

# Assessing Aquatic Mammal Welfare While Assessing Differing Values and Imperfect Tradeoffs

## Supplemental Appendix

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**Supplemental Appendix.** Aquatic mammal-specific considerations of the *Five Domains Model* of animal welfare (Mellor, 2017), with additional considerations that directly or indirectly affect aquatic mammal welfare listed in bold and underlined

Domain	Component	Captive or stranding considerations	Notable tradeoffs or dilemmas	Free-ranging considerations	Notable tradeoffs or dilemmas
<b>1. Nutrition</b>	Water (Note that this addresses dietary water; bodies of water are covered under Domain 2, Environment.)	Dietary fresh water availability is primarily a concern for semi-aquatic species that are not housed with access to bodies of water for swimming, although this is a concern for all species that are not housed in water due to medical needs.	Stranded marine mammals which cannot be placed in rehabilitation facilities will generally not have access to food and water, and will become dehydrated.	There is the presumption that free-ranging diets are appropriate and meet aquatic mammals' needs.	Seasonal or other transient or permanent changes in food quantity or quality can adversely affect aquatic mammal health. This variation can be caused by or magnified by human activities. The degree to which humans accept responsibility for naturally or anthropogenically compromised food source quantity, quality, or availability, and their willingness to take corrective action, is variable and can face profound practical obstacles.
	Food	For all species, high-quality food is needed. Where warranted (e.g., fish diets), appropriate supplements are needed.	Dietary food items may need to be varied by species of food item, nutritional content, aquatic mammal health, or other specific needs.		
	Malnutrition	Malnutrition is generally a sign of substantively substandard captive conditions or is associated with stranding.	If malnourished animal's condition cannot be improved <i>in situ</i> and there is not a facility that can accept the animal due to space limitations, euthanasia may need to be considered.		
<b>2. Environment</b>	Water quality and availability	Engineering standards include maximum coliform counts, pH, salinity, levels of chemical additives (e.g., chlorine/halogens), filtration and water flow, and particulates. Absence of access to water is a source of frustration to captive (production) mink.	Sterile aquatic environments (e.g., algae or microbial communities) may not be ideal for aquatic mammal health, whereas managed microbial communities may be more appropriate. Access to water may need to be limited for some health management needs.	There is the presumption that free-ranging environments are appropriate and meet aquatic mammal needs.	Seasonal or other transient or permanent changes in the environment can adversely affect aquatic mammal health. This variation can be caused by or magnified by human activities. The degree to which humans accept responsibility for naturally or anthropogenically compromised environments and their willingness to take corrective action are variable and can face profound practical obstacles.
	Temperature	Maintenance within species' normal temperature is advisable.	Whether animal welfare benefits from the use of normal seasonal variations in water temperature has not been fully explored. The impact of housing healthy animals outside of their normal temperature range and the degree to which this can be compensated for (e.g., cool water availability for polar bears housed where air temperatures exceed normal temperature ranges) has been incompletely characterized.		
	Auditory	Cetaceans may strand secondary to inner ear hemorrhage caused by anthropogenic sonar sources. Captive aquatic mammals may be exposed to acute and chronic auditory stimuli that could compromise hearing and health.	There is little information available on the impacts of chronic and acute auditory stimuli on captive aquatic mammal health and welfare. Ad hoc approaches are used to balance the impacts of sound from construction near captive aquatic mammals against facility needs. Medical management strategies for addressing inner ear hemorrhage in cetaceans have not been established.		

<b>External stimuli (including environmental diversity)</b>	Environmental variation in water (e.g., bubbles or waves), temperature, light, animals (e.g., wild birds), and other features can serve as sources of enrichment. Spatial diversity and irregular enclosure shapes can serve to provide enrichment and support positive affective states. Some species (e.g., platypus [ <i>Ornithorhynchus anatinus</i> ]) require nest boxes.	Animals can become acclimated to some external stimulation to a point to which it is no longer enriching. Assessments of positive and negative impacts due to external stimuli are largely subjective.
<b>Structural safety</b>	Structural safety can include an absence of sharp edges, compromised exhibit structure, and other factors that pose a physical risk to captive animals.	Retrofitting some aquatic mammal enclosures can pose a source of distress due to noise, dust, or other disturbances, whereas moving the animals can also be a source of distress and/or transient short-term suboptimal housing.
<b>Shade</b>	Absence of shade has been hypothesized to compromise ocular health in cetaceans and is recommended for debilitated animals and where thermoregulatory concerns exist. Shade is also a general husbandry consideration for semi-aquatic species as it is for terrestrial species. The amount of shade needed may be influenced by the substrate coloration. Positioning animals so that they are not forced to gaze into the sun while being fed or for other activities may moderate the impact of shade absence.	Research documenting optimal shade needs for aquatic mammals has not been published and may need to be context-specific (e.g., dependent upon sun declination, health needs, etc.).
<b>Natural substrate</b>	The industry standard is concrete, and this might not be optimal.	Research on the use of sand vs concrete and other substrates has not been published. Tradeoffs include hygiene and engineering concerns with nonconcrete substrates.
<b>Appropriate substrate coloration</b>	Bright reflective colors are hypothesized to be a risk for ocular health.	Research supporting optimal enclosure coloration and reflectiveness has not been published.
<b>Exposure to natural sunlight</b>	Excessive exposure to sunlight can cause overheating and dehydration. Exposure to natural sunlight might be enriching.	Outside of aquatic primates (e.g., Japanese macaque [ <i>Macaca fuscata</i> ]) that presumably need sunlight to avoid vitamin D deficiency (or a dietary replacement), absence of exposure to sunlight is of uncertain impact on aquatic mammals.
<b>Match between individual's needs and facility structure</b>	This consideration will vary by species, individual, and social groupings and addresses aquatic mammals' need for functional space and their use of existing facilities.	There is little objective data for addressing this concern, and there is a need for good judgment when there are specific medical, social, or other considerations.

**3. Health**

Disease	Avoidance and treatment of disease is a part of basic veterinary and management activities.	Tradeoffs exist between the impacts of medical therapy (including pain and distress) and available medical therapies. Exact causes of disease and appropriate therapies can be undetermined. Quantification of disease in aquatic mammal populations can result in subjective interpretations of cause, effect, and status of animal welfare.	The health of free-ranging aquatic mammals can vary due to natural or anthropogenic causes.	The degree to which humans can address the health of free-ranging animals is limited by practical constraints. Broad-scale changes in human activities that can benefit aquatic mammal health range from some degree of success (e.g., reducing boat-induced trauma) to no change (e.g., continued contamination of aquatic environments).
Injury	Injuries can occur due to facilities, natural environments, contaminants, human activities, conspecifics, other animal species, and other causes.	Rake marks in cetaceans are typical lesions seen in captive and free-ranging populations, and the degree to which this would be considered acceptable under captive conditions is currently subjective and prone to misinterpretation by those who are unfamiliar with normal cetacean interactions.		
Functional impairment	Some functional impairments can be managed in captive conditions with minimal compromise in animal welfare. Functional impairments due to poor captive management are generally unacceptable.	Stranded cetaceans can have functional impairments of uncertain causes.		

	<b>Veterinary care</b>	Veterinary programs must meet the animal's routine and emergency needs, and should be strongly supported by animal training programs (for long-term captive animals) that minimize animal distress and the need for manual restraint. Preventive health and pathology programs, trained immediate response capabilities, and the availability of external consultants, as needed, are necessary. Facilities and equipment for separation from conspecifics, obtaining routine weights, and provision of intensive medical care are warranted. Knowledge of species-specific analgesic, anesthetic, and sedative protocols is required.	Use of training for low/no handling distress is limited for rehabilitating and stranded animals. While many facilities invest in expensive medications for treatment, as needed, the tradeoff between the benefits and deleterious effects of some treatments must be addressed on a case-by-case basis. Short-term pain or distress may occur with some veterinary activities and be judged as acceptable when beneficial long-term outcomes are anticipated.	Veterinary care is generally limited to rehabilitation settings, capture for research or other reasons, and population-level monitoring.	Veterinary care may be limited by practical constraints and may be focused on populations, by necessity. Orientations toward individual animal welfare can divert resources available to address population-level animal welfare and vice versa.
	<b>Monitoring</b>	Continual, critical assessment of aquatic mammals' animal welfare status, as well as processes for resolution of "problems," is essential for ensuring animal welfare. This is also a reflection on management effectiveness.	Monitoring of stranded mammals in high surf environments can be difficult and pose human safety concerns.		
<b>4. Behavior</b>	Individual and conspecific	Expression of "normal" behavior is an important indicator of animal welfare.	Ranges of "normal" behaviors can be subjective. Some contexts (e.g., medical disability) may prevent expression of normal behaviors.	Individual, intra-, and interspecific behaviors serve as behavioral baselines.	Individual and population-level variations in behavior exist. Intra- and interspecific agonism (including predation) exists.
	Social with other species	Some captive management scenarios may result in interactions with other vertebrate taxa. Co-housing of compatible aquatic mammal species may occur.	Housing piscivorous aquatic mammal species with fish can be enriching for the mammal but a source of distress for prey fish, as well as a potential source of parasite transmission to mammal species.		
	Social with humans	<i>Caretakers:</i> Positive interactions with staff, as also addressed below for human-animal bond, is optimal. For rehabilitation animals and some other situations, minimization of distress in association with humans is optimal.  <i>Public:</i> Permanent collection animals in public interaction settings should have the option to choose whether interactions occur (e.g., provision of escape routes, animals do not depend on food rewards to maintain body condition, etc.) and whether or not to participate in shows. There should be continual and close staff supervision to ensure that animals are not exposed to negative actions by the public, and that positive interactions are optimized to the extent possible. The public should be kept distant to minimize distress in stranded animals.	Whether or not humans can serve as sources of enrichment and overall benefit to the affective states of aquatic mammals, and which interactions are most beneficial, have been incompletely documented.  Whether or not humans can serve as sources of enrichment and benefit the affective states of aquatic mammals overall, and which interactions are most beneficial, have been incompletely documented.	Behavioral responses to humans can include inquisitiveness, aggression, predation, fear, and avoidance.	Interactions with humans can result in close affiliations that engender positive perceptions from humans. However, close interactions can also be associated with acclimatization of aquatic mammals to humans. This can result in aquatic mammal behavior that conflicts with human interests and results in injury or death to the aquatic mammal.
<b>5. Mental components</b>	Breathlessness Thirst Pain Nausea Hunger Dizziness Sickness Debility Weakness	These components are best addressed via effective husbandry and veterinary programs.	Complete elimination of these components is not possible (e.g., some animals develop illness regardless of whether under captive or wild circumstances), and some may be transiently required (e.g., fasting before surgery). Improvements in pain management are an ongoing process.	These components can occur due to natural or anthropogenic causes. Under natural conditions, humans generally do not feel responsible for aquatic mammals' mental stimulation or attainment of positive affective states.	Practical constraints generally limit the impact that humans can have on these components. Limiting or modifying activities that incidentally harass or injure aquatic mammals (e.g., limiting boat speed) can be practical but difficult to reinforce. Human behavior during capture of aquatic mammals for research, harvest, or other activities can be optimized to limit negative affective states, pain, and other components, although elimination of these outcomes is not generally practical.

	Anxiety Fear Helplessness Other forms of distress	Avoidance of these components is best addressed by minimizing sources of distress, by providing animals with options for avoiding sources of distress, the existence of trusting relationships with caretakers, and the maintenance of consistency in the environment.	Excessive consistency can lead to boredom for long-term captive maintenance. These components may not be practically addressed for rehabilitation and stranded animals, and medications may be required that reduce the degree of these components.		
	Mental stimulation	This outcome is commonly addressed via training and enrichment programs, and less commonly via environmental characteristics, and is a subjective assessment.	Continued research on characterizing mental stimulation outcomes, optimizing strategies for addressing mental stimulation, staff understanding of how to optimally apply these strategies, and animal welfare-related outcomes is warranted.		
	Positive affective state/happiness	Long-term captive aquatic mammals are presumed to have positive affective states (be happy) based on subjective assessments of typical behavior, structured or unstructured play, and other activities.	This is a key outcome for animal welfare and is of concern to the public. However, this is difficult to characterize. The “happiness” of rehabilitation animals may be compromised as a part of morbidity and/or captivity, but it is accepted with the assumption that happiness returns upon release to the wild. Assumptions of happiness in the wild, and perceptions that happiness is not possible in captivity, have not been sufficiently documented to permit conclusions; the balance of uncertainties in food availability and risks of harm in the wild are difficult to balance compared with what can be provided to captive animals.		
Human elements	Training	Training of long-term captive animals for husbandry and veterinary procedures is an important strategy for minimizing distress associated with some captive activities and can be useful for mental stimulation and positive relationships with caretakers.	Continued research on optimizing animal training methods, staff understanding of how to optimally apply these methods, and animal welfare-related outcomes is warranted as poor training methods can cause animal confusion and distress. There is also a need to characterize the degree to which humans can address animals’ social needs and contribute to animals’ affective states.	These are generally not considered worthy or practical human obligations to free-ranging aquatic mammals.	Aversive training of polar bears ( <i>Ursus maritimus</i> ) to human habitations can potentially prevent euthanasia of animals that are considered threats to humans. Cooperative human–aquatic mammal fishing wherein free-ranging mammals voluntarily participate and benefit from the harvest may benefit the animals’ welfare. Free-ranging aquatic mammals may play with human artifacts as a source of enrichment but could also be harmed by these artifacts (e.g., serve as gastrointestinal foreign bodies if swallowed or strangle aquatic mammal body parts).
	Enrichment	Provision of enrichment is recognized as a strategy for providing mental stimulation and avoidance of boredom. This can be accomplished via a variety of routes and for multiple objectives (e.g., mental stimulation, olfactory stimulation, and other animal senses and/or affective states).	There is the need to proactively evaluate enrichment for safety and other considerations as well as conduct ongoing assessment to ensure that enrichment objectives are met. Variety is generally warranted to continue animal interest.		
	Human–animal bond	A strong and balanced human–animal bond is critical for optimizing captive animal welfare. This bond depends on a high level of caring for what animals experience, as well as the knowledge, skills, and critical thinking required to achieve outcomes that benefit the animals’ welfare.	This is a subjective, difficult to document characteristic, particularly as this can be a very dynamic outcome. There is a need to fully document institutional cultures that favor strong human–animal bonds with positive animal welfare benefits.		
	“Work” expectations	As mentioned above, aquatic mammals optimally are allowed the option of participating in “work” expectations.	In contrast to shows and public interactions, some work (e.g., military) expectations may result in harm to humans or human interests if aquatic mammals choose not to meet work expectations.		
	Institutional culture and support	Quality control and assurance of a focus on continuously assessing and improving animal welfare are outcomes of institutional cultures that manage for these perspectives.	Strategies for addressing institutional culture exist, but characterizations of institutional cultures that benefit aquatic mammal welfare have not been adequately characterized.	Formal oversight and regulation of human management of free-ranging aquatic mammals is a generality; regulatory and institutional (e.g., NGO) guidelines generally apply to aquatic mammals.	There is a subjective balance between institutional guidance or addressing the welfare of free-ranging aquatic mammals and the need for flexibility to address novel or dynamic contexts.
	Records	Quality recordkeeping of all aspects of aquatic mammal management is needed to ensure quality control of animal welfare and to permit external review of animal welfare concerns. Appropriately designed and archived records can also serve as the basis for research for improving animal welfare.	Quality recordkeeping is dependent upon caretaker commitment and conscientiousness as well as an institutional culture that strives for optimized animal welfare and continual development of strategies for improving animal welfare.		

**External review**

External review by knowledgeable personnel can ensure the presence and application of appropriate protocols for ensuring animal welfare.

Absence of external review can permit the persistence of unacceptable animal welfare concerns. External reviewers must be sufficiently knowledgeable and capable of balanced welfare assessments to ensure that the welfare needs of animals are met and are the central objective for the review.

**Population and resource management**

Aquatic mammals under human control should be managed at the population level to match available resources and long-term animal welfare. This extends to breeding decisions to avoid deleterious genetic-based concerns, or minimization of “surplus” animals (e.g., use of sperm sorting to produce females and avoid a surplus of males).

This is an inexact process, and desirable management outcomes vary by value systems. There can be dissonance between individual animal and population-level needs.

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