another precedent for such policy changes occurred in the United Kingdom in the case of the well-established cultural practice of hunting red deer (*Cervus elaphus*) with hounds. Increased scientific and public concern for the welfare of red deer during the prolonged hunts prompted a study to be commissioned by the National Trust to assess the physiological effects of the hunts on the deer (Bateson & Bradshaw, 1997). The physiological state of hunted versus nonhunted but humanely killed red deer were compared and the results showed, among other indicators, high concentrations of cortisol, typically associated with extreme physiological and psychological stress. The study also found that damage to red blood cells occurred early in the hunts. The authors concluded that "red deer are not well-adapted by their evolutionary or individual history to cope with the level of activity imposed on them when hunted with hounds" (p. 1707). These scientific findings led to the banning of this type of hunting practice in the United Kingdom (Hunting Act, 2004).

Animals used for commercial purposes have been afforded the status of sentient beings under the Treaty of Amsterdam Amending the Treaty on European Union (Treaty of Amsterdam, 1997). Therefore, there exists a moral and legislative obligation to exercise a high standard of care for animals under the control of humans. It would seem appropriate that those animals who fall under human control during systematic hunts at the time of their death be treated following the accepted international principles described by the treaty. As humans determine when and where these animals die, there is an ethical obligation, as well as a practical opportunity, to control the method of death to minimize pain or suffering (Mellor & Littin, 2004). Based on available scales for pain, including both the National Institutes of Health and British Pain Society numeric scales, this method would register as extremely aversive—at the highest level of gross trauma, pain, and distress (British Pain Society, 2006; National Institute of Health Pain Consortium, 2007).

Within Japan, domesticated animals are afforded protection under the Act on Welfare and Management of Animals (Japan Ministry of the Environment, 2007), where guidelines to minimize pain and suffering are outlined for species such as horses, cattle, sheep, pigs, dogs, and other animals under human care. Dolphins and whales are not protected by this law, nor are they afforded protection under the Japan Wildlife Protection and Hunting Management Law (2011), which manages the keeping and custody of wild mammals in Japan and outlines procedures for the protection, management, and hunting of wild mammals in Japan through the oversight of the Ministry of Environment. Instead, dolphins and whales fall under the jurisdiction of the Fisheries Agency under the Department of Agriculture, which affords them little protection. This is in sharp contrast to the protection for dolphins and whales in legislation in other parts of the world such as New Zealand and the United States.

The U.S. Marine Mammal Protection Act (U.S. MMPA) of 1972 affords full protection from the *taking* or deliberate killing of marine mammals except under certain conditions for scientific research, enhancement for survival or recovery, and public display (U.S. MMPA, 1972). In New Zealand, intentional or deliberate killing of marine mammals, notably within commercial fisheries, is prohibited and similar provisions are provided by the Marine Mammals Protection Act (New Zealand Legislation Marine Mammals Protection Act, 1978).

In contrast, and looking to other Japanese whale and dolphin hunts for comparison, Japan conducts *special permit whaling* hunts for five species of large whales in the North Pacific and for minke and fin whales in the Southern Ocean. These hunts occur in open water at sea, and the killing methods are applied from a vessel. During drive hunts killing occurs when the hunter and the animal are next to each other on the stable ground of the shore. In contrast, whaling occurs at a distance, with the whale swimming in a moving sea and the hunter aiming at the target from a moving platform.

The killing methods also differ due to the difference in size of the animals (large baleen whales, rather than dolphins, or smaller toothed whales). The primary killing method used during Japanese whaling is a penthrite grenade harpoon that is aimed at the thorax. The objective is to cause sufficient blast-induced neurotrauma to render the whale "instantaneously" insensible or dead (Knudsen & Øen, 2003). Data show that for the Japanese hunt in the Southern Ocean during the 2003–2005 seasons, only 44% of harpooned minke whales ($N = 880$) were reported to have died "instantaneously" (Ishikawa, 2005). In some cases where whales do not die instantaneously a secondary killing method is applied: another grenade, harpoon, or a rifle. The rifle is aimed at the head while the whale is still attached to the harpoon line at the front of the vessel.

Neither the Japanese drive hunts nor the special permit whaling hunts can provide a guaranteed swift or humane death for these mammals and it is our view that because the meat procured from these activities is sold for commercial purposes it is legitimate to compare both special permit hunting and drive hunts with the standards required for other commercial meat production, such as those provided by the World Organization for Animal Health (OIE) recommendations for the slaughter of animals for food (OIE Terrestrial Animal Health Code, 2011).

What is particularly unusual about these drive hunts is the proximity of the hunters to the animals they are killing, which provides an opportunity for a swift death with potentially less margin of error than hunting at sea. For example, euthanasia of injured or moribund dolphins stranded on the beach is usually conducted by a veterinarian or a trained individual with a rifle at very close range. Best practice for cetaceans in extremis has been developed in order to administer the swiftest and most humane death. However, we do not recommend the use of rifles for killing cetaceans captured during these hunts, for a number of reasons. First of all, although rifles are a recommended euthanasia procedure for stranded cetaceans in some stranding protocols, the Royal Society for the Prevention of Cruelty to Animals (RSPCA) guidelines for veterinarians attending stranded cetaceans (RSPCA, 1997) do not recognize rifle shooting as the preferred method. Instead, these guidelines only recommend the use of rifles for toothed cetaceans up to 4 m in length if euthanasia drugs are unavailable. Second, there are many differences between an individual "mercy killing" associated with euthanasia of a stranded cetacean and the frequent and consecutive commercial killing of dolphins on the shore. In the latter case, the individuals waiting for slaughter are likely to be in an extreme state of anxiety, having been forced ashore, and could witness the shooting of other individuals to whom they may be related or share close social bonds.

Finally, the use of rifles as a humane euthanasia method for stranded cetaceans is only recommended on the basis that the operator, usually a veterinarian, using the rifle is well trained in such procedures and that the outcome is documented. Such caveats to the use of rifles could theoretically be applied to the use of rifles during a drive hunt, but it is our view that it is highly unlikely that even with a highly skilled operator administering the shot, there would be a humane outcome for each dolphin. Unlike a stranded dolphin who is shot because he or she cannot be refloated, dolphins caught in drive hunts are not moribund, but instead they are usually conscious, panicked, and moving, thus increasing the likelihood of error in bullet placement to the brain.

In addition, during the dolphin drive hunts the footage shows that some of the animals are secured by their tailstock. This is a particularly aversive practice due to the risk of the dolphins drowning as a result of forcing the head and blowhole under the water. In this respect there exist no useful comparisons with other terrestrial mammal drives or hunts. In addition, because the primary sense in these highly social mammals is hearing, the impact of hearing other cetaceans—and specifically members of their social group—being killed has the potential to further compound the negative effects of this hunting method.

The process of spinal transection carried out in a fully conscious large animal is likely to be profoundly distressing, traumatic, and painful and create unnecessary suffering and distress because a complete transection is difficult to achieve. The AVMA *Guidelines on Euthanasia* (AVMA, 2007) suggest that cervical dislocation can be considered a potential method for euthanasia of rabbits weighing not more than1 kg and of other small mammals of less than 200 g. The dolphins observed in this study weigh in the region of 200 kg and would not be considered suitable candidates for cervical dislocation under any laboratory or zoo veterinary guidelines. Additionally, the use of the punctilla (a knife designed to sever the spinal cord) is not permitted in slaughter processes in developed countries (Tidswell, Blackmore, & Newhook, 1987).

Pain is most often attributed to a physical condition, whereas discussions of suffering require consideration of the psychological and emotional capacity of the animals being slaughtered. Japan's own slaughter guidelines for livestock, which do not apply to the drive hunts and other whale and dolphin killing methods used around Japan's coastline, require the inducement of loss of consciousness and "methods that are scientifically proven to minimize, as much as possible, any agony to the animal" (Japan Ministry of the Environment, 2007). These guidelines also define *agony* as pain and suffering due to the excitement of the central nervous system by stimulating pain, fear, anxiety, or depression, all arguably elements of suffering in higher vertebrates. The systematic mistreatment of dolphins and whales, allowed and sanctioned by a highly developed country such as Japan, is in striking contrast to European Union, United States, and even existing Japanese legislation that aims to protect the welfare and ensure the humane treatment of animals on the farm, in domestic situations, and in the laboratory.

CONCLUSION

In conclusion, despite profound differences in their body form, dolphins, like our closest relatives the great apes, are sentient, highly social mammals who exhibit complex cognitive abilities (Herman, 2006; Marino et al., 2007), possess self-awareness as demonstrated by their ability for mirror self-recognition (Reiss & Marino, 2001), and demonstrate epimeletic (helping and caregiving) behaviors (Connor & Norris, 1982). Japanese scientists have been international leaders in great ape research, and their scientific knowledge has been used to provide the rationale to increase protection of the great apes. In 2006 Japan placed an unofficial ban on invasive chimpanzee research.

Our scientific knowledge of dolphins could and should result in similar protections against the suffering and distress resulting from this current method utilized in drive hunts. Existing scientific knowledge and understanding of cetacean anatomy, physiology, social behavior, and cognition should inform local and global animal welfare policies on the treatment of these species. There thus appears to be no logical reason to accept a killing method that is clearly not carried out in accordance with fundamental and globally adopted principles on the commercial utilization, care, and treatment of animals.

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REFERENCES

American Veterinary Medical Association. (2007). *Guidelines on euthanasia*. Retrieved from https://www.avma.org/KB/Policies/Documents/euthanasia.pdf

Anil, M. H., McKinstry, J. L., Gregory, N. G., Wotton, S. B., & Symonds, H. (1995). Welfare of calves: 2. Increase in vertebral artery blood flow following exsanguination by neck sticking and evaluation of chest sticking as an alternative slaughter method. *Meat Science*, *41*, 113–123.

Bateson, P., & Bradshaw, E. L. (1997). Physiological effect of hunting red deer (*Cervus elaphus*). *Proceedings of the Royal Society B, 264*, 1707–1714.

British Pain Society. (2006). *Pain scales*. Retrieved from http://www.britishpainsociety.org/pain_scales_eng.pdf

Brownell, R. L., Nowacek, D. P., & Ralls, K. (2008). Hunting cetaceans with sound: A worldwide review. *Journal of Cetacean Research and Management, 10*(1), 81–88.

Commission of the European Communities COM. (2006). EU Commission working document on a community action plan on the protection and welfare of animals 2006–2010. *Official Journal of the European Union, 49*(C 308E), 171–178.

Connor, R. C. (2007). Complex alliance relationships in bottlenose dolphins and a consideration of selective environments for extreme brain size evolution in mammals. *Philosophical Transactions of the Royal Society: Biological Sciences, 362*, 587–602.

Connor, R. C., & Norris, K. S. (1982). Are dolphins reciprocal altruists? *American Naturalist, 119*, 358–374.

Daly, C. C., Kalweit, E., & Ellendorf, F. (1988). Cortical function in cattle during slaughter: Conventional captive bolt stunning followed by exsanguination compared with shechita slaughter. *Veterinary Record, 122*, 325–329.

Faroese Ministry of Foreign Affairs, Uttanrikisradid. (2012). *Whaling in the Faroe Islands: In brief.* Torshavn, Faroe Islands: Author. Retrieved from http://www.whaling.fo/

Food and Agriculture Organization (FAO) Animal Production and Health. (2004). *Good practices for the meat industry manual* (FAO Publication 92-5-105146-1). Rome, Italy: Author.

Forney, K. A., St. Aubin, D. J., & Chivers, S. J. (2002). *Chase encirclement stress studies on dolphins involved in eastern tropical Pacific Ocean purse seine operations during 2001* (Southwest Fisheries Science Center Administrative Report). La Jolla, CA: National Marine Fisheries Service.

Hemmi, S. (2011). *The dolphin drive hunt: Appropriate management? Observations from the emergency extension of the hunting season of the dolphin drive hunt in Taiji*. Tsukuba, Japan: Elsa Nature Conservancy.

Herman, L. M. (2006). Intelligence and rational behaviour in the bottlenosed dolphin. In S. Hurley & M. Nudds (Eds.), *Rational animals?* (pp. 439–468). Oxford, UK: Oxford University Press.

Humane Slaughter Act, 7 U.S.C. § 1901 et seq., 9 C.F.R § 313.1-90 (2003).

Humane Slaughter Association. (2001). *Guidance notes no. 2: Captive bolt stunning of livestock* (3rd ed.). Wheathampstead, UK: Author.

Hunting Act of 2004, Chapter 37, 1–11 (2004). Retrieved from http://www.legislation.gov.uk/ukpga/2004/37/pdfs/ukpga_20040037_en.pdf

International Whaling Commission. (2003). *Revised action plan on whale killing methods* (IWC/55/Rep5). Cambridge, UK: Author.

International Whaling Commission. (2004). *Resolution 2004-3: Resolution on Whale Killing Issues* (56th annual report of the International Whaling Commission covering the 2003–2004 financial year). Cambridge, UK: Author.

Ishikawa, H. (2005). *Improvement of the time to death in the Japanese Whale Research Program in the Antarctic Sea* (*JARPA*) *and Northwestern Pacific Ocean* (*JARPN and JARPN II*) (IWC/57/WKM&AWI 11). Cambridge, UK: IWC.

Iwasaki, T., & Kai, Y. (2010). *Improved method of killing dolphins in the drive fishery in Taiji, Wakayama Prefecture* (Report of the Fishery Research Institute of Far Seas Fisheries and Taiji Fishery Cooperative). Retrieved from http://www.cypress.ne.jp/jf-taiji/geiruihosatu.pdf

Janik, V. M., & Slater, P. J. B. (1998). Context-specific use suggests that bottlenose dolphin signature whistles are cohesion calls. *Animal Behaviour, 56*, 829–838.

Japan Ministry of the Environment. (2007). *Guidance on slaughter of animals* (Notice No. 05, November 12, 2007, revision). Tokyo, Japan: Author.

Japan Wildlife Protection and Hunting Management Law. (2011). *Summary of the Wildlife Protection and Hunting Management Law.* Retrieved from http://www.env.go.jp/en/laws/nature/law_wphm-summary.pdf

Joulia, F., Lemaitre, F., Fontanari, P., Mille, P. M. L., & Barthelemy, P. (2009). Circulatory effects of apnoea in elite breath-hold divers. *Acta Physiologica*, *197*(1), 75–82.

Kasuya, T. (2007). Japanese whaling and other cetacean fisheries. *Environmental Science and Pollution Research*, *14*(1), 39–48.

Katsura, K., Kristian, T., & Siesjo, B. K. (1994). Energy metabolism, ion homeostasis and cell damage in the brain. *Biochemical Society Transactions, 22*, 991–996.

Knudsen, S. K., & Øen, E. O. (2003). Blast induced neurotrauma in whales. *Neuroscience Research*, *46*, 377–386.

Kooyman, G. L., Ponganis, P. J., & Howard, R. S. (1999). Diving animals. In C. E. G. Lundgren & J. N. Miller (Eds.), *The lung at depth* (pp. 587–614). New York, NY: Marcel Dekker, Inc.

Lin, F. Y., Lin, R. P., & Chou, L. S. (1998). Structure of the thoracic retia mirabilia of three cetacean species. *Acta Zoologica Taiwanica, 9*, 111–118.

Marino, L., Connor, R. C., Fordyce, R. E., Herman, L. M., Hof, Lefebvre, L., ... Whitehead, H. (2007). Cetaceans have complex brains for complex cognition. *PLoS Biol 5*(6), e139. doi:10.1371/journal.pbio.0050139

Mellor, D. J., & Littin, K. E. (2004). Using science to support ethical decisions promoting humane livestock slaughter and vertebrate pest control. *Animal Welfare, 13*, 127–132.

Melnikov, V. V. (1986). Arterial system of the head and truncal anterior part of the whale *Balaenoptera edeni. Arkhiv Anatomii Gistologi I Embriologi*, *90*(5), 57–63.

Miller, N. J., Daniels, C. B., Schurch, S., Schoel, W. M., & Orgeig, S. (2006). The surface activity of pulmonary surfactant from diving mammals. *Respiratory Physiology & Neurobiology, 150*, 220–232.

Morisette, L., Christensen, V., & Pauly, D. (2012). Marine mammal impacts in exploited ecosystems: Would large scale culling benefit fisheries? *PLOS One, 7*(9), e43966. doi:10.1371/journal.pone.0043966

Nagel, E. L., Morgane, P. J., McFarlan, W. L., & Galliano, R. E. (1968). Rete mirabile of dolphin: Its pressure damping effect on cerebral circulation. *Science*, *161*(3844), 898–902.

National Institute of Health Pain Consortium. (2007). *Pain intensity scales.* Retrieved from http://painconsortium.nih.gov/pain_scales/index.html

National Research Institute of Far Seas Fisheries. (2009). *Japanese progress reports on small cetacean research* (JapProgrep SM/2009). Tokyo, Japan: Author.

New Zealand Legislation Marine Mammals Protection Act of 1978, Public Act 1979 No. 80 (2005).

Noren, S. R., & Williams, T. M. (2000). Body size and skeletal muscle myoglobin of cetaceans: Adaptations for maximizing dive duration. *Comparative Biochemistry and Physiology: Part A. Physiology, 126*, 181–191.

Ohsumi, S. (1972). Catch of marine mammals, mainly of small cetaceans by local fisheries along the coast of Japan. *Bulletin Far Seas Fisheries Research Laboratory, 7*, 137–166.

Olsen, J. (1999). *Killing methods and equipment in the Faroese pilot whale hunt* (NAMMCO/99/WS-2: 1-14). Tromso, Norway: North Atlantic Marine Mammal Commission.

Reiss, D. (2010, February). Self-awareness and dolphins. In S. J. Bird (Chair), *Intelligence of dolphins: Ethical and policy implications*. Symposium conducted at the American Association for the Advancement of Science annual meeting, San Diego, CA.

Reiss, D., & Marino, L. (2001). Mirror self-recognition in the bottlenose dolphin: A case of cognitive convergence. *Proceedings of the National Academy of Sciences*, *98*(10), 5937–5942.

Rommel. S. A., & Lowenstein, L. J. (2001). Gross and microscopic anatomy. In L. A. Dieruaf & F. M. D. Gulland (Eds.), *CRC handbook of marine mammal medicine* (Chapter 9, pp. 129–164). Boca Raton, FL: CRC.

Royal Society for the Prevention of Cruelty to Animals. (1997). *Stranded cetaceans: Guidelines for veterinary surgeons*. Horsham, UK: Author.

Snyder, G. K. (1983). Respiratory adaptations in diving mammals. *Respiratory Physiology, 54*, 269–294.

Tidswell, S. J., Blackmore, D. K., & Newhook, J. C. (1987). Slaughter methods: Electroencephalographs (EEG) studies on spinal cord section, decapitation and gross trauma of the brain in lambs. *New Zealand Veterinary Journal, 35*(4), 46–49.

Treaty of Amsterdam Amending the Treaty on European Union. (1997). Retrieved from http://www.eurotreaties.com/amsterdamtreaty.pdf

U.S. Marine Mammal Protection Act, 16 U.S.C. § 1371 (1972).

Vail, C. S., & Risch, D. (2006). *Driven by demand: Dolphin drive hunts in Japan and the involvement of the aquarium industry.* Wiltshire, UK: Whale and Dolphin Conservation Society (WDCS).

Welfare of Animals (Slaughter or Killing) Regulations. (1995). UK Council Directive 93/119/EC.

Williams, T. M., Haun, J. E., & Friedl, W. A. (1999). The diving physiology of bottlenose dolphins (*Tursiops truncatus*): 1. Balancing the demands of exercise for energy conservation at depth. *The Journal of Experimental Biology*, *202*, 2739–2748.

World Organization for Animal Health. (2011). *OIE Terrestrial Animal Health Code* (*2011*). Retrieved from http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_1.7.5.htm