Marine Mammal Euthanasia Best Practices

Executive Summary

Throughout the marine mammal stranding and response process, it is inevitable to have situations where euthanasia of a marine mammal is the most humane response. The best euthanasia outcomes occur when response personnel are trained and prepared for this challenging decision. This document brings together the best practices and standardized protocols that the National Marine Fisheries Service (NMFS) recommends to make the most appropriate decision and determine a course of action for euthanasia, given a particular stranding scenario. The euthanasia information is a living document that will be updated periodically as more data and observations become available.

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1. Introduction

1.1 Background

In 1992, the Marine Mammal Health and Stranding Response Program (MMHSRP), under the National Marine Fisheries Service (NMFS), was established by Congress under Title IV of the Marine Mammal Protection Act (MMPA). The MMHSRP serves to coordinate marine mammal stranding response efforts in the United States by working to standardize regional network operations and define national stranding response policy.

NMFS published the guidance document “Standards for Rehabilitation Facilities" in 2009 as part of the broader Policies and Best Practices: Marine Mammal Stranding Response, Rehabilitation, and Release. The Standards for Rehabilitation Facilities give detailed guidance on facility and husbandry procedures for rehabilitating marine mammals, and discuss that euthanasia should be performed following accepted guidelines (*e.g.,* AVMA 2020), but did not include detailed euthanasia procedures or protocols specific to marine mammals. Non-Endangered Species Act (ESA) species responses can be conducted, with authorization by NMFS, under a Stranding Agreement (by the Stranding Agreement holder) or by a government employee acting under MMPA Section 109(h). Additionally, the MMHSRP holds an MMPA/ESA research and enhancement permit that allows the program to authorize qualified individuals to administer euthanasia for ESA species when the decision is approved by NMFS.

Therefore, the Marine Mammal Euthanasia Best Practices outlined here will provide guidance to both the National Marine Mammal Stranding Network (the Stranding Network) and individuals operating under the MMHSRP MMPA/ESA permit, SA or 109(h).

1.2 Legislation Pertinent to Marine Mammal Euthanasia

There are two key pieces of legislation that govern interactions with marine mammals in the United States.

Marine Mammal Protection Act (MMPA): The MMPA, signed into law in 1972, prohibits the “take” of marine mammals in U.S. waters and by U.S. citizens on the high seas, which includes harassing or disturbing these animals, as well as harming or killing, unless such take is specifically exempted in the statute or authorized. The MMPA divides responsibility for marine mammal species between the Secretary of Commerce, who oversees NMFS, and the Secretary of the Interior, who oversees the U.S. Fish and Wildlife Service (USFWS). NMFS has jurisdiction over cetacean and pinniped species (with the exception of walrus), and USFWS has jurisdiction over walrus, polar bear, sea otters, and manatees. The 1992 amendments to the MMPA included

Title IV of the MMPA, which established the MMHSRP under NMFS to collect and disseminate information about the health trends of marine mammal populations through the collection of data from strandings, by catch, subsistence harvest, and research.

Endangered Species Act (ESA): The ESA, enacted in 1973, provides for the conservation of species that are listed as endangered (in danger of extinction) or threatened (at risk of becoming endangered in the foreseeable future). The ESA also contains a prohibition on "take" including harassment and disturbance as well as injuring and killing.

1.3 Purpose and Intended Use

NMFS and the Stranding Network have developed protocols and procedures for responding to live marine mammals that are stranded and/or otherwise in distress to ensure the health, welfare, and safety of both the human responders and animals. These protocols balance the need for standardized procedures while allowing flexibility to address specific needs of different situations for diverse species and habitats, as well as unforeseen circumstances. For more information on general stranded marine mammal rescue and rehabilitation, the reader should consult references such as *Marine Mammals Ashore* (Geraci *et al.* 2005) and the *CRC Handbook of Marine Mammal Medicine* (Gulland *et al.* 2018). Human and animal safety is the top priority for NMFS and the Stranding Network. NMFS, the Stranding Network, and other parties that may have land jurisdiction [*e.g.*, tribes, National Park Service (NPS), state, etc.] evaluate many factors before making a decision to intervene. Each stranding event is unique and requires the consideration of multiple aspects, which are addressed below. This document will aid in the application of professional judgment when an end of life decision needs to be made for a stranded or injured marine mammal.

These best practices have been developed to serve as guidance and recommendations. This document is not intended for independent use as a training manual, and does not by itself qualify the reader for any actions or authorizations. In some situations, responders may choose a course of action not outlined in these documents, but consultation with NMFS is encouraged if the course of action will vary greatly from the best practices outlined in this document. These best practices are a "living document," and as such, we plan to periodically review and update them as new information becomes available. Responders should never stop striving for innovative and new methods and training to increase safety and success, and nothing in these best practices should prevent or limit advances in technology, techniques, and training.

1.4 Funding

The John H. Prescott Marine Mammal Rescue Assistance Grant Program provides funding for eligible

members of the Stranding Network through an annual competitive grant process. These grants support the rescue and rehabilitation of stranded marine mammals, data collection from living or dead stranded marine mammals for health research, and facility operation costs. However, as these grants are competitive and limited, individual Stranding Network members often support many of the costs for normal operations, including euthanasia.

2. Planning for Euthanasia and Euthanasia Concerns

2.1 Planning for Euthanasia

There are many situations that could call for the consideration of euthanasia, such as an animal with a severe injury or illness. Each scenario should be evaluated on a case-by-case basis to provide the best outcome for the individual animal.

The term "euthanasia" comes from Greek roots and means "a good death." It is typically used in veterinary medicine to describe the humane ending of the life of an individual animal in a way that minimizes or eliminates pain and distress (AVMA 2020). Euthanasia reflects the veterinarian or authorized responder's desire to do what is best for the animal and serves to bring about the most appropriate outcome for an animal (AVMA 2020). Stranding Network veterinarians and/or NMFS designated authorized responders possess the expertise to properly care for marine mammals, including assessing the chances of recovery and return to the wild for an individual animal.

If recovery and return to the wild is not possible, these responders also have the experience and training to relieve unnecessary pain and suffering by using euthanasia as a tool. The goal of euthanasia is to make the death of an animal as painless, quick, and free of distress as possible by using the best and most effective method for the specific situation.

When preparing for euthanasia, it is important for the responder(s) to contact their NMFS Regional Stranding Coordinator as soon as possible with an assessment. Approval for euthanasia comes from NMFS, either through pre-approval of existing protocols for commonly stranded species, or on a case-by-case basis for uncommon, difficult cases, or ESA-listed species. As part of that approval process, NMFS will discuss euthanasia methods with the relevant federal, state, tribal, or other local land authority if applicable.

2.2 Training, Safety, Personnel

Human and animal safety is the top priority for NMFS and the Stranding Network. Euthanasia should only be carried out by an experienced and approved Stranding Network member or veterinarian who is

trained in, and familiar with, proper euthanasia methods for that species. Responders of the Stranding Network should maintain training in first aid/CPR, animal handling during euthanasia, general euthanasia protocols, and communication with the public and media if euthanasia is performed in the field. It is the responsibility of the team lead to know the team's experience, skills, and limitations, and to continually assess the safety of the situation (Barco *et al.* 2016).

Before determining that euthanasia is the most suitable course of action, it is important to fully triage the individual, understand the situation, and be able to answer the following questions:

- Where is the animal located? Is it in the water, surf, or on the beach? Is it in a public or remote area?
- How long has the animal been stranded? Is a trained team available for field assessment and diagnostics, if applicable?
- What is the species? Animal size? And the behavior of the animal?
- Are there laws, regulations, or policies that apply to the land jurisdiction of the stranding where communication, coordination, and approval is needed and/or required?
- What equipment is needed? Do you have all the equipment?
- Do you have the proper amount/method of euthanasia available to humanely euthanize?
- Do you have all of the required data sheets?
- Do you have approval from NMFS to perform euthanasia, and an authorized member that can perform it?
- Do you have an appropriate number of responders necessary to handle the animal safely and euthanize?
- Are team member assignments clear (*i.e.,* who is performing euthanasia, who is the handling the animal, who is addressing the public/media)?
- Do you have an established plan for a "Zone of Safety" around animals/drugs/tools (Barco *et al.*, 2016)?
- Is there a contingency plan in place for accidental human exposure to sedatives or euthanasia drugs, including where is the location of the closest hospital in case of accidental human exposure?
- Has the media/communication plan been reviewed or coordinated with the organizations involved (*e.g.*, NMFS, the Stranding Network, tribes, state, federal, NPS, etc.)? Are talking points and a public information officer ready to address and educate the public?

Concerns and risks during field euthanasia include, but are not limited to the following:

- Human safety concerns while operating close to the animal, in addition to the environmental hazards and conditions. If animals are small enough, they should be removed from the water prior to euthanasia to avoid operating in the water. Working in the active surf zone with larger animals is not preferred and should only be done under very specific protocols that emphasize human safety and minimize risks (Barco *et al.* 2016).

- Risk of accidental human exposure to drugs via an accidental injection, needle stick, or spray back of drugs; luer lock syringes are recommended because they reduce the likelihood

of spray back (Barco *et al.* 2016).

- Ballistics injuries. There are many considerations when using firearms, such as avoiding using firearms over substrates that carry a high risk of ricochets (*e.g.,* stones and rock platforms) (Hampton *et al.* 2014).

2.3 Administering Euthanasia

Euthanasia methods are commonly classified into two main categories: chemical methods and physical methods (further explained in section 3). Chemical methods include non-inhalant agents (*i.e.*, injectable) and inhalant agents that include anesthetic gasses such as isoflurane. Physical methods of euthanasia include ballistics, explosives, and exsanguination.

There are many ways to administer chemical euthanasia: intravenous (IV), intramuscular (IM), intraperitoneal (IP), intranasal (blowhole), retro-bulbar, intracardiac (IC), etc. For species- and drug-specific chemical euthanasia injection sites (landmarks), refer to section 4. Intracardiac administration requires that the animal be unconscious or anesthetized. Intravascular administration is the most rapid and common method used in marine mammals (Gulland *et al.* 2018), but in some situations, it may not be safe or feasible. Sedation or anesthesia is recommended for some marine mammal species prior to administration of euthanasia drugs. In some cases, sedation may result in euthanasia prior to the administration of further physical or chemical means.

Intrahepatic, intrathoracic, intrapulmonary, intrathecal, intraoral/buccal, sublingual injection, and intraglossal are not acceptable forms of administration of chemical euthanasia agents in marine mammals (Barco *et al.* 2016). Intraoral/buccal may be used as an administration method for sedation but is not recommended for administering euthanasia drugs.

Physical euthanasia using ballistics must be carried out by accredited state, local, tribal, or federal law enforcement personnel provided they euthanize the marine mammal in the normal course of their duties as an official or employee under Section 109(h) of the MMPA (50 CFR 216.22). For non-ESA species, no further authorization (*e.g.,* a NMFS SA) is required under Section 109(h) as long as euthanasia is for the protection or welfare of the animal or for the protection of the public health and welfare (50 CFR 216.22; Geraci *et al.* 2005). Additionally, a member of the Stranding Network could conduct euthanasia via ballistics under their SA if all other state and local requirements (*e.g.*, permits) were met and they were adequately trained. For ESA species, both 109(h) and SA holders would require authorization under the MMPA/ESA Permit to conduct euthanasia. To administer the ballistics method, it is recommended that the animal be shot in the brain. Refer to section 3.2 for more specific information on physical methods of euthanasia for specific species/taxa.

2.4 Verification of Death

When euthanizing a marine mammal, it is important to verify the death of the animal to ensure the animal does not experience unnecessary pain and suffering. Death may be difficult to determine in cetaceans in some situations. Confirmation of death can be accomplished in a variety of ways. Depending on the species, listening for a heartbeat is not a reliable confirmation method, as the heartbeat may normally be undetectable. Therefore, secondary techniques should be used to verify death. The method(s) used for confirmation may depend on the logistics and safety as well as the species involved, but should include as many applicable methods as feasible. Human safety is critically important to evaluate as decisions are made on how to assess the success of euthanasia. For cetaceans and pinnipeds, indicators of death may include:

- Loss of jaw tone
- Absence of menace, palpebral and corneal reflexes
- Fixed dilated pupils
- No capillary refill time on the gums
- Absence of tongue reflex
- Prolonged absence of respiration
- Absence of blowhole tone
- Absence of flipper tone
- ECG indicating cardiac asystole
- Lack of response to painful stimuli
- Ocular/skin temperature differential
- Loss of anal tone

2.5 Records

It is important that each event be fully documented. Information should be collected, not only for general stranding and species data, but also to obtain information on the successes and failures of euthanasia protocols and methods. There are also laws that require specific record-keeping for use of pharmaceuticals in wildlife (*e.g.*, AMDUCA). Information on the animal's response to the euthanasia method including behavior, time to death, clinical signs of response, and other factors will be very useful in identifying species differences in responses, especially to chemical methods. This feedback will be used to inform and improve protocols and modify techniques for future events, especially if there are species or situational differences. Any human injuries during euthanasia should also be documented to prevent future injuries. See Appendix A for examples of standardized euthanasia datasheets and forms that can be used during an event.

2.6 Disposition of Euthanized Animal

All carcass disposal should follow local, state, tribal, and federal laws and regulations. An animal euthanized by physical methods can be disposed of by beach burial, leaving in place, landfill, towed out to sea, rendering, composting, or incinerating, depending on the situation and physical access. If an animal was euthanized by chemical agents (*e.g.,* pentobarbital) that may cause secondary poisoning to scavengers (*e.g.,* birds, coyotes, sharks that might feed on a carcass), then the carcass needs to be disposed of in a safe manner that prevents risk to wildlife or the environment. Carcasses containing high concentrations of pentobarbital euthanasia solutions must be incinerated, rendered, composted, or buried in licensed landfills that accept pentobarbital carcasses (Geraci *et al.* 2005). If a carcass is too large to move, and sedatives were administered, the sedative injection site should be excised and disposed of appropriately. Refer to the Carcass Disposal Best Practices for detailed information on marine mammal carcass disposal methods.

2.7 Decision Matrix

Before determining that euthanasia is the most suitable course of action, it is important to fully triage the individual and understand the logistical situation. The decision to euthanize a marine mammal is made by the NMFS Regional Stranding Coordinator, the local Stranding Network group, the attending veterinarian, the Marine Mammal Health and Stranding Response Program staff, and/or other management agencies, depending upon the circumstances. Once euthanasia has been determined to be necessary, then it is important to determine the best euthanasia method that has the ability to induce loss of consciousness and death with the minimum pain and distress. Selection of the most appropriate method of euthanasia, in any given situation, depends on the species and number of animals involved, animal size, available resources (including means of animal restraint), skill of personnel, available carcass disposal method, safety in administering the methods, need for biological samples for diagnostic testing or other purposes, as well as other criteria.

When selecting a euthanasia method you should consider (AVMA 2020):

1) Time required to induce loss of consciousness
2) Reliability
3) Safety of personnel
4) Safety of other animals in close proximity
5) Irreversibility
6) Compatibility with intended animal use and purpose
7) Documented emotional effect on observers or operators
8) Compatibility with subsequent evaluation, examination, or use of tissue
9) Drug availability and human abuse potential

10) Compatibility with species, age, and health status
11) Ability to maintain equipment in proper working order
12) Carcass disposal options that consider safety for scavengers should the animal's remains be consumed
13) Legal requirements
14) Environmental impacts of the method or disposition of the animal's remains.

When making the final decision on the euthanasia method, it is good practice to go through a decision matrix (Figure 1) to ensure all variables and information have been taken into account.

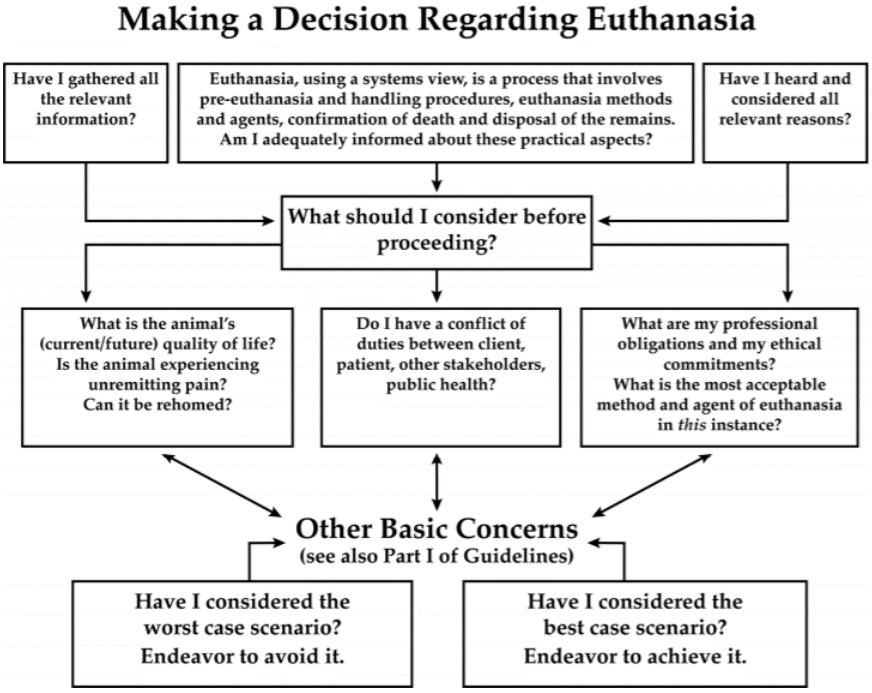

Figure 1: Veterinarians may refer to this decision tree as a way to consider the variables associated with the euthanasia decision. Taken from the AVMA Guidelines for Euthanasia of Animals: 2020 Edition.

3. Methods of Euthanasia

Euthanasia methods are commonly classified into two main categories: (1) chemical methods, and (2) physical methods.

Chemical methods include injectable drugs such as tranquilizers, sedatives, anesthetics, barbiturates (*e.g.*, pentobarbital), and potassium chloride. Chemical methods can also include inhalant drugs such as anesthetic gasses (*e.g.*, isoflurane). Intravascular administration of an acceptable pharmaceutical agent is considered the most rapid and reliable means of obtaining euthanasia in mammals (Andrews *et al.* 1993;

Close *et al*. 1996), and is the most common method used in marine mammals (Gulland *et al.* 2018).

Physical methods of euthanasia include ballistics (dispatched from conventional firearms) for animals under 26 feet (8 meters), explosives (not currently used in the United States), and exsanguination (with sedation administered prior). These physical methods are generally used in remote or logistically constrained situations where the carcass must remain in place and access to euthanasia drugs is limited.

All methods have pros and cons, and some methods may have more limitations and concerns than others. There may also be limited information on the outcomes of certain methods for specific species or taxa, so careful consideration is always given to lessons learned from previous cases in order to select the best and most humane option. Refer to section 4 for the currently available species-specific euthanasia and chemical euthanasia injection sites (landmarks). To view more information on euthanasia matrixes and effective euthanasia methods for cetaceans, refer to Appendices B and C.

3.1 Chemical Methods

Using a chemical method for euthanasia is usually the most rapid and reliable method if it can be administered safely and effectively. In general, it is recommended that a two-step process be used, with administration of a pre-euthanasia sedative agent followed by at least one other euthanasia drug to cause permanent death (Barco *et al.* 2016, AVMA 2020). However, some smaller pinnipeds (*e.g.,* phocids) may not require a pre-euthanasia sedative, if pentobarbital is used. Also in some instances, the sedative may result in the euthanasia of the animal prior to any additional drug administration.

3.1.1 Sedation Drugs

As noted above, to decrease the risk of injury to responders and handlers, and to diminish the animal's perception/response to the chosen euthanasia method, it is recommended that a sedative or tranquilizer be administered to the marine mammal prior to euthanasia when appropriate (Harms *et al.* 2018). In some cases, cetaceans may exhibit severe excitatory reactions, including spinning and fluking, when administering an intravenous barbiturate without prior sedation and this reaction puts responders and the public at risk for injury (Barco *et al.* 2016). The sedative or tranquilizer reduces pain and stress that may be experienced by the animal during administration of euthanasia drugs. In some small cetacean species, excitatory reactions have also been observed with administration of sedatives. Species-specific sedation and euthanasia protocols are available for some species, and should be utilized whenever possible in order to provide the best euthanasia process for each animal (Barco *et al.* 2016). Provision of sedation is required prior to intracardiac or intraperitoneal injections, administration of potassium chloride (KCl), or exsanguination. Another benefit to using a sedative is that it may lessen the euthanasia drug volume needed (Barco *et al.* 2016). If an animal is severely debilitated, it is possible that the pre-euthanasia drugs

(tranquilizers, sedatives, some injectable anesthetics) may result in the death of the animal without the need for euthanasia drugs.

	Sedatives Used
Large Cetaceans	Acepromazine, butorphanol*, midazolam, xylazine*
Small Cetaceans	Butorphanol*, diazepam, ketamine-diazepam, midazolam, tiletamine*-zolazepam, xylazine*
Pinnipeds	Butorphanol*, diazepam, ketamine-diazepam, midazolam, tiletamine*-zolazepam

*indicates analgesic effects.

3.1.2 Euthanasia Drugs

Barbiturates (*e.g.*, pentobarbital) are the most commonly used chemical euthanasia agents in marine mammals, and are the same as those commonly used in companion animals. They are usually administered intravenously or intracardially. If administered intraperitoneally, they can be irritating, so a local anesthetic or pre-euthanasia sedation should be used. These barbiturate chemical agents are rapid and limit discomfort in the animal during euthanasia. Barbiturates act by depressing the medullary respiratory and vasomotor centers to a degree that results in unconsciousness and respiratory and cardiac arrest. Sedation is also usually administered prior to administration of the barbiturates, to further reduce any pain or stress.

If carcasses must be left in place or will be buried on the beach, the use of intracardiac potassium chloride is the preferred chemical method in large cetaceans, small cetaceans, or larger pinnipeds because there is little risk of secondary poisoning to scavengers (Harms *et al*. 2014; Whitmer *et al.* 2021). A two-step euthanasia process should be used with this method since the marine mammal must be heavily sedated (unconscious or "asleep") prior to administration of the potassium chloride (Harms *et al*. 2014). Etorphine, T-61, and paralytics are not recommended as chemical agents for marine mammal euthanasia.

3.2 Physical Methods

3.2.1 Ballistics

If chemical methods are not practical, the use of firearms has been demonstrated to be an effective physical method for euthanizing small marine mammals (Blackmore *et al.* 1995). This method may be most appropriate in remote or logistically challenging situations. While it results in a rapid death and the equipment is typically readily available, the shooter must have knowledge of the anatomical locations of the heart and brain so that the gunshot is accurately placed and will be most effective. This technique

requires skill, training, and legal authorization for the weapon, and public safety must be assessed if it is to be used in a public area. If physical euthanasia methods are the only option on a busy beach, be aware of both animal and human safety concerns (Geraci *et al.* 2005). Ballistics should not be carried out if the animal is in deep water or the surf zone. If ballistics are to be used, make sure to consider any secondary lead poisoning for scavengers if the carcass will remain in place and lead shot is used. Please see the Carcass Disposal Best Practices for more details.

There are four main components that should be evaluated when assessing the ballistic option (Barco *et al.* 2016):

1) Size and anatomy of the animal(s);
2) Firearm and projectile to be used;
3) Skill and training of the marksman; and
4) Consideration of public safety and perception.

If any of these components are not ideal, then the procedure should be aborted (Harms *et al.* 2018). Ballistics are not recommended for cetaceans larger than 26 feet (8 meters) because the size and density of the skull may not allow effective penetration of ballistics from conventional weapons. Large cetaceans have different skull anatomy and/or extremely tough skin and blubber layers that restrict projectile penetration.

Smaller cetaceans (less than 26 feet (8 meters)) can be euthanized effectively with a firearm. For an immediate and painless result, the shot should be targeted at the brain (preferably the brain stem). Donoghue (2006) recommends a series of three shots in a line halfway between the eye and the insertion of the flipper at the level of the eye. The area can be accessed laterally, dorsally, or ventrally (see Figure 2 below). Another target option is to shoot from the side. Aim about halfway between the posterior margin of the eye and a point above the origin of the pectoral flipper, and for added assurance, fire three shots in a line through the targeted area (see Figure 3 below for placement) (Geraci *et al.* 2005).

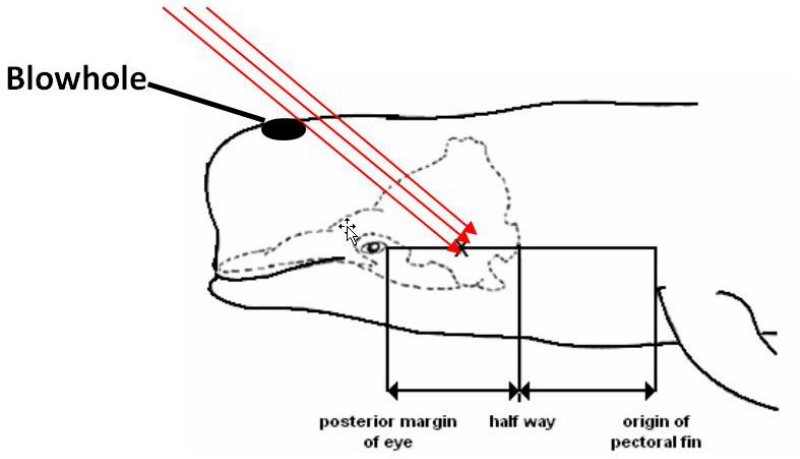

Figure 2: When euthanizing a small cetacean with a firearm, a series of three shots in a line, halfway between the eye and the insertion of the flipper at the level of the eye, is recommended. Image adapted from Donoghue 2006.

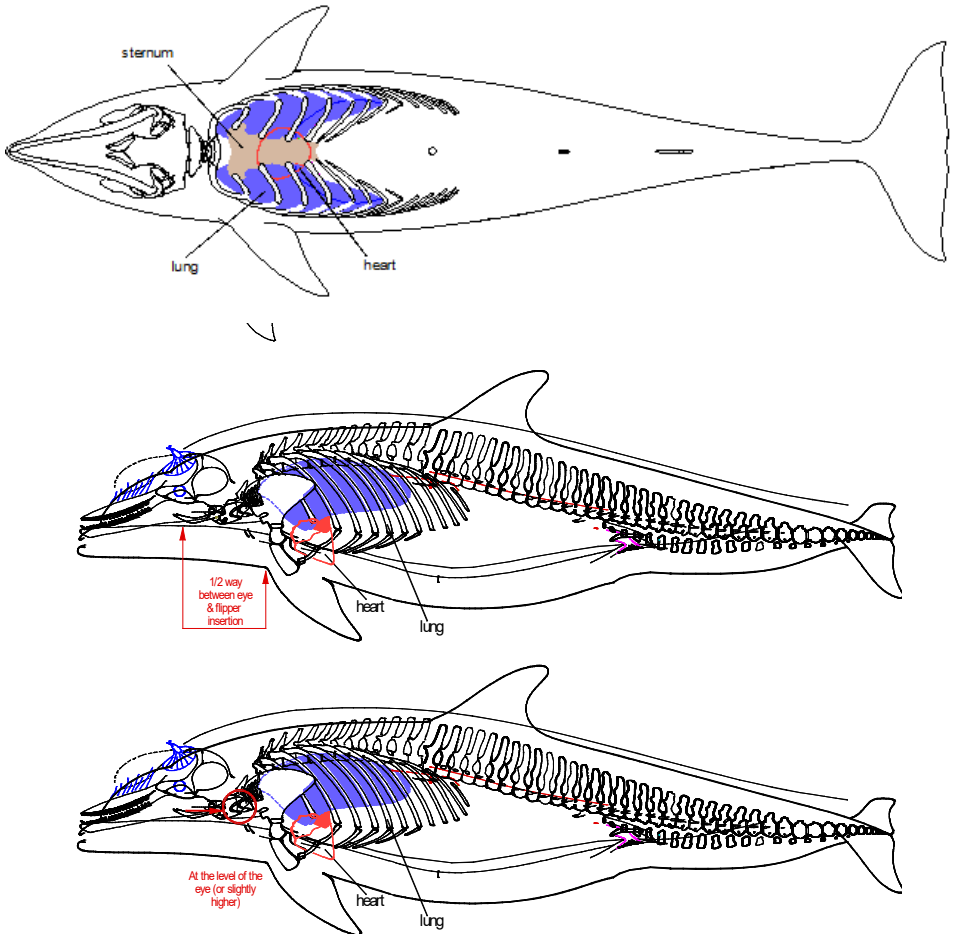

Figure 3: Outline of skeletal elements and target area for small cetacean ballistics euthanasia (images ©Rommel)

The use of ballistics for euthanasia is easier for pinnipeds since they are smaller and conventional guns or rifles can be used to penetrate the skull, resulting in a rapid death. When using this method (Figure 4), target one of three areas (Geraci *et al.* 2005):

1) Frontal shot- placed slightly behind the line of eyes;
2) Poll shot- from the rear of the skull; or
3) Temporal shot- from the side of the skull.

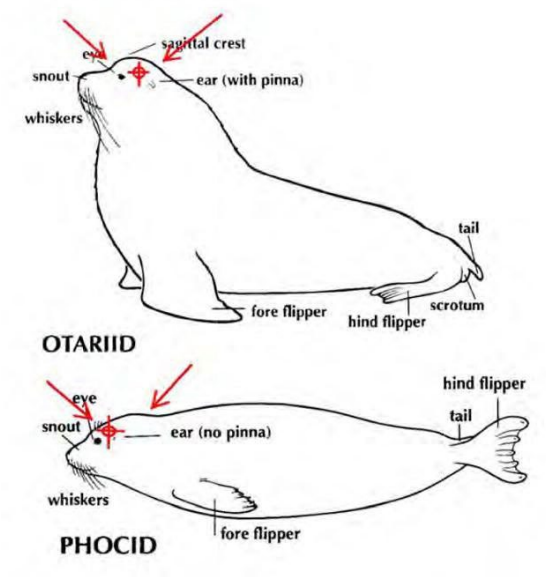

Figure 4: Recommended targets when euthanizing a pinniped with a firearm. Adapted from Geraci & Lounsbury, 2005 by the Northwest Marine Mammal Stranding Network.

3.2.2 Explosives

In other countries, explosives have been used in large whale euthanasia situations when other methods were unavailable or difficult, but these methods are not currently developed, trained, or available for use the United States. If considered in the United States in the future, development, training, partnerships, and legal issues will need to be addressed. For more details on this method, see Donoghue 2006.

3.2.3 Other Methods

There are a few other methods of physical euthanasia that are not as common or typically recommended. Exsanguination, although not considered an acceptable primary method, can be used in remote or logistically challenging situations as long as heavy pre-euthanasia sedation is used (for landmarks see section 4). Consult with NMFS if exsanguination is the only viable euthanasia option.

Lastly, depending on the stranding conditions and human safety considerations, sometimes the only option is to let the animal expire naturally without assistance.

3.3 Considerations of Chemical versus Physical Methods

There are different items to consider when choosing the best euthanasia method.

Chemical Methods	
PROS	**CONS**

● Reliable/effective when administered correctly ● Public perception in the U.S. is that this method is more common since it is used for domestic animals ● Pre-euthanasia sedatives/analgesics reduce pain and suffering incrementally prior to euthanasia. ● Does not destroy brain for postmortem examination	● Requires specialized expertise and training to administer properly ● Majority are controlled substances (require a license) ● Limited availability (quantities needed may not be stocked locally especially in the volumes needed for larger animals or for mass situations) ● Need of specialized needles for large whales and for different sizes of cetaceans ● Can be expensive ● Limited carcass disposal options if pentobarbital is used (proper disposal is needed to reduce secondary poisoning risk to scavengers and/or contamination of the environment) ● Blood vessel collapse/shunting/inability to access, requiring intracardiac or intraperitoneal administration ● Potential human safety risk from accidental exposure to drugs
Physical Methods	
PROS	**CONS**
● Easily attainable equipment (*e.g.,* law enforcement officers) ● Rapid death (except exsanguination method or if the target is missed) ● Minimal risk to scavengers if non-toxic ammunition is used or measures are taken to prevent exposure to scavengers of the lead fragments	● Licensed marksman ● Dependent on familiarity with the anatomy of the species ● Loud noise (ballistics) ● Possibility of ricocheting (off animal, substrate, etc.), not applicable to exsanguination ● Public perception is that these methods are not as humane ● Size restrictions (ineffective in animals larger than 8 meters) ● May increase human safety concerns and risks of injury ● Increases pain and distress if not immediately effective and without pre-sedation ● Destroys brain, precluding postmortem examination

3.4 General Recommendations and Ethical Considerations

Numerous ethical considerations are factored into the decision to euthanize a marine mammal, which is why the circumstance of every situation needs to be assessed thoroughly with the organizations and authorities involved. If euthanasia is identified as the best course of action for an animal's welfare, then it must be performed in a safe manner by trained and experienced staff with appropriate equipment (Hampton *et al.* 2014). All euthanasia methods should strive to provide the most rapid, painless, and humane death possible. The carcass must be disposed of per federal, state, tribal, and local requirements. For more detailed information on marine mammal carcass disposal methods, refer to the Carcass Disposal Best Practices.

4. Landmarks and Euthanasia

All figures presented in this section are by illustrator S. Rommel through the *CRC Handbook of Marine Mammal Medicine* (Gulland *et al.* 2018) or Barco *et al.* 2016.

4.1 Landmarks for Large Cetaceans

For large cetaceans, intramuscular administration of sedatives is usually injected into the epaxial muscles. The typical landmarks for intravenous injection for large cetaceans are 1) caudal vascular bundle, 2) peduncle veins, 3) dorsal fin vein, and 4) pectoral flipper vein (Gulland *et al.* 2018). However, working near the flukes of large cetaceans can be hazardous, so for a more rapid effect, most large cetaceans are euthanized via intracardiac administration following deep sedation. A detailed diagram for an intracardiac approach can be found in Barco *et al.* 2016 and Harms *et al.* 2014.

Large Cetaceans: Intracardiac Needle Size (Barco *et al.* 2016)	
Whale size: 12-25'	12 to 15 in. (30.5-38.1 cm), 16- to 20-gauge
Whale size: >25'	12 to 20 in. (30.5-50.8 cm), >18-gauge

4.2 Landmarks for Small Cetaceans

For small cetaceans, intramuscular administration of sedation drugs is usually injected into the epaxial muscles. The typical landmarks for intravenous injection for small cetaceans are 1) peduncle (caudal vascular bundle; requires a long needle - 1.5 to 3.5 in.), 2) fluke vessels, 3) dorsal fin vein, and 4) pectoral flipper vein (Gulland *et al.* 2018). Additionally, some small cetaceans are euthanized via intracardiac administration of euthanasia drugs, especially if the cetacean is shunting blood from the extremities. See Figure 5a for veins that can be used for chemical euthanasia. Figure 5b shows

landmarks for exsanguination.

Small Cetaceans: Intravenous Needle Size	
Calf	1.0 in (2.5cm), 18- to 22-gauge or butterfly set
Juvenile	1.0 in (2.5cm), 18- to 22-gauge or butterfly set
Adult	1.0 to 2.0 in. (2.5-5.0 cm), 18- to 22-gauge or butterfly set

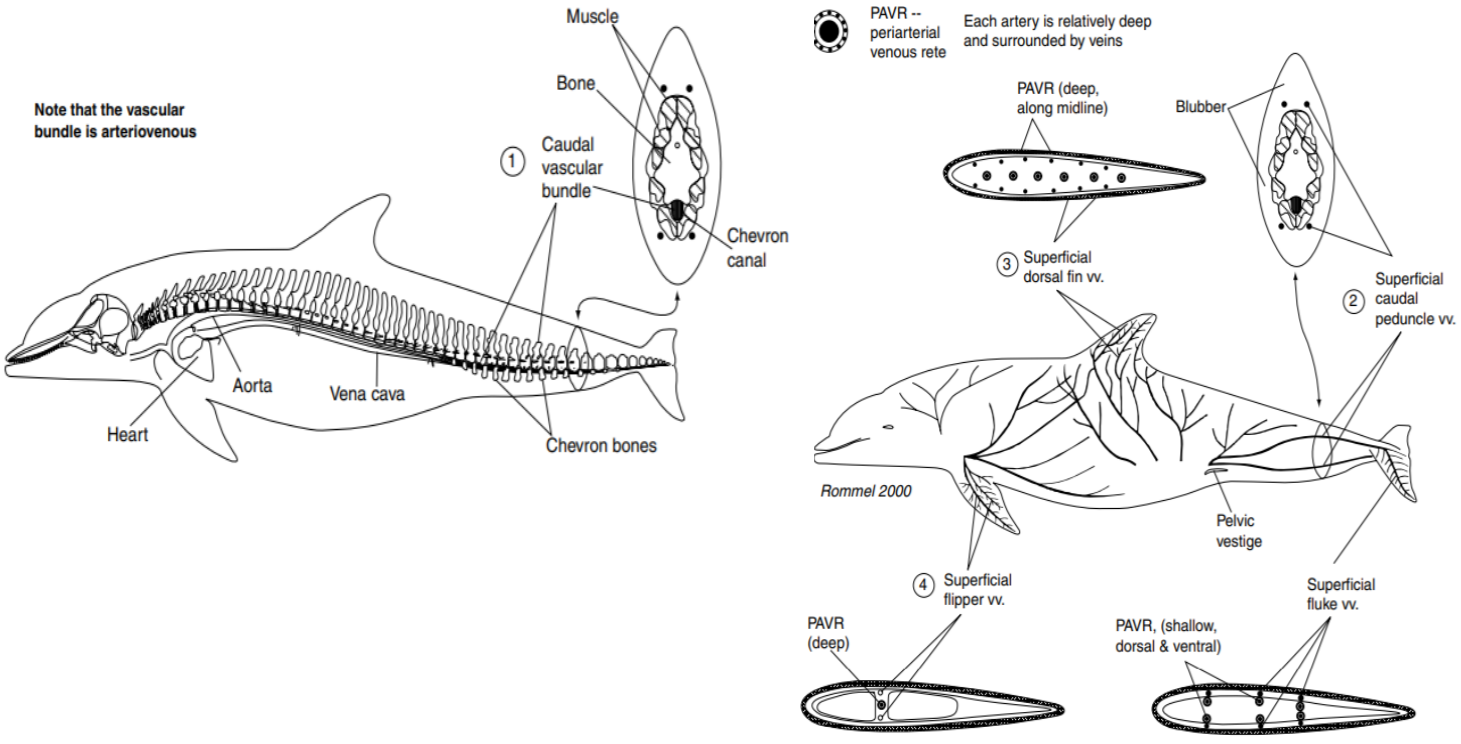

Figure 5a: Veins used for blood collection in small cetaceans (images ©Rommel)

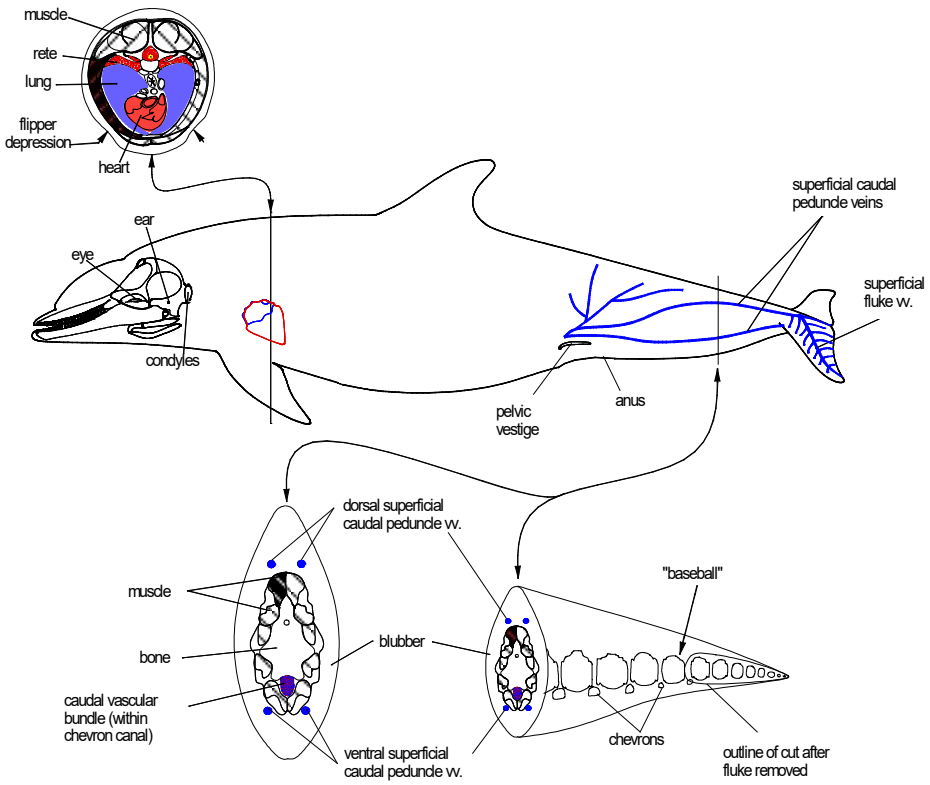

Figure 5b: Landmarks for Exsanguination in Cetaceans. Lateral and cross sectional view of peduncle vessels for intravenous access and knife/lance placement for exsanguination. The caudal vascular bundle is the target for exsanguination. Note that caudal to the anus, access to this vascular bundle is blocked by the chevron bones and a cutting interment must cut between the chevron bones. (images ©Rommel)

4.3 Landmarks for Pinnipeds

For pinnipeds, intramuscular administration of sedatives is usually injected into the caudal gluteal or epaxial muscles (Figure 6). In otariids, the landmarks (Figure 6) for intravenous administration include the 1) caudal gluteal vein, 2) interdigital veins of hind flipper, 3) subclavian, and 4) jugular vein. The landmarks for intravenous injections in phocids are 1) epidural vertebral vein and 2) interdigital veins of hind flipper (Gulland *et al.* 2018). Additionally, some pinnipeds are euthanized via intracardiac, intraperitoneal, or intrarenal administration of euthanasia drugs.

Pinnipeds: Needle Size	
Pup	1.0 to 1.5 in (2.5 - 3.8 cm), 18- to 20-gauge or butterfly set
Juvenile	1.0 to 2.5 in (2.5 - 6.4 cm), 18- to 20-gauge or butterfly set
Adult	1.0 to 5.0in. (2.5 - 12.7 cm), 18- to 20-gauge or butterfly set

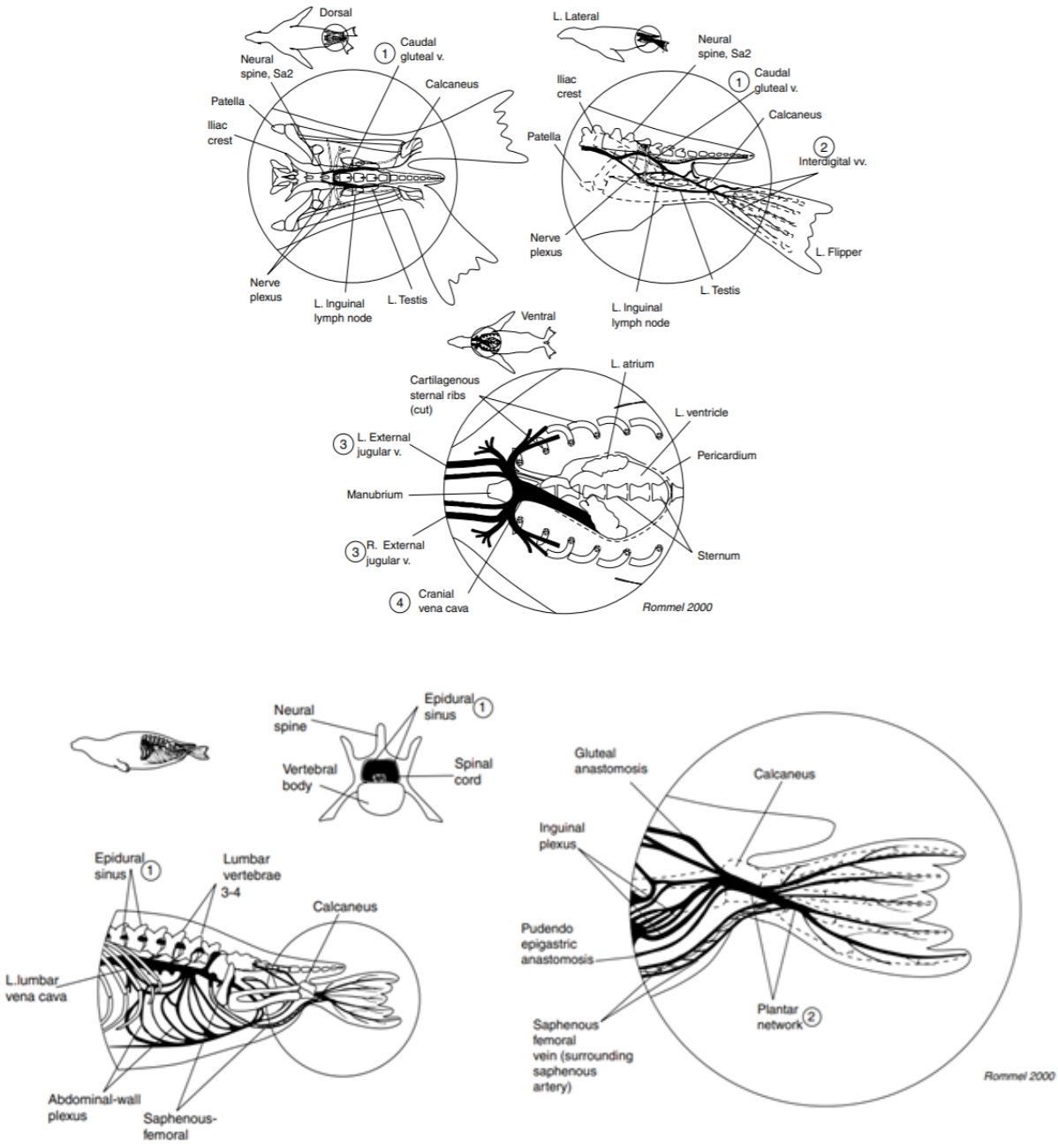

Figure 6: Veins used for blood collection in pinnipeds (images ©Rommel)

4.4 Specific-Species Information

Below are a few cetacean species-specific observations compiled from records that have some drug reaction results and recommendations for administering euthanasia. This list is not all encompassing and documentation still needs to be compiled to learn more about the euthanasia administration effects on different species. This reinforces the need to document future cases because such information can be used

to gain more insight on the efficacy and safety of different techniques and results. See Appendix B, C, and D for cetacean specific information. See Appendix D for pinniped information.

Species	**Observations/Recommendations** (Barco *et al.* 2016)
Delphinus delphis	● Sensitive animal (minimal handling and noise) ● Respond better to enclosed environments ● Recommend using a single agent euthanasia (IV) ● Common to have violent movement at time of death
Kogia spp.	● Recommend using pre-euthanasia sedation ● Shunting may occur, caudal peduncle or intracardiac administration may be needed ● *Kogia sima* tend to react more strongly to sedatives ● In *K. sima*, sedation alone will take a long time (greater than 45 minutes to several hours)
Grampus griseus	● Not recommended to use Alpha-II agonists for sedation (*e.g.*, xylazine, medetomidine) ● Recommend using Diazepam IV for a sedative
Tursiops spp.	● Recommend pre-euthanasia sedation
Globicephala spp.	● *G. melas* was sedated quietly but slowly (45 minutes) when using acepromazine and xylazine ● *G. macrorhynchus* had an agonal response when KCl was administered after acepromazine and xylazine
Steno bredanensis	● Recommend pre-euthanasia sedation
Eschrichtius robustus	● Not recommended to use xylazine (excitatory reaction)
Mysticetes (excluding xylazine for *Eschrichtius robustus*)	● Typically recommend preanesthetic and anesthetic drugs (midazolam, acepromazine, xylazine +/- butorphanol or other combination) following by saturated KCl with custom needles and basic pressurized canister (Harms *et al.* 2014)

5. Conclusion

Euthanasia reflects the veterinarian or authorized responder's desire to do what is best for the animal and serves to bring about the most appropriate outcome for an animal that is suffering. Stranding Network veterinarians and/or NMFS designated authorized responders have the experience and training to relieve unnecessary pain and suffering through euthanasia, if the recovery and return to the wild of a stranded marine mammal is not possible. The goal of euthanasia is to make the death of an animal as painless, quick, and free of distress as possible by using the best and most effective method for the specific situation. No one event is the same and each has their own aspects to consider. This document aids in the decision-making process and assists with providing information and guidance about marine mammal

euthanasia.

6. Acknowledgements

We would like to thank the many people who contributed information, protocols, and expertise to this Best Practices document. We would like to especially thank: International Fund for Animal Welfare, Michelle Barbieri, Craig Harms, and Sarah Sharp.

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Appendix A: Example Datasheets

Cetacean Euthanasia Data Record (Dec 2011)

Field Number: _____ **Species:** _____ **Date:** _____

Euthanizing Agency: _____ **Initial Report Time:** _____ **Time of Arrival:** _____

Officiating Veterinarian: _____ **Lead Responder:** _____

Location Description (Circle): ND Marsh/mudflat Beach In surf Still/shallow water Bar/shoal Other _____

Decision to perform euthanasia authorized by _____ **@ NOAA and reason for euthanasia:**

Pre- Euthanasia Data Time taken:

Heart rate	Palpate/auscultate ___ beats/1 min	**Attitude**	Alert Lethargic Non-responsive
Resp. rate; exudate	_____ breaths/ ____ min ; Y N	**Body position**	ND Upright Left side up Right side up
Resp. character	Strong Weak Regular Irregular Other	**Eyes** (Open / Closed)	Palpebral reflex- Y N Menace reflex- Y N
Body condition	ND Robust Normal Thin Emaciated	**Movement**	None Arch Fluke Swim Tremble Other
Body temp. (°F C)	Skin @ _____ Warm Cool ND	**Other:***(describe in comments)*	Vocalize Vomit Feces Urine Lesions

Method of Euthanasia: **Pre-euthanasia Sedation** **Chemical Method** **Non-Chemical Method** *(describe)*

(Circle all that apply)

Agent 1:

Location of animal for administration of Agent 1 (Circle): Water Shore Vehicle Facility Other

Time of admin.		**Heart rate**	Palpate/auscultate ___ beats/1 min
Drug & conc.		**Resp. rate**	_____ breaths/ ____ min
Amount		**Resp. character**	Strong Weak Regular Irregular
Route	IM IV IP IH IC Other	**Resp. exudate**	Y N (Clear Foam Blood Other)
Injection site	R L D V Body area:	**Attitude**	Alert Lethargic Non-responsive
Response to agent	Y N	**Movement**	None Arch Fluke Swim Tremble Other
Time observed		**Eyes** (Open/Closed)	Palpebral reflex- Y N Menace reflex- Y N
Type of response	↑ ↓ Activity ↑ ↓ Responsiveness ↑ ↓ Respirations ↑ ↓ Heart rate ↑ ↓ Other		

Agent 2:

Location of animal for administration of Agent 2 (Circle): Water Shore Vehicle Facility Other

Time of admin.		**Heart rate**	Palpate/auscultate ___ beats/1 min
Drug & conc.		**Resp. rate**	_____ breaths/ ____ min
Amount		**Resp. character**	Strong Weak Regular Irregular
Route	IM IV IP IH IC Other	**Resp. exudate**	Y N (Clear Foam Blood Other)
Injection site	R L D V Body area:	**Attitude**	Alert Lethargic Non-responsive
Response to agent	Y N	**Movement**	None Arch Fluke Swim Tremble Other
Time observed		**Eyes** (Open/Closed)	Palpebral reflex- Y N Menace reflex- Y N
Type of response	↑ ↓ Activity ↑ ↓ Responsiveness ↑ ↓ Respirations ↑ ↓ Heart rate ↑ ↓ Other		

Additional sections for agents and comments are located on the back of this sheet.

Post Euthanasia Data:

Time of death		**Carcass necropsied**	Y N ND
How determined		**Carcass disposal method**	Bury Landfill Render Other

Instructions for Filling Out the Cetacean Euthanasia Record

Overview

This cetacean euthanasia record has been developed and distributed as part of a NOAA John H. Prescott Marine Mammal Rescue Assistance Grant Program project titled: "The Collaborative Development of Stranded Cetacean Euthanasia Recommendations". The goal of this project is to develop recommendations for stranding networks to facilitate the humane euthanasia of live stranded cetaceans when rehabilitation or release is not an option.

The collection and compilation of data from this euthanasia record is a critical part of the project. These data, as well as national historic cetacean euthanasia information, will be compiled and entered into a database that was specifically designed with this data record for our project. An expert advisory panel will examine and evaluate this information. Potential correlations regarding effects and outcomes as they relate to various methods of euthanasia (ex. techniques, drug types and doses, etc.) and the stranding situations encountered (ex. mass or single stranding, species specific reactions, logistics, environmental conditions, etc.) will be investigated. This information, as well as published information, will be used to assist in the determination of cetacean euthanasia recommendations. A final workshop report including the recommendations will be distributed to all contributors and participants. All participants will be acknowledged for their contribution to this project in any resulting products.

This cetacean euthanasia record will also facilitate standardizing data collection for cetacean euthanasia efforts.

Below we have provided instructions and explanations for entering information and data into the cetacean euthanasia record.

Identification Section

Field Number: Unique identifying number originally assigned to the animal by responder/responding organization. This number should coincide with the same information on the Marine Mammal Stranding Report – Level A Data.

Species: Genus and species and/or common name of the animal

Date: Date that the euthanasia was performed

Euthanizing Agency: Name of the lead Stranding Agreement holder or agency performing the euthanasia

Initial Report Time: Time of earliest known report of the animal to the responding agency

Time of Arrival: Time of arrival on scene by the responding agency

*Be sure to use the **Comments** section on the back of this record to expand on observations, descriptions, etc.*

***Decision to perform euthanasia authorized by _____ @ NOAA and reason for euthanasia*:** enter the name of the NOAA staff person who authorized the euthanasia and document the factor(s) that influenced the decision to euthanize the animal (e*xample: severe injury, species, size, age, logistics, lack of rehab facility, etc.)*

Pre-Euthanasia Data Section

Pre-euthanasia data time taken: record the time of initial examination

Heart rate: record the number of heart beats per one minute (e*xample: 30 beats/1 min*)

Circle the method used to determine heart rate:

Palpate: feel heart beat with hand

Auscultate: listen for internal heart sounds, generally with a stethoscope

Resp. rate; exudate (Respiratory exudate): record the number of breaths per 3 minutes (e*xample: 4 breaths/3 min*)

Circle **Y** if exudate is observed around blowhole and write description in comments section

(*ex. clear, foam, blood, other*); Circle **N** if none is observed

Resp. character (Respiratory character): the quality, depth, ease of breaths

Circle most accurate descriptions regarding strength and regularity:

Strong: "normal" forceful breaths

Weak: depressed or shallow respirations

Pre-Euthanasia Data Section *(continued)*

Body temp.: ***(°F C)*** If actual body temperature taken, record degrees Fahrenheit or Celsius

Skin @ _____: describe anatomical area used to determine skin temperature

Circle most accurate description of palpated skin temperature:

Warm: a slight, comfortable heat evident

Cool: lacking heat, "clammy"

ND: no data

Attitude: the animal's behavior/action (or lack thereof)

Circle most accurate description(s):

Alert: animal is alert and aware, follows movement with eyes

Lethargic: animal is sluggish or inactive, eyes closed, little reaction to touch/sound

Non-responsive: animal is not reactive to stimuli

Body position: the position of the animal's body upon initial discovery

Circle the most accurate description(s):

ND: no data

Upright: laying on ventrum

Left side up: laying on right side, right lateral recumbency

Right side up: laying on left side, left lateral recumbency

Method of Euthanasia:

Circle all methods that apply:

Pre-euthanasia Sedation: Circle if chemical agent(s) administered to the animal prior to euthanasia, including: tranquilizers (*ex. acepromazine maleate*), sedatives (*ex. xylazine*), immobilizers (*ex. ketamine*) and/or general anesthetics (ex. *tiletamine-zolazepam*)

Chemical Method: Circle if chemical agent(s) administered to euthanize the animal

Non-Chemical Method: Circle if euthanasia method included the use of non-chemical methods

Describe: describe method(s) used (*ex. ballistics – include type of firearm and ammunition used; exsanguination – include type of equipment used and anatomical location; etc.*)

Agent # Sections

We have provided "Agent #" sections for you to record the administration of up to four chemical agents (*#1 & #2 on first page, #3 & #4 on second*). If you did not administer any chemical agents please record N/A after Agent 1. If you used more than 4 agents, please use additional data sheets.
The Agent sections refer to the animal's response to the actual drug or agent (or the effect of the agent on the animal), not the physical reaction to the administration of the agent(s).

Location of animal during administration of Agent #:
Circle most appropriate answer:
- ***Water:*** Circle if "Agent #" was administered while the animal was being maintained in water body
- ***Shore:*** Circle if "Agent #" was administered while the animal was being maintained on a beach, marsh, mudflat, sandbar, etc.
- ***Vehicle:*** Circle if "Agent #" was administered while the animal was being maintained in a vehicle
- ***Facility:*** Circle if "Agent #" was administered while the animal was being maintained at a facility
- ***Other:*** Circle if "Agent #" was administered while the animal was in an area not listed (e*xample: on boat, etc.*)

Time of admin. (administration): record the time that "Agent #" was administered
Drug and conc. (concentration): record the name of drug(s) administered and its concentration(s) (*example: number of mg/ml*)
Amount: Record the total amount of "Agent #" administered to the animal (*total mls or mgs*)
Route: Circle most appropriate answer(s):
- ***IM (Intramuscular):*** into the muscle
- ***IV (Intravenous):*** into the vein
- ***IP (Intraperitoneal):*** into the peritoneal cavity
- ***IH (Intrahepatic):*** into the liver
- ***IC (Intracardiac):*** into the heart
- ***Other:*** circle if route used is not listed and write in most appropriate answer

Injection site: Circle most appropriate answer(s) and then write the anatomical location(s) in which the agent was administered:
- ***R:*** right
- ***L:*** left
- ***D:*** dorsal
- ***V:*** ventral
- ***Body area:*** anatomical location (*ex. fluke, epaxial muscle, etc.*)
  (*ex. If administered in the dorsal side of right fluke =* ***(R) L (D) V body area:*** *fluke*)

Response to agent: Did animal exhibit any reaction to the drug administered
Circle most appropriate answer:
- ***Y:*** if a response was observed after "Agent #" administered (*ex: animal becomes more sedate/agitated, heart rate or respirations decrease/increase, etc.*) and complete the next sections for "time of response" and "type of response"
- ***N:*** if no response was observed. Skip "time of response" and "type of response" and move on to "heart rate", etc.

Time observed: Record time(s) response(s) was observed
Type of response: Describe response(s) to agent(s)
Circle most appropriate answer(s) (↑= increase, ↓= decrease)
- ***Activity:*** amount of body movement (*ex. Twitching, fluking, etc*)
- ***Responsiveness:*** animal's reaction to stimuli
- ***Respirations:*** number and/or strength of respirations/minute
- ***Heart Rate:*** number and/or strength of heartbeats/minute

Agent # Sections (*continued)*

Heart rate: same definitions and instructions as in the "pre-euthanasia" section
Resp. rate: same definitions and instructions as in the "pre-euthanasia" section
Resp. character (Respiratory character): same definitions and instructions as in the "pre-euthanasia" section
Resp. exudate (Respiratory exudate): same definitions and instructions as in the "pre-euthanasia" section
Attitude: same definitions and instructions as in the "pre-euthanasia" section
Movement: same definitions and instructions as in the "pre-euthanasia" section
Eyes: same definitions and instructions as in the "pre-euthanasia" section

Post Euthanasia Data Section

Time of death: record time that the animal was presumed deceased
How determined: record method(s) used to determine death of the animal (*example: no heart beat or respirations for specified amount of time, no palpebral reflex, rigor mortis present, etc.*)
Carcass necropsied: circle **Y** if the animal was necropsied, **N** if carcass was not necropsied or **ND** (no data) if unknown
Carcass disposal method: record method of disposal of the carcass
Bury: carcass placed in the ground and covered
Landfill: carcass taken to landfill
Render: carcass melted down
Other: sunk, towed, incinerated, chemically dissolved, etc.

Comments and Observations Section

Indicate, on a scale of 1 to 5 with 1 being worst case and 5 being best case, how the euthanasia proceeded. From the list provided, check any areas where you had concerns about the event and elaborate in the comment area below.

Also use this section to document details and/or explanations regarding the event that may not be captured in other documents.
Information may include:

- weather or other environmental conditions
- comments on the outcome of the event (*ex. did the event go well or poorly and reasons for this opinion*)
- details and/or a timeline of reactions to specific agents
- safety issues
- other personal observations or comments

Use extra pages if needed.

Appendix B: Cetacean Euthanasia Matrix Tables (Barco *et al.*, 2016)

Small Cetacean Euthanasia Matrix

#	Method	Drugs	Dose(s)	Route(s)	Pros	Cons	Concerns specific to euthanasia: Responder safety	Concerns specific to euthanasia: Ecotoxicity	Concerns specific to euthanasia: Public perception	Needs	Research needs
	Not chemically limited										
1	Sedation followed by euthanasia solution	see table of effective drugs and dosages	see table of effective drugs and dosages	IM (sedatives) IV, IC, IP,	we know it works	disposal concerns	moderate	high	low	Need more data on best sedatives and drug combinations, moderate length needles needed for larger animals, better guidance on safe IV delivery	Need to research tissue residue levels by disposal method; need more data on lowest effective dose & better weight estimators
2	euthanasia solution only		1ml/10lbs	IV, IC, IP	we know it works; relatively inexpensive	possible negative reactions, disposal concerns	moderate, if not in surf and not administering via fluke	high	low if no rxn		Need more data on lowest effective dose & better weight estimators; tissue residue levels
	Barbiturate limited										
3	Over-sedation	see table of effective drugs and dosages	see table of effective drugs and dosages	IM, IV	no barbiturate, can be achieved without controlled drugs	may take longer (~hour) in deep diving species, higher doses may still be a risk for relay toxicity	moderate	moderate	low	need to compile dosage data and protocol for determining when animal is over-sedated	
4	Sedation followed by KCl	see table of effective drugs and dosages	see table of effective drugs and dosages	IM, IV, IC, IP,	fewer chemicals, no barbiturate; volume KCl readily available and less expensive	requires deep sedation	moderate	low/moderate	low	need to compile dosage data and protocol for determining when animal is sedated enough to adminster KCl	
5	Sedation followed by exsanguination	see table of effective drugs and dosages	see table of effective drugs and dosages	IM, IV	fewer chemicals, no barbiturate, less expensive	requires deep sedation; needs training; disturbing to responders and public	high	low/moderate	high	need to compile dosage data and protocol for determining when animal is sedated enough, need better training and development specialized tools (two-bladed knives)	training and diagram(s) needed
	Chemically limited (for various reasons)										
6	exsanguination		NA	NA	no drugs; inexpensive	method of last resort; disturbing to responders and public	high	zero	high	need better training especially in thorascic cuts, two bladed knife?	training and diagram(s) needed
7	ballistics		NA	NA	no drugs, ammunition inexpensive	some responders need training and access to firearm, may be disturbing to responders and public	low	low	high	need better training, need to acquire appropriate weapons and ammunition; permitting	training and diagram(s) needed
8	natural death		NA	NA	no drugs	can take a long time; public safety; requires constant site/PR management	low	zero	high	need to educate local enforcement; NOAA deputize local enforcement; public safety issues	

Large Whale Euthanasia Matrix

#	Method	Drugs	Dose(s)	Route(s)	Pros	Cons	Concerns specific to euthanasia: Responder safety	Concerns specific to euthanasia: Ecotoxicity	Concerns specific to euthanasia: Public perception	Needs	Research needs
	Not chemically limited										
1	Sedation followed by euthanasia solution	see table of effective drugs and dosages	see table of effective drugs and dosages	IM, IV, IC, IP, IT, RB, IN	we know it works if we have enough drugs	need large drug volumes on hand; expensive, availabilty issues	moderate	high	low	Safe delivery of drugs for animal in water ; very long needles just developed, may need to stock-pile drugs	Need to research pole delivery of sedation; tissue residue levels
2	Euthanasia solution only			IV, IC, IP, IT	we know it works; inexpensive	need large drug volumes on hand; possible animal reactions	high	high	low if no rxn	Safe delivery of drugs for animal in water; very long needles just developed; may need to stock-pile euthanasia solution	Need to research pole delivery of euthsolution; tissue residue levels
	Barbiturate limited										
3	Over-sedation	see table of effective drugs and dosages	see table of effective drugs and dosages	IM, IV	no barbiturate, can be achieved without controlled drugs	drug volumes needed may not be readily available, may take >hr, higher doses may still be a risk for relay toxicity	moderate	moderate	low	need to compile dosage data and protocol for determining when animal is over-sedated; may need to stock-pile sedatives	
4	Sedation followed by KCl	see table of effective drugs and dosages	see table of effective drugs and dosages	IM, IV, IC, IP, IT, RB, IN	fewer chemicals, no barbiturate; volume KCl readily available and inexpensive	requires deep sedation	moderate	low/moderate, depending on agent, more info needed	low	safe delivery of drugs for animal in water ; very long needles just developed; need to compile dosage data and protocol for determining when animal is over-sedated;	
5	Sedation followed by exsanguination	see table of effective drugs and dosages	see table of effective drugs and dosages	IM, IV	fewer chemicals, no barbiturate	requires deep sedation; need training	high	low/moderate, depending on agent, more info needed	high	need better training; need to compile dosage data and protocol for determining when animal is over-sedated; need to design knife or lance (long, thin double bladed semi-stiff, knife-stiletto)	training and diagram(s) needed
	Chemically limited (for various reasons)										
6	Exsanguination		NA	NA	no drugs; inexpensive	method of last resort	high	zero	high	need better training, need to design knife or lance	training and diagram(s) needed
7	Cranial implosion (Cochran et al. 2012)		NA	peri-cranial	no drugs	logistics, training, carcass destruction, not foolproof	high	zero	unknown/needs education	legal issues regarding explosives handling, supply,	Can only be a reality in the US if federally supported for training/deployment (DOD; mining, demolition expts) directed by NOAA
8	Ballistics		NA	NA	no drugs, ammunition inexpensive	not on animals >7m	low	zero	high	need better training, need to acquire appropriate weapons and ammunition; permitting	training and diagram(s) needed
9	Natural death		NA	NA	no drugs	can take a long time; public safety; requires constant site/PR management	low	zero	high	need to educate local enforcement NOAA deputize; local enforcement public safety issues	

Appendix C: Effective Cetacean Euthanasia Methods (Barco *et al.* 2016)

Category	# of agents	*Acceptability	AGENT 1				AGENT 2				AGENT 3				AGENT 4			
			Generic Name	Dose	Route	Comments	Generic Name	Dose	Route	Comments	Generic Name	Dose	Route	Comments	Generic Name	Dose	Route	Comments
CONTROLLED DRUG LIMITED																		
Oversedation *It may require 3 x the normal dosage to accomplish euthanasia. Over-sedation with other drugs would also be acceptable, refer to the survey-based tables and use clinical judgement*	2	*Acceptable *(Once effects of IM administration are evident, it is acceptable to administer subsequent doses IC)*	Acepromazine	1 mg/kg	IM	Allow approximately 10 minutes between adminitrations. Repeat as needed to accomplish euthanasia. Adverse reaction has been observed when administered to *Delphinus* .	Xylazine	2 mg/kg	IM	Allow approximately 10 min for acepromazine to take effect prior to xylazine administration. Adverse reactions have been observed when administered to Grampus without prior administration of another sedative/tranquilizer. Repeat as needed to accomplish euthanasia.								
Heavy Sedation followed by KCl		**Conditionally Acceptable ONLY if animal is heavily sedated.	Midazolam	0.05-0.1 mg/kg	IM	Omit if not available or if controlled drugs are not an option. Allow approximately 10 minutes between adminitrations. Administer sedatives prn sequentially to effect prior to KCL.	Acepromazine	0.2-1 mg/kg	IM	Allow approximately 10 minutes between adminitrations. Administer sedatives prn sequentially to effect prior to KCL. Adverse reaction has been observed when administered to *Delphinus* .	Xylazine	3-4 mg/kg	IM (*or IV if safe*)	Allow approximately 10 minutes between administrations. Administer sedatives prn sequentially to effect prior to KCL. Adverse reactions have been observed when administered to *Grampus.*	KCL Administer supplementary doses of sedatives as necessary to render animal unresponsive to KCL injection	1-2 mmol/kg (75-150 mg/kg)	IC	IV may require higher dose than IC. Especially when carcass removal is an issue (ecotoxicological impact)
Heavy Sedation followed by exanguintation		**Conditionally Acceptable ONLY: 1) If animal is heavily sedated; 2)personnel is skilled and knowledge about proper severing sites	Midazolam	0.05-0.1 mg/kg	IM	Omit if not available or if controlled drugs are not an option. Allow approximately 10 minutes between adminitrations. Administer sedatives prn sequentially to effect prior to exsanguination.	Acepromazine	0.2-1 mg/kg	IM	Allow approximately 10 minutes between adminitrations. Administer sedatives prn sequentially to effect prior to KCL. Adverse reaction has been observed when administered to *Delphinus* .	Xylazine	3-4 mg/kg	IM (*or IV if safe*)	Allow approximately 10 minutes between administrations. Administer sedatives prn sequentially to effect prior to KCL. Adverse reactions have been observed when administered to Grampus.	Exsanguinate	Need better information and training. This method requires a solid anatomic knowledge, training and appropriate tools. Sites may include: ventral peduncle, brachial artery; *deep neck area *(*noting that cetaceans do not have large superficial carotid arteries)*		
Ballistics		**Conditionally Acceptable in small cetaceans ONLY if personnel are: well trained and knowledgeable	Need better information and training. Techniques can be found in RSPCA (1997) for small cetaceans, Blackmore (1995) for pilot whales and Suisted (1999) for baleen whales				Shooter must have proper equipment and knowledge of cetacean cranial anatomy. Site must have strict crowd contral.			Disarticulating the brain from the spinal cord at the occipital condyles is the goal. The recommended target area in guidelines is 1/2 way between the eye and flipper insertion with either dorsal or lateral entry. Never fire with barrel in direct contact with the animal. Be sure caliber size matches animal. Projectiles track off target with thick soft tissue coverage. Do NOT fire at the melon from the front of the animal, bullet may ricochet.					Not acceptible with sperm whales >7m. Conditionally acceptable in cetaceans under 7m in length.			
Explosives		Not currently acceptable in US	See Coughran *et al.* 2012				Must have qualified, permitted personnel and directional or shaped charges (see reference).								Permitting is likely to be a problem in the US.			

"Normal Sedation" drug dosages for cetaceans

Butorphanol	0.05 to .1mg/kg IM	Has been used in rigtht whales at 0.1 mg/kg with midazolam at 0.1 mg/kg
Diazepam	0.05 to 0.1 mg/kg IM	Less consistant than midazolam IM Meperidine 0.5 to 2 mg/kg IM. Has been used in conjunction with midazolam at 1 mg/kg or higher
Midazolam	.05 to .1 mg/kg IM	Can be given at higher levels and in combination with

Cetacean stranding situations and species can be extremely complex and diverse. Taking this into consideration ,below we have listed dosages for several agents NOT typically used in clinical cetacean sedation for those times when these are the only options available. These drugs are not generally used in healthy animals but may be considered for euthanasia if no other drugs are available. Typically the dosage for euthanasia is three times the theorectical dose in order to avoid suffering and promote a quiet death.

Other drugs used for cetacean euthanasia protocols BUT NOT USED FOR CLINICAL CETACEAN SEDATION

Acepromazine (1 mg/kg); Medatomadine (40-80 mcg/kg); Detomidine (30-60 mcg/kg); Xylazine (2mg/kg)

**** Acceptable methods: most consistently result in most humane cetacean euthanasia and fewer public safety hazards.***

*****Conditionally Acceptable methods: not considered humane and greater potential for public safety hazards.***

Appendix D: Large Whale Sedation and Euthanasia Drug Examples

In beached whales, sedation has been used to reduce resistance to limit the risk during procedures (Moore *et al.* 2010) or used prior to administering euthanasia. Below are Tables D1 and D2 outlining drug combinations for use in live stranded whales that may be released and sedation drugs to be used prior to euthanasia.

Protocol for sedation prior to euthanasia in large baleen whales (IFAW based on Harms *et al.* 2014):

Option 1: For smaller baleen whales (sub-adult minkes, humpback calves), use sedation & sodium pentobarbital. This may be utilized if the carcass can be disposed of properly to minimize secondary poisoning and environmental contamination.

Sedation and traditional pentobarbital euthanasia:

- Midazolam +/- Butorphanol 0.2 mg/kg IV/IM
- Wait 10-20 min, then acepromazine 0.2 mg/kg IV/IM
- Wait 20+ min, then Xylazine 2-4 mg/kg IV (IM)
- Wait 5 min (until sedation apparent) then sodium pentobarbital 1ml/10 lbs (87mg/kg) IV

Option 2: For larger baleen whales. If leaving a carcass in situ after using this option, all IM injection sites should be excised and disposed of properly.

Sedation and intra-cardiac KCL chloride:

- Midazolam +/- Butorphanol 0.2 mg/kg IV/IM
- Wait 10-20 min, then acepromazine 0.2 mg/kg IV/IM
- Wait 20+ min, then Xylazine 2-4 mg/kg IV (IM)
- Wait 5 min – assess sedation level, if not unconscious repeat dosing as needed
- Once the whale is unresponsive (no palpebral reflex, no menace response, no jaw tone, no blowhole tone, no flipper tone, no nociception/pain), inject 100 mg/kg supersaturated KCl solution via appropriate length intracardiac needle.

Table D1: Large whale sedative dosage administered IM or IV for whales that might be released (Moore *et al.* 2010, Moore *et al.* 2012)

Sedation Drug (can use either regular or compounded concentration, depending upon availability)	**Dosage (example calculation)**
Midazolam (compounded conc.)	0.1 mg/kg x 10,000 kg = 1000 mg = 20 ml of 50mg/ml solution
Midazolam (regular conc.)	0.1 mg/kg x 10,000 kg = 1000mg = 200 ml of 5mg/ml solution
Butorphanol (compounded conc.)	0.1 mg/kg x 10,000 kg = 1000 mg = 20 ml of 50mg/ml solution
Butorphanol (regular conc.)	0.1 mg/kg x 10,000 kg = 1000 mg =100 ml of 10mg/ml solution
Reversal Drug (can use either regular or compounded concentration, depending upon availability)	**Dosage (example calculation)**
Naltrexone (compounded conc.; reversal for Butorphanol)	0.1 mg/kg x 10,000 kg = 1000 mg = 20 ml of 50mg/ml solution
Flumazenil (reversal for Midazolam)	0.01 mg/kg x 10,000 kg = 100 mg = 1,000 ml of 0.1 mg/ml solution

Table D2: Large whale sedative dosage administered IM or IV prior to euthanasia (IFAW based on Harms *et al.* 2014)

Sedation and Euthanasia Drugs Option 1 – Smaller Whales	**Dosage (example calculation)**
Midazolam (compounded conc.)	0.2 mg/kg x 2,500 kg = 500 mg = 10 ml of 50mg/ml solution
Midazolam (regular conc.)	0.2 mg/kg x 2,500 kg = 500 mg = 100 ml of 5mg/ml solution
Butorphanol (compounded conc.)	0.2 mg/kg x 2,500 kg = 500 mg = 10 ml of 50mg/ml solution
Butorphanol (regular conc.)	0.2 mg/kg x 2,500 kg = 500 mg = 50 ml of 10mg/ml solution
Acepromazine	0.2 mg/kg x 2,500 kg = 500 mg = 50 ml of 10mg/ml solution
Xylazine	2-4 mg/kg x 2,500 kg = 5,000-10,000 mg = 50-100 ml of 100mg/ml solution
Pentobarbital	87 mg/kg x 2,500 kg = 217,500 mg = 558 ml of 390mg/ml solution

Sedation and Euthanasia Drugs Option 2 – Larger Whales	**Dosage (example calculation)**
Midazolam (compounded conc.)	0.2 mg/kg x 10,000 kg = 2,000 mg = 40 ml of 50mg/ml solution
Midazolam (regular conc.)	0.2 mg/kg x 10,000 kg = 2,000 mg = 400 ml of 5mg/ml solution
Butorphanol (compounded conc.)	0.2 mg/kg x 10,000 kg = 2,000 mg = 40 ml of 50mg/ml solution
Butorphanol (regular conc.)	0.2 mg/kg x 10,000 kg = 2,000 mg = 200 ml of 10mg/ml solution
Acepromazine	0.2 mg/kg x 10,000 kg = 2,000 mg = 200 ml of 10mg/ml solution
Xylazine	2-4 mg/kg x 10,000 kg = 20,000-40,000 mg = 200-400 ml of 100mg/ml solution
Potassium chloride (KCL saturated soln ~300mg/ml.)	100 mg/kg x 10,000 kg = 1,000,000 mg= 3,333 ml of 300mg/ml solution

Appendix E: Pinniped Sedation and Euthanasia Drug List

The following table lists the drugs currently used in pinnipeds, possible adverse effects, and the pharmacokinetics of each drug (*i.e.*, known information on how the body responds to the drug, including how the drug is absorbed, distributed, the rate of action and duration of effect, chemical changes in the body, and effects and routes of excretion of metabolites).

Drug Name	Dosage/Route of Administration	Use in pinnipeds	Possible Adverse Effects	Pharmacokinetics
Butorphanol	0.05-0.2 mg/kg PO, SQ, IV, IM (higher doses up to 1-5 mg/kg can be used for sedation pre-euthanasia) (Haulena and Schmidt 2018)	Opiate partial agonist/antagonist. Used in combination with midazolam or diazepam to aid in deeper sedation, as necessary; mildly analgesic	Adverse effects in dogs/cats include ataxia, anorexia or diarrhea (rare) and are typically less severe than adverse effects reported in full opiate agonists. May cause CNS depression or excitation in dogs. Can increase parasympathetic tone and decrease blood pressure and heart rate; these cardiovascular effects are similar to but lesser than opiate agonists. (Plumb 2008)	Fully absorbed with oral administration but undergoes substantial first-pass effect. Fully metabolized in liver. Onset of action is 3 min. in horses with peak effect at 15-30 min and duration of action up to 4 hours. (Plumb 2008)
Diazepam	0.1-0.3 mg/kg IV (up to 0.5-1 mg/kg IV for heavy sedation prior to euthanasia) (Haulena and Schmidt 2018, Plumb 2008)	A benzodiazepine used as a sedative (anxiolytic, muscle relaxant, hypnotic) for capture events or as a pre-anesthetic.	Dogs may exhibit CNS excitement; in horses may cause muscle weakness and ataxia; in cats may cause irritability, depression, aberrant demeanor.	Highly lipid soluble and widely distributed throughout the body; readily crosses blood-brain barrier and is highly bound to plasma proteins; metabolized in liver to active metabolites nordiazepam, temazepam, and oxazepam, which are eliminated primarily in urine.
Midazolam	0.15-0.3 mg/kg IV, IM (higher doses up to 1-2 mg/kg can be used for sedation pre-euthanasia)	An injectable benzodiazepine used as a sedative for capture events or as a pre-anesthetic.	Few adverse effects have been reported in humans including effects on respiratory and cardiac rates and blood pressure; other effects reported in humans include pain on injection, local irritation, headache, nausea, vomiting, and hiccups. Possibility of respiratory depression is a principal concern in veterinary patients.	Rapidly and nearly completely absorbed after IM injection; highly protein-bound and rapidly crosses the blood-brain barrier; metabolized in liver; elimination half-life in dogs averages 77 minutes and in humans is approximately 2 hours.

Potassium Chloride	100mg/kg IV (saturated solution 300mg/ml)	Euthanasia. Requires heavy pre-sedation with other sedatives prior to use.		
Sodium pentobarbital	60-120 mg/kg IVCRC Handbook, 6th Ed.)	Euthanasia.	Barbiturates depress the CNS in descending order starting with the cerebral cortex and loss of consciousness progressing to anesthesia; with overdose, deep anesthesia progresses to apnea due to depression of the respiratory center, followed by cardiac arrest (AVMA 2020).	Onset of action within 1 minute after IV administration. Distributes rapidly to all body tissues with highest concentrations in the brain and liver.
Tiletamine/ Zolazepam (Telazol)	1 mg/kg IM, IV (higher doses up to 5-10mg/kg can be used for sedation pre-euthanasia)	Anesthetic/tranquilizer would be used for pre-medication to make animal more amenable to handling for euthanasia.	Apnea, bradycardia, tremors reported in multiple phocid species; mortalities have occurred in small numbers of animals at higher doses (Haulena and Schmidt 2018). Can cause respiratory depression and apnea in most species, temporary pain is associated with IM injection (likely due to low pH).	Little pharmacokinetic information is available. Rapid onset of action (within 8 min in cats/dogs); mean duration of anesthesia is 27 min in dogs.

*References: Haulena, M. and T. Schmitt. 2018. Anesthesia. In: CRC Handbook of Marine Mammal Medicine, Third Edition, L.A. Dierauf, F.M.D. Gulland, and K. L. Whitman (eds.), CRC Press LLC, Boca Raton. Pp. 587-606; Plumb, D.C. 2008. Veterinary Drug Handbook, Sixth Edition. Blackwell Publishing, Minnesota. 1120p

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Appendix F: Euthanasia Questions and Answers

Q: What is euthanasia?

A: The term "euthanasia" comes from Greek roots and means "a good death." It is typically used in veterinary medicine to describe the humane ending of the life of an individual animal in a way that minimizes or eliminates pain and distress (AVMA 2020). Euthanasia reflects the veterinarian or authorized responder's desire to do what is best for the animal and serves to bring about the most appropriate outcome for an animal (AVMA 2020).

Q: How ethical is euthanasia?

A: Numerous ethical considerations are factored into the decision to euthanize a marine mammal, which is why the circumstances of every situation need to be assessed thoroughly with the organizations and authorities involved. If euthanasia is identified as the best course of action for an animal's welfare, then it must be performed in a safe manner by trained and experienced staff with appropriate equipment (Hampton *et al.* 2014). All euthanasia methods should strive to provide the most rapid, painless, and humane death possible.

Q: When does the Marine Mammal Stranding Network consider euthanasia for marine mammals?

A: Before deciding euthanasia is the most appropriate course of action, it is important to fully assess the health of the individual animal and evaluate the logistics of response and rehabilitation *(e.g.*, can the animal be safely moved, are there available rehabilitation facilities, is the animal likely to survive transport, does the species do well in rehabilitation settings?). Situations that may necessitate the consideration of euthanasia include animals suffering with severe injuries (*e.g.*, internal or external) or illness (*e.g.*, disease or poor body condition). If an animal has a serious injury or illness from which recovery is unlikely, euthanasia may be the best and most humane course of action to alleviate its prolonged suffering; however, each scenario will be carefully evaluated on a case-by-case basis to provide the most humane outcome for the individual animal. Once euthanasia has been determined to be necessary, then it is important to decide the best euthanasia method that has the ability to induce loss of consciousness and death

with the minimum pain and distress, while having little to no negative environmental impact that cannot be mitigated. Selection of the most appropriate method of euthanasia depends on the situation, including:

- species and number of animals involved
- animal size(s)
- available resources (including means of animal restraint)
- skill of personnel
- available carcass disposal method
- safety in administering the methods
- need for biological samples for diagnostic testing or other purposes

The decision to euthanize a marine mammal is made by the NOAA Fisheries Regional Stranding Coordinator, the local Stranding Network group, the attending veterinarian, the Marine Mammal Health and Stranding Response Program staff, and/or other management agencies, depending upon the circumstances.

Q: When does the Stranding Network consider euthanasia for large whales?

A: For cases involving large whales, euthanasia is discussed on a case-by-case basis and qualified veterinarians and biologists may recommend euthanasia as the most humane option for the whale based on the size and condition of the animal, the circumstances, and available resources. If a large whale with a serious injury (*e.g.*, internal or external) or illness (*e.g.*, disease; poor body condition) can be safely approached, the best and most humane course of action may be to euthanize it to alleviate prolonged suffering. However, given the immense size of full grown large whales (50+ feet long and 55,000 pounds or more), euthanasia may not be feasible or safe because of the location and limited local resources; in such cases, it may be necessary to let nature take its course.

Euthanasia is typically considered when a stranded large whale is in overall poor condition (emaciated, malnourished), has severe internal or external injuries, or is a dependent calf with no adult present. Length of time the whale remains onshore is also a consideration, because gravity and the immense size of the animals start to crush their internal organs. Time is not on the animals' side, and the longer it remains stranded, the more suffering it experiences. The decision

to euthanize is made by the NOAA Fisheries Regional Stranding Coordinator in consultation with the local Stranding Network group, attending veterinarian, and Marine Mammal Health and Stranding Response Program staff. If a decision is made to euthanize, the procedure is conducted by qualified personnel under the authorization of the MMHSRP permit, a Stranding Agreement, or a government employee authorized under MMPA Section 109(h).

Q: How are marine mammals humanely euthanized? What special considerations need to be made to humanely euthanize large whales given their immense size?

A: Euthanasia methods are commonly classified into two main categories: (1) chemical methods, and (2) physical methods.

Chemical methods include injectable drugs such as tranquilizers, sedatives, anesthetics, barbiturates (*e.g.*, pentobarbital), and potassium chloride. Chemical methods can also include inhalant drugs such as anesthetic gasses (*e.g.*, isoflurane).

Physical methods of euthanasia include ballistics (dispatched from conventional firearms) for animals under 26 feet (8 meters), explosives (not currently used in the United States), and exsanguination (with sedation administered prior).

All methods have pros and cons, and some methods may have more limitations and concerns than others. There may also be limited information on the outcomes of certain methods for specific species or taxa, so careful consideration is always given to lessons learned from previous cases in order to select the best and most humane option.

Currently, the preferred method for euthanasia of large whales is through a chemical dose of potassium chloride administered directly into the heart via an intracardiac needle. This method has been used successfully in several cases with little secondary poisoning risk to animals that may scavenge the carcass afterwards (thus allowing for natural carcass disposal). It is a relatively safe and inexpensive method for resource-limited Stranding Networks. Since this method first involves administering deep sedation drugs, the animal is fully unconscious (or "asleep") before the potassium chloride is administered. The location and condition of the stranded animal (shallow vs. deeper water; wet vs. dry) may impact the ability of a Stranding Network veterinarian to safely approach the whale to administer the potassium chloride solution, in which

case other euthanasia methods may be used.

Q: Does euthanasia cause pain to large whales? How do they react when euthanized? How long does euthanasia take?

A: When using potassium chloride chemical euthanasia, large whales are first given a high dose of a strong sedative to reduce their pain and stress before administering the dose of potassium chloride to stop their heart. The initial doses of sedatives are given with long, skinny needles that do not cause much pain, similar to a vaccine shot. The sedatives will result in the animal being unconscious or "asleep" prior to euthanasia. After the sedatives have taken effect, the potassium chloride is then delivered through a large intracardiac needle that reaches the heart. Potassium chloride works by inhibiting the ability of the heart muscles to contract and effectively stops the heart when administered. When delivering the potassium chloride, the veterinarian needs to get backflow from the needle to make sure it is in the right place. This process may cause the whale to bleed at the injection site, which can look much worse than it is since a relatively small amount of blood can mix with the nearby water, and can be noticeable.

As it dies, the whale may react by opening its mouth or raising its pectoral flippers or flukes. This is always difficult to witness. Since the animal is sedated and unconscious, its suffering is minimized.

The time of death varies for each case; in past cases using only sedation, the time to death ranged from ~50 minutes to 2.5 hours given the immense size of large whales and how slow their metabolism is compared to smaller cetaceans. When potassium chloride is used, the time to death ranges from ~4 minutes to 10 minutes after administration of the drug.

Stranding Network veterinarians and/or NOAA Fisheries designate authorized responders that have the experience and training to relieve unnecessary pain and suffering through euthanasia, if the recovery and return to the wild of a stranded marine mammal is not possible. The goal of euthanasia is to make the death of an animal as painless, quick, and free of distress as possible by using the best and most effective method for the specific situation. Species-specific sedation and euthanasia protocols are available for some species and should be used whenever possible to provide the best euthanasia process for each animal.

Q: Does euthanasia cause pain to small cetaceans or pinnipeds? How do they react when euthanized? How long does euthanasia take?

A: Both small cetaceans and pinnipeds are generally given a sedative to reduce pain and stress during the administration of euthanasia drugs. The sedatives will often result in the animal being unconscious or "asleep" prior to euthanasia. In some small cetacean species, excitatory reactions have been observed with the administration of sedatives. This reaction is involuntary and does not indicate the animal is in greater pain or distress. When euthanizing by chemical methods (*e.g.*, barbiturates), the time of death varies for each case – from seconds to several minutes. If firearms are used, it should be completed by trained personnel so the shot provides rapid death.

Stranding Network veterinarians and/or NOAA Fisheries designate authorized responders that have the experience and training to relieve unnecessary pain and suffering through euthanasia, if the recovery and return to the wild of a stranded marine mammal is not possible. The goal of euthanasia is to make the death of an animal as painless, quick, and free of distress as possible by using the best and most effective method for the specific situation. Species-specific sedation and euthanasia protocols are available for some species and should be used whenever possible to provide the best euthanasia process for each animal.

Q: What chemical drugs are most used for euthanasia?

A: Barbiturates (*e.g.*, pentobarbital) are the most commonly used chemical euthanasia agents in marine mammals, and are the same as those commonly used in companion animals. They are usually administered intravenously or intracardially. These barbiturate chemical agents are rapid and limit discomfort in the animal during euthanasia. Sedation is also usually administered prior to administration of the barbiturates, to further reduce any pain or stress.

If carcasses must be left in place or will be buried on the beach, the use of intracardiac potassium chloride is the preferred chemical method in large cetaceans, small cetaceans, or larger pinnipeds because there is little risk of secondary poisoning to scavengers (Harms *et al*. 2014; WC Network Guidance 2018; Whitmer *et al.* 2021). A two-step euthanasia process should be used with this method since the marine mammal must be heavily sedated (unconscious or

"asleep") prior to administration of the potassium chloride (Harms *et al*. 2014).

Q: When do you use the physical methods of euthanasia?

A: If chemical methods are not practical, the use of firearms has been demonstrated to be an effective physical method for euthanizing small marine mammals (Blackmore *et al.* 1995). This method may be most appropriate in remote or logistically challenging situations. While it results in a rapid death and the equipment is typically readily available, the shooter must have knowledge of the anatomical locations of the heart and brain so that the gunshot is accurately placed and will be most effective. Ballistics are not recommended for cetaceans larger than 26 feet (8 meters) because the size and density of the skull may not allow effective penetration of ballistics from conventional weapons. Large cetaceans have different skull anatomy and/or extremely tough skin and blubber layers that restrict projectile penetration.

In other countries, explosives have been used in large whale euthanasia situations when other methods were unavailable or difficult, but these methods are not currently developed, trained, or available for use in the United States.

There are a few other methods of physical euthanasia that are not as common or typically recommended. Exsanguination, although not considered an acceptable primary method, can be used in remote or logistically challenging situations as long as heavy pre-euthanasia sedation is used.

Q: Do euthanized carcasses harm the environment?

A: If an animal was euthanized by chemical agents (*e.g.,* pentobarbital) that may cause secondary poisoning to scavengers (*e.g.,* birds, coyotes, sharks that might feed on a carcass), then the carcass needs to be disposed of in a safe manner that prevents risk to wildlife or the environment. Carcasses containing high concentrations of pentobarbital euthanasia solutions must be incinerated, rendered, composted, or buried in licensed landfills that accept pentobarbital carcasses to prevent the accidental poisoning of scavengers (Geraci *et al.* 2005). If carcasses must be left in place or will be buried on the beach, the use of intracardiac potassium chloride is the preferred chemical method in large cetaceans, small cetaceans, or larger pinnipeds because there is little risk of secondary poisoning to scavengers (Harms *et al*. 2014; WC Network

Guidance 2018; Whitmer *et al.* 2021). If a carcass is too large to move, and sedatives were administered, the sedative injection site should be excised and disposed of appropriately.

All carcass disposals should follow local, state, tribal, and federal laws and regulations. An animal euthanized by physical methods can be disposed of by beach burial, leaving in place, landfill, towed out to sea, rendering, composting, or incinerating depending on the situation and physical access.