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Differentiating Serious and Non-Serious Injury of Marine Mammals:

Report of the Serious Injury Technical Workshop 10-13 September 2007, Seattle, Washington

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United States Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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This Technical Memorandum contains summaries of presentations given at the 2007 Serious Injury Technical Workshop. These summaries (sections 3.0-6.0) were prepared by the author(s) of the presentations; therefore, statements and recommendations represent the views and opinions of the respective presenter(s). The summaries do not necessarily represent the views of the workshop Steering Committee or the National Marine Fisheries Service (NMFS). The Steering Committee did not make any substantive changes to the summaries without permission from the author(s). The Steering Committee edited the summaries only to correct grammatical errors and other minor edits.

This Technical Memorandum contains summaries of plenary and subgroup discussions that occurred during Days 1-3 of the workshop. While many of the comments and suggestions provided by the individual participants represent shared opinions among the participants, the intent of these discussions was not to reach consensus recommendations. Instead, the intent was to gather input from each individual participant based on his or her expertise and experience. For this reason, the discussions summarized in this Technical Memorandum do not represent consensus recommendations from the workshop participants to NMFS.

This Technical Memorandum contains recommendations of Federal Government participants and the workshop Steering Committee concerning the guidance and process for distinguishing serious from non-serious injuries. These recommendations do not represent official NMFS policy.

Executive Summary

Background

The Marine Mammal Protection Act (MMPA) section 117 requires the National Marine Fisheries Service (NMFS) to prepare stock assessment reports (SAR) for all stocks of marine mammals that occur in waters under the jurisdiction of the United States. These reports summarize human-caused mortalities and serious injuries to marine mammals by source. In addition, MMPA section 118 requires commercial fisheries to reduce mortality and serious injury of marine mammals to insignificant levels approaching a zero mortality and serious injury rate. This charge requires that NMFS distinguish between injuries that are serious and those that are not serious. NMFS defined "serious injury" in regulations (50 CFR 229.2) as "any injury that will likely result in mortality." However, the MMPA and its legislative history do not provide guidance on how severe an injury must be to qualify as "serious."

To promote national consistency for interpreting the regulatory definition of serious injury, NMFS convened a workshop in April 1997 to discuss available information related to the impact of injuries to marine mammals incidental to commercial fishing operations (Angliss and DeMaster, 1998). Since 1997, additional information has been collected on human-caused injuries to marine mammals and survival rates of certain individual and/or species of marine mammals. For this reason, NMFS convened the Serious Injury Technical Workshop on September 10-13, 2007, with the primary objectives to: 1) review the recommendations and guidance from the 1997 workshop; 2) review new information obtained since the first workshop; and 3) discuss the use of, and necessary changes to, existing guidance for distinguishing serious from non-serious injuries. The 2007 workshop extended beyond discussions related only to marine mammal-commercial fishery interactions. Although other sources of human-caused injuries were mentioned during the workshop, much of the 2007 workshop discussions focused on types of injuries commonly observed from encounters with vessels and fisheries (e.g., blunt force trauma, penetrating, hidden, and gear and hooking injuries) because these interactions have been examined to the greatest extent.

The 2007 workshop consisted of two sessions: an open session (Days 1-3) attended by over 65 federal and non-federal participants, and a closed session (Day 4) attended by 36 federal participants. NMFS invited workshop participants based on their expertise in marine mammal serious injury issues, including marine mammal management, policy, marine mammal biology, pathobiology, and veterinary medicine. The primary purposes of Days 1-3 were to present a synthesis of new science and to gather new information on injured marine mammals. The information from Days 1-3 was also used to provide a scientific basis for recommendations by government officials in the closed session on Day 4. The primary purpose of the closed session (Day 4) was to draw on Days 1-3 presentations and discussions to consider potential changes to the existing serious injury guidance and associated administrative approaches.

The topics addressed during Days 1-3 included:

1) Evaluation of current data and determination systems (in plenary and breakout sessions);
2) Overview of new information on survival of injured marine mammals (large cetaceans, small cetaceans, pinnipeds, and manatees);

3) Pathobiology of injuries; and
4) Breakout activities to address key questions on the topic of determining severity of injuries to marine mammals.

Presentation Sessions (Days 1-2)

Current Data Sources and Collection Programs
This session included presentations by the NMFS observer, stranding, and disentanglement programs. The presentations were designed to describe the types of information that are collected in these programs and the scope (including limitations) of the kinds of information that are reasonable to collect. In this way, these presentations provided workshop participants with a background of the information used to distinguish between serious and non-serious injuries in order to inform discussion and lead to realistic suggestions on the types of additional data needs for distinguishing between serious and non-serious injuries.

Current Serious Injury Determination Systems
Representatives from each NMFS region provided presentations describing the types of data collected and associated challenges, evaluating regional approaches for distinguishing serious from non-serious injuries, and the overall challenges each region faces. Workshop participants then discussed and evaluated the procedures described in each presentation for distinguishing serious from non-serious injuries. The most common comments from participants indicated a need for more national consistency in distinguishing between serious and non-serious injuries, and for increased communication between data collectors, stranding networks, and the staff responsible for distinguishing between serious and non-serious injuries.

New Information on the Survival of Injured Marine Mammals: Large Cetaceans, Small Cetaceans, and Manatees
Invited speakers presented and discussed new information obtained over the past decade on the survival of injured marine mammals by taxonomic group (large cetaceans, small cetaceans, and manatees). The presentations were designed to present information gathered since the 1997 workshop from longitudinal studies of various cetacean populations and scar-based analyses. Following the presentations, in plenary sessions, participants discussed if and how the information presented could be incorporated into the system for distinguishing serious from non-serious injuries.

Pathobiology of Injuries
The final group of presentations addressed the pathobiology of injuries. The presentations were designed to describe how pathobiology may be used to determine whether an injury caused or contributed to the death of an animal, information that could serve to help predict the lethality of injuries to marine mammals. Following the presentations, in plenary sessions, participants discussed if and how the information presented could be incorporated into the system for distinguishing serious from non-serious injuries.

Subgroup Discussions (Day 3)

Day 3 of the workshop was devoted to morning and afternoon breakout session discussions, which were designed to address the following six topics without gathering consensus recommendations from the group (i.e., all suggestions were considered opinions of individual participants):

Concurrent morning sessions:

1) Longitudinal/survival rates from a modeling perspective;
2) Categorization of injuries and pathological consequences: Gear-related injuries; and
3) Categorization of injuries and pathological consequences: Sharp, blunt force, and penetrating injuries.

Concurrent afternoon sessions:

4) Large cetaceans;
5) Small cetaceans; and
6) Pinnipeds and other species.

Key Outcomes from Day 3 Subgroup Discussions

Most common comments related to serious injury criteria and the determination process:

1) NMFS should develop a risk assessment/matrix approach for use in distinguishing serious from non-serious injuries that is nationally consistent (incorporating flexibility while limiting subjectivity) and is based on factors affecting survival for each marine mammal species.
2) NMFS should gather a national panel annually, including NMFS staff from each region, decision analysis experts, and other external experts to review serious injury determinations.
3) NMFS should revise (and/or develop) and use consistent terminology based on the observable physical injuries to objectively describe injuries.

Diverging views related to serious injury criteria and the determination process:

1) Aside from assuming all injuries are mortal unless proven otherwise, a new approach is unlikely to significantly increase the number of injuries classified as "serious injuries" for large whales if it relies on anecdotal reports, as do current large whale systems. Even in well-documented populations, individuals are under observation by researchers for a small fraction of their lives.
2) We must differentiate between means for improving the accuracy of injury assessment and prognosis when injuries are observed, and means for improving the accuracy of estimates of all (observed and unobserved) human-caused mortality and serious injury. The reliance on anecdotal reports makes these distinctly different for large whales.

Most common comments related to data needs:

1) The observer, stranding, and disentanglement programs are collecting useful data and have improved over the past decade. Further improvements could be made by standardizing data between all regions and between data collection programs; and increasing communication and coordination between NMFS staff from different programs and different regions.

2) NMFS should examine data collected by a variety of NMFS programs and external researchers to determine whether injured animals are documented in multiple data sets.
3) NMFS should continue longitudinal studies for currently well-monitored marine mammal populations and begin (or expand) studies for lesser or unmonitored populations.

Most common comments related to the categorization of injuries:
1) Participants agreed the following are or could be considered serious injuries for all marine mammals species:
   - Ingestion of gear;
   - Constricting lines or lines with the potential to constrict as an animal grows;
   - Head trauma; and
   - Body cavity penetration.
2) Physiological and behavioral differences exist between species and taxonomic groups, which cause differences in the severity of certain injuries for different species.
3) Vessel size and speed "source" information should be included in any guidance for distinguishing between serious and non-serious injuries because the severity of the injury resulting from a vessel strike depends on the size and speed of the vessel.

Recommendations of Government Staff: Updated Process and Guidance for Distinguishing Serious from Non-Serious Injury (Day 4)

The primary purpose of the closed federal session was to draw on presentations and discussions from the first three days, consider what has worked well in distinguishing serious from non-serious injuries since 1997, what has not worked well, and recommend potential changes to the existing serious injury guidance (Angliss and DeMaster, 1998, and subsequent NMFS Regional publications).

<u>Key Outcomes from Day 4 Discussions:</u>
1) Most of the Day 4 participants expressed the view that the current serious injury guidance should be revised and updated to capture current knowledge about impacts of injury on marine mammals and to strive for improvements in national consistency in distinguishing serious from non-serious injuries.

2) Nearly all the Day 4 participants recognized that NMFS is close to where it should be in the assessments of detected animals. However, undetected injuries exist that are not being incorporated into population assessments; therefore, NMFS needs to devise a mechanism to better account for undetected injuries. One participant noted that the development of one single set of criteria was not the appropriate mechanism for accounting for undetected injuries.

3) The Day 4 participants supported the development and publication of an official NMFS policy to reflect the recommended serious injury guidance discussed on Day 4 (outlined below). This policy should strive for nationally consistent criteria to use when distinguishing serious from non-serious injuries, while allowing for flexibility in data-rich situations. This policy should also include what is meant by the term "likely" in the definition for serious injury, "injury that will *likely* result in a mortality," because

different working definitions are currently in use for different stocks nation-wide. However, participants specifically recommended against pursuing these changes through rulemaking. Creating a legal definition for the term *likely* in the serious injury definition is not necessary and could have far-reaching implications beyond the realm of serious injury determinations.

4) Federal participants constructed a matrix containing revised guidance for distinguishing serious from non-serious injuries (Table 1 below). The recommendations are expressed in matrix form for 33 injury scenarios arrayed across three taxonomic groups of marine mammals: large cetaceans, small cetaceans, and pinnipeds. Table 1 is based upon guidance from the 1997 Workshop (Angliss and DeMaster, 1998) and technical memoranda from NMFS' Northeast Fishery Science Center (Cole *et al.*, 2005; Cole *et al.*, 2006; Nelson *et al.*, 2007; Glass *et al*., 2008). Table 1 categorizes each injury scenario as "serious injury," "not serious injury," or "cannot be determined/case specific" (CBD) for each taxonomic group. Table 1 incorporates a synthesis of new information presented and discussed at the workshop. This table is meant to provide guidance for distinguishing serious from non-serious injuries in situations where there are little data and/or the resighting of an injured animal is unlikely. The purpose of the table is to improve national consistency in distinguishing serious from non-serious injuries, and to provide a starting point for developing future NMFS policy for distinguishing serious from non-serious injuries.

   In addition to specific revisions and updates to the existing guidance, Table 1 outlines two substantial recommended changes from the current process for distinguishing between serious and non-serious injuries as a whole:

   - Expand the dichotomous determination process (all injuries are "serious" or "not serious") to include a third category representing uncertain cases (injuries can now be classified as "serious," "not serious," or "CBD/case specific"). The recommended addition of a "CBD/case specific" category takes into account two circumstances: 1) there is insufficient information about the impact of a particular injury to determine whether it is a serious or non-serious injury; and/or 2) it is possible to determine whether a particular injury is a serious or non-serious injury, but additional factors must be considered on a case-by-case basis.
   - Create guidance with separate criteria for different marine mammal taxonomic groups, to allow for differences in physiology and in the amount and type of data that are available.

Table 1: Recommended Serious Injury Criteria for Different Taxonomic Groups *

SI = Serious Injury; **NSI** = Not Serious Injury; **CBD/case specific** = Potential SI, but either 1) insufficient information about the impact of a particular injury, or 2) additional factors must be considered on a case-by-case basis to determine the severity; **n/a** = not applicable; **TBD**= To Be Determined; __ = areas lacking near-complete agreement among Day 4 participants.

Criterion	Injury/Information Categories	Large Cetaceans	Small Cetaceans	Pinnipeds
Pre-Existing Guidance (included in Angliss and DeMaster (1998) and/or NEFSC publications, retained with no changes)				
1	Ingestion of gear or hook	SI	SI	SI
Modified Criteria (some aspects retained from guidance provided in Angliss and DeMaster (1998) and/or NEFSC publications, with some changes or additions)				
2	A free-swimming animal observed at a date later than its human interaction, exhibiting a marked change in skin discoloration, lesions near the nares, fat loss, or increased cyamid loads, etc.	SI	SI	SI
3	Gear constricted on any body part, or likely to become constricting as the animal grows	SI	SI	SI
4	Uncertain whether gear is constricting, but appendages near the entanglement's point of attachment are discolored	SI	SI	SI
5	Anchored/immobilized (not freed)	SI	SI	SI
6	Head trauma (including eye injuries)	SI	SI	SI
7	Hook in mouth (excluding case 9 below), no trailing gear	CBD/case specific	SI	SI
8	Hook confirmed in head (excluding mouth), no trailing gear	NSI	SI	CBD/case specific
9	Hook confirmed in lip only, no trailing gear	n/a	CBD/case specific	CBD/case specific
10	Gear attached to free-swimming animal with potential to 1) wrap around pectoral fins/flippers, peduncle, or head; 2) be ingested; or 3) accumulate drag	CBD/case specific	SI	SI
11	Animal freed from gear and released without gear	CBD/case specific	CBD/case specific	CBD/case specific
12	Social animal separated from group or released alone	CBD/case specific	CBD/case specific	CBD/case specific
13	Dependent animal (e.g., calf, pup) alone post-interaction	SI	SI	SI
14	Wrap(s) of gear around pectoral fin/flippers, peduncle, head, abdomen, or chest	CBD/case specific	SI	SI
New Criteria				
15	Deep, external cut or laceration to body	CBD/case specific	CBD/case specific	CBD/case specific
16	Body cavity penetration by foreign object or body cavity exposure	SI	SI	SI

Criterion	Injury/Information Categories	Large Cetaceans	Small Cetaceans	Pinnipeds
17	Visible blood loss	CBD/case specific	CBD/case specific	CBD/case specific
18	Loss or disfigurement of dorsal fin	CBD/case specific	CBD/case specific	n/a
19	Partially severed flukes (transecting midline)	SI	SI	n/a
20	Partially severed flukes (not transecting midline)	CBD/case specific	CBD/case specific	n/a
21	Partially severed pectoral fins or flippers	CBD/case specific	CBD/case specific	CBD/case specific
22	Severed pectoral fins or flippers	CBD/case specific	CBD/case specific	SI
23	Entanglement, immobilization or entrapment of a certain duration before being freed (TBD, species-dependent)	SI	SI	SI
24	Body trauma not covered by cases 6, 15, and 16 above (e.g., broken appendages, hemorrhaging)	CBD/case specific	CBD/case specific	CBD/case specific
25	Detectable fractures	SI	SI	SI
26	Hook in appendage, without trailing gear or with trailing gear that does not have the potential to wrap, be ingested, or accumulate drag	NSI	NSI	NSI
27	Animal brought on vessel deck following entanglement/entrapment	n/a	SI	CBD/case specific
28	Vertebral transection	SI	SI	SI
29	Collision with vessel of certain minimum size (TBD, species-specific)	SI	SI	CBD/case specific
30	Collision with vessel traveling at a certain minimum speed (TBD, species-specific)	SI	SI	CBD/case specific
31	Collision with vessel below a certain size threshold (TBD, species-specific)	CBD/case specific	CBD/case specific	CBD/case specific
32	Collision with vessel traveling below a certain speed threshold (TBD, species-specific)	CBD/case specific	CBD/case specific	CBD/case specific
33	Dog Bites°	n/a	n/a	CBD/case specific

***** See section 8.1 for additional details on the intent and purpose of Table 1.

° This criterion was not included by the Day 4 Participants. The workshop Steering Committee added this criterion for clarity. About ¾ of the Day 4 participants preferred subsuming dog bites under criteria 6, 15, 16, or 24 (depending on the injury inflicted by the dog bite). The pinniped experts generally preferred to include dog bites in a separate category, because of the additional potential for inter-species disease transmission.

Acronyms

AFSC	Alaska Fisheries Science Center
AKR	Alaska Regional Office
CBD	Cannot Be Determined/Case Specific
ESA	Endangered Species Act
FWS	U.S. Fish and Wildlife Service
GAMMS	Guidelines for Assessing Marine Mammal Stocks
LOF	List of Fisheries
MMC	Marine Mammal Commission
MMHSRP	Marine Mammal Health and Stranding Response Program
MMPA	Marine Mammal Protection Act
NEFSC	Northeast Fisheries Science Center
NER	Northeast Regional Office
NGO	Non-Governmental Organization
NMFS	NOAA's National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	NOAA's National Ocean Service
PBR	Potential Biological Removal Level, as defined by the MMPA
PIFSC	Pacific Islands Fisheries Science Center
PIR	Pacific Islands Regional Office
SEFSC	Southeast Fisheries Science Center
SER	Southeast Regional Office
SWFSC	Southwest Fisheries Science Center
SWR	Southwest Regional Office
TBD	To Be Determined
TRP	Take Reduction Plan
TRT	Take Reduction Team
ZMRG	Zero Mortality Rate Goal, as defined by the MMPA

1.0 Introduction

The Marine Mammal Protection Act (MMPA) section 117 directs the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) to prepare stock assessment reports (SAR) for all stocks of marine mammals that occur in waters under the jurisdiction of the United States. These reports summarize human-caused mortalities and serious injuries by source. The MMPA also states that a stock of marine mammals is designated as a strategic stock if it is listed as depleted under the MMPA, is listed or is likely to be listed as or threatened or endangered under the Endangered Species Act (ESA), or has serious injury and mortality levels exceeding the stock's Potential Biological Removal (PBR) level.[1]

MMPA section 118 governs the taking of marine mammals incidental to commercial fishing operations and directs NMFS to categorize fisheries based upon whether a fishery has frequent (Category I), occasional (Category II), or remote likelihood (Category III) of incidental mortality and serious injury of marine mammals. In addition, MMPA section 118(b) requires commercial fisheries to reduce mortality and serious injury of marine mammals to insignificant levels approaching a zero mortality and serious injury rate.[2] Section 118(f) of the MMPA states that NMFS shall develop a take reduction plan (TRP) for strategic stocks interacting with Category I or II fisheries, and may develop a TRP for any marine mammal stocks interacting with Category I fisheries, to reduce incidental mortality and serious injury levels to specified goals.

Under the MMPA, NMFS must manage serious injuries and mortalities of marine mammals incidental to commercial fishing operations. This charge requires that NMFS be able to distinguish between injuries that are serious and those that are not serious. Serious injury has regulatory meaning under the MMPA; however, the MMPA and its legislative history do not provide guidance on how severe an injury must be to be considered serious. To implement MMPA sections 117 and 118, NMFS defined "serious injury" in regulations (50 CFR 229.2) as "any injury that will likely result in mortality."

To promote national consistency in the interpretation of the regulatory definition of serious injury, NMFS convened a workshop in April 1997 to discuss available information related to the impact of injuries to marine mammals incidental to commercial fishing operations (Angliss and DeMaster, 1998). These discussions resulted in a framework upon which NMFS could develop a consistent approach for determining which injuries should be considered serious injuries.

The guidance developed at the 1997 Workshop (Angliss and DeMaster, 1998) served as the best available scientific information for distinguishing serious from non-serious injuries. NMFS staff have used the information from the 1997 workshop in evaluating injury reports submitted by commercial fishers, fishery observers, and stranding and disentanglement network participants to determine which injuries should be considered serious. Since 1997, additional information has been collected on human-caused injuries to marine mammals and survival rates of certain individual and/or species of marine mammals. For this reason, NMFS convened the 2007

[1] *Potential Biological Removal (PBR)* is the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.
[2] Referred to as the Zero Mortality Rate Goal (ZMRG). NMFS identified ZMRG as 10% of a stock's PBR level (69 FR 73338; July 20, 2004).

Serious Injury Technical Workshop to review information obtained since 1997, review recommendations and guidance from the 1997 workshop and the use of this guidance in distinguishing serious from non-serious injuries, and discuss any necessary changes to the process and guidance for distinguishing serious from non-serious injuries.

2.0 The 2007 Serious Injury Technical Workshop Goals, Objectives, and Organization

Additional information has been collected that may allow NMFS to re-evaluate whether a particular injury to a marine mammal would likely result in the death of that animal. In addition, annual updates to the SARs required under MMPA section 117 indicate that, while incidental take of marine mammals in fisheries is a large source of human-caused serious injury, injuries to marine mammals from vessel collisions are also relatively common. Accordingly, participants at the 2007 workshop recognized the need to extend the guidance for distinguishing between serious and non-serious injuries of marine mammals beyond injuries sustained by interactions with fisheries, to include other anthropogenic causes of injuries. Although other sources of human-caused injuries were mentioned during the workshop, much of the workshop discussions focused on types of injuries commonly observed from encounters with vessels and fisheries (e.g., gear[3] and hooking, penetrating, blunt force trauma, and hidden injuries) because these interactions have been examined to the greatest extent. The 2007 workshop was organized to focus on the type of injury, regardless of the cause or source of the injury.

2.1 Description and Causes of Injuries to Marine Mammals

Marine mammals interact with multiple anthropogenic activities, which sometimes result in injury or death of the animal. Injuries observed in marine mammals include blunt force trauma, penetrating, and fishery-related injuries. Human interactions can also cause various internal injuries to marine mammals that cannot be detected by visual or external observations.

<u>Gear and Hooking Injuries</u>
Gear and hooking injuries most commonly observed in marine mammals include injuries resulting from interactions with hooks, fishing line, fishing nets, etc. Marine mammals generally become entangled in gear around the head, body, and, in cetaceans, the flukes, pectoral fins, or dorsal fin. Entanglement can lead to constricting lines wrapped around the animal or anchoring (immobilizing) the animal. Entanglement around the head can impede the animal's ability to feed. Constricting line can cut into or through blubber, muscles and bone (i.e., penetrating injuries), or can constrict blood flow to or sever appendages. Line with pots/traps attached or heavy gear with or without anchors attached can create drag as the animal swims altering the energetics of swimming. Drag can cause the lines to constrict, further injuring the animal or pulling the lines through an appendage entirely. If anchoring (immobilization) does not cause the animal to drown or asphyxiate, it can cause injuries resulting from constricting lines, starvation from the inability to feed, and internal injuries from prolonged stress and/or severe struggling.

Hooking injuries and ingested gear are most common in small cetaceans and pinnipeds, but have been observed in large cetaceans (e.g., sperm whales). The severity of the injury depends on the species, whether ingested gear includes hooks, whether the gear works its way into the gastrointestinal (GI) tract, whether the gear penetrates the GI lining, and the location of the hooking (e.g., embedded in the animal's stomach or other internal body parts).

[3] For the purposes of this Technical Memorandum, *gear* is defined as any part of the fishing equipment, excluding the hook.

Penetrating Injuries (Non Gear- or Hook-Related)
Penetrating injuries can result from interactions with a variety anthropogenic activities. In addition to the penetrating injuries caused by interactions with fishing gear and hooks described above, penetrating injuries that have also been observed in marine mammals include propeller cuts from vessels or alternative energy sources with underwater blades, gunshot and stab wounds, and bite wounds (e.g., pinniped interactions with domestic pets or wild terrestrial carnivores, such as coyotes). The severity varies depending on the species, the individual, location of the injury on the body, and the depth of penetration.

Blunt Force Trauma
Blunt force trauma to cetaceans and manatees is most often the result of a vessel strike or inter- or intraspecific aggression. Blunt force trauma to pinnipeds can be caused by vessel strikes or direct interaction with humans (e.g., hit with a blunt object). Blunt force injuries include, but are not limited to, bone fractures, organ damage, and internal hemorrhages. Determining the severity of a blunt trauma injury can be difficult since blunt trauma injuries often show little or no external evidence. Therefore, these injuries are likely to be missed by a visual, external examination or by assessment at sea in live animals.

Hidden Injuries
Hidden injuries to marine mammals can result from interactions with a large range of human activities, including those described in the preceding paragraphs. Examples of hidden injuries include bone fractures, damage to vital organs, muscle tears, myopathy as a result of entanglement, and stress-related internal damage. In order to determine the likelihood of a hidden injury, one would assess the animal’s actions and behaviors. While hidden injuries were discussed at the workshop, they cannot be quantified or assessed through visual or external examination alone; therefore, they were not considered in extensive detail by the workshop participants.

2.2 Goals and Objectives

During the 2007 workshop, NMFS scientists and managers evaluated the agency’s process for distinguishing between serious and non-serious injuries that have been used since the 1997 workshop and reviewed additional information, research, and data needs from fishery observer, disentanglement, and stranding programs that would facilitate the evaluating of injuries.

The primary objectives of this workshop were to:

1) Review recommendations from the 1997 workshop and information obtained since 1997.
    a. Types and frequencies of observed injuries.
    b. Evidence of survival of marine mammals sustaining such injuries.

2) Discuss the use of, and necessary changes to, existing guidance for distinguishing serious from non-serious injuries.
    a. Identify when information is insufficient to determine the severity of the injury.
    b. Identify data needs for distinguishing serious from non-serious injuries.

c. Review existing data sources, raise awareness in these data collection programs of information needed, and identify constraints in distinguishing serious from non-serious injuries.

3) Discuss potential actions following the workshop.

2.3 Workshop Organization

The workshop consisted of two sessions: an open session (Days 1-3) and a closed federal session (Day 4). Days 1-3 of the workshop were open to federal and non-federal participants, and public observers. The format for the first three days included a mix of plenary presentations and discussions and breakout session activities. The primary purposes of Days 1-3 were to present a synthesis of new science and to gather new information from longitudinal studies and pathobiology experts on the survival of injured marine mammals. The information from Day 1-3 was also used to provide a scientific basis for recommendations by government officials in the closed session on Day 4. The primary purpose of the closed session was to draw on Days 1-3 presentations and discussions to consider potential changes to the existing serious injury guidance and associated administrative approaches.

The main topics addressed during Days 1-3 included the following (see Appendix A for Days 1-3 agenda):

- Evaluation of current data and determination systems (in plenary and breakout sessions).
- Overview of new information on survival of injured marine mammals (large cetaceans, small cetaceans, pinnipeds, and manatees).
- Pathobiology of injuries.
- Breakout activities to address key questions on the topic of determining severity of injuries to marine mammals.

The workshop was organized around three presentation sessions. Day 1 began with presentations describing the types of data collected, challenges in data collection, evaluating regional approaches to distinguishing serious from non-serious injuries, and the challenges each region faces. Day 2 began with speakers presenting and discussing new information obtained over the past decade on the survival of injured marine mammals by taxonomic group (large cetaceans, small cetaceans, and manatees). The final group of presentations addressed the pathobiology of injuries, including: predicting lethality from vessel trauma, gear and hook trauma, pathobiological consequences of injury, capture myopathy,[4] and hidden trauma in pinnipeds.

Over 65 invited and public participants attended the Serious Injury Technical Workshop. NMFS invited a broad range of participants based upon their expertise in marine mammal serious injury

[4] *Capture myopathy* is a phenomenon associated with, and following, the capture, handling and transportation of animals. Alternate names for capture myopathy include: muscular dystrophy, capture disease, degenerative polymyopathy, overstraining disease, white muscle disease, leg paralysis, muscle necrosis, idiopathic muscle necrosis and exertional rhabdomyolysis. The pathophysiology associated with capture, handling and transportation of animals is extremely complex and associated with the sex, body condition, health of the animal, length of time of chase/pursuit, method/roughness of handling, the environmental condition (heat/cold) and other factors (Spraker, presentation at the 2007 workshop).

issues, including marine mammal management and policy, marine mammal biology, pathobiology, and veterinary medicine. NMFS staff from each regional office and science center, and the headquarters' Office of Protected Resources participated. Other invited participants included federal agencies, state resource management agencies, stranding response organizations, and representatives of the three regional Scientific Review Groups (SRGs), universities, research institutes, and environmental non-government organizations (NGO). In addition to the 65 invited participants, Days 1-3 were open to the public. One member of the public attended. A full list of participants is provided in Appendix C.

2.4 Existing Guidance for Distinguishing Serious from Non-Serious Injuries

The 1997 Serious Injury Workshop discussed several options for the process and criteria used for distinguishing between serious and non-serious injuries. Recommendations from the workshop were outlined in the 1997 workshop report (Angliss and DeMaster, 1998), and focused almost exclusively on injuries from interactions with fisheries. The intent of the 1997 workshop was for NMFS to use the results and recommendations from the workshop to develop proposed guidelines for what constitutes a serious injury, to be published in the *Federal Register*. However, the recommended serious injury guidance was never published as official guidelines or regulations. NMFS Regional staff responsible for distinguishing serious from non-serious injuries have followed the guidance in Angliss and DeMaster (1998) to varying degrees.

1997 Workshop Guidance for Distinguishing Serious from Non-Serious Injuries

Participants at the 1997 workshop did not reach agreement on what process NMFS should use to determine which injuries should be considered serious. Participants discussed three options:

1) Provide training to editors of observer data so they can determine which injuries are likely to be serious.
2) Have one person or a group of NMFS employees determine which injuries are likely to be serious.
3) Develop a panel of outside experts to determine which injuries are likely to be serious.

Participants at the 1997 workshop recognized that guidelines for what constitutes a serious injury across marine mammal species could include:

1) All animals should be considered seriously injured if they are observed injured in any way or are observed trailing gear;
2) Some portion of animals trailing gear or injured in any way should be considered seriously injured; or
3) No animals that are observed injured or trailing gear that are not moribund[5] should be considered seriously injured.

The workshop participants generally accepted the second option as the realistic middle ground because of observations of living or dead marine mammals with healed injuries and observations of marine mammals that disentangle themselves from fishing lines and/or nets.

Participants did identify certain injuries scenarios that could be considered serious or not serious, and which should be assessed on a case-by-case basis, for each taxonomic group separately.

[5] A moribund animal is one that is in a state of dying or approaching death.

Large cetacean subgroup[6]
Participants in the large whale subgroup indicated that any entanglement which impeded mobility or feeding, and the entanglement of young whales in ways that could cause trauma and mortality as the animal grows, should be considered a serious injury. However, specific criteria that indicated how to determine whether an entanglement impeded locomotion or ability to feed were not identified.

Small cetacean subgroup[7]
Types of injuries that should be considered serious:
1) Ingestion of hooks.
2) Swimming abnormally when released.
3) Entanglement with trailing gear when released.
4) Entanglements that result in an animal being separated from its pod.
5) Hooked near the eyes or the head.

Types of injuries that should be considered not serious:
1) Hooked externally (e.g., skin, blubber), except when hook is near the eyes or the head.
2) Swimming normally or were entangled in line or net, but have subsequently become disentangled.

Considerations for the case-by-case examination:
1) Behavioral response of the animal (e.g., abnormal swimming behavior).
2) The specific portion of the gear involved in an entanglement, and the weight and drag characteristics of the gear.

Pinnipeds[8]
Types of injuries that could be considered serious:
1) Hooked in the mouth (internally).
2) Entanglement with trailing gear.

Types of injuries that could be considered not serious:
1) Hooked in the body.

Types of injuries to be assessed on a case-by-case basis:
1) Entanglement without gear trailing.
2) Auditory damage via acoustic harassment devices.

Recommendations Identified at the 1997 Workshop
General:
1) Include marine mammal scientists in the observer debriefing process.
2) Improve marine mammal training for observers.
3) Increase observer coverage in fisheries where the potential for serious injury problems appears to be significant (i.e., longline fisheries).

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[6] The large whale subgroup specifically addressed entanglement interactions.
[7] The small cetacean subgroup specifically addressed interactions with longline fisheries.
[8] A pinniped subgroup was not formed to discuss pinniped injuries, but a discussion was led by D. DeMaster of the AFSC.

4) Develop a reporting system for observers that encourages more elaborate comments by observers on injuries, such as hooking, and whether an entangled animal was completely disentangled prior to being released.
5) Provide guidelines for use by data editors/peer review committee for determining whether an injury should be classified as serious.

Research Needs:

1) Determine survival rates of animals entangled/injured in different types of fishing gear.
2) Analyze existing data on large cetacean survival and reproductive fitness by examining entanglement type and scarring data. Also, examine stranding data for evidence of scars likely related to past or existing entanglements.
3) Develop/improve methods for collecting blood and biopsy samples from entangled, stranded, or free-ranging animals to enable better determination of the effects of stress and marine mammal stock structure.
4) Develop methods for radio or satellite tagging entangled animals released alive. Ensure that equipment is available for tagging entangled animals.
5) Survey the existing stranding networks for evidence of hook and line interactions.
6) Develop necropsy methods that would provide information on fishery specific mortality that can be added to the database on salvaged animals and to existing databases on individually recognizable animals.

Regional Criteria to Evaluate Injuries of Large Whales

The NMFS Northeast Fisheries Science Center (NEFSC) adapted the guidance outlined in Angliss and DeMaster (1998) and developed specific criteria for distinguishing serious from non-serious entanglement and ship-strike injuries in baleen whales. These criteria were developed over a decade of evaluation of case histories and published in NEFSC mortality and serious injury determination reports (Cole *et al.*, 2005; Cole *et al.*, 2006; Nelson *et al.*, 2007; Glass *et al.*, 2008).[9]

The NEFSC categorizes entanglement events as serious injuries if one of the following indications is confirmed on a living whale:

1) Fishing line constricted on any body part, or likely to become constricting as the whale grew.
2) It was uncertain if the line was constricting, but appendages near the entanglement's point of attachment were discolored and likely compromised.
3) The whale showed a marked change in appearance following entanglement, including skin discoloration, lesions near the nares, fat loss, or increased cyamid loads.
4) Gear was ingested.
5) Whale was anchored.

[9] NMFS' Northeast Region (NER) first published interim criteria for distinguishing serious from non serious injuries to right, humpback, and minke whales interacting with the Northeast lobster trap/pot fishery in the 1997 LOF (62 FR 33, January 2, 1997, comment/response 14). Because of the absence of national guidelines and because interim criteria for serious injury were urgently needed to address the impact of the lobster pot fishery to right and humpback whales at the time, the NER developed and utilized interim criteria for determining what constitutes a serious injury to baleen whales. After the April 1997 Serious Injury Workshop, the NEFSC revised their criteria based on the Workshop Report (Angliss and DeMaster, 1998).

A whale is typically not considered seriously injured by the NEFSC (or the Alaska Fisheries Science Center [AFSC]) if all constricting lines were removed or shed, and the whale had no other injuries that would otherwise be considered "serious." The NEFSC does not forecast how an entanglement or injury might increase the whale's susceptibility to further injury (e.g., from additional entanglements or collisions with vessels). The NEFSC does not consider injuries that impaired the whale's locomotion or feeding serious injuries unless they were likely to be fatal in the foreseeable future.

The NEFSC categorizes ship strike events as serious injuries if, following the appearance of a linear laceration or large gouge, a living whale exhibited a marked change in skin discoloration, lesions near the nares, fat loss, or increased cyamid loads.

3.0 Current Data Sources and Collection Programs

The following sections (3.0-6.0) contain summaries of presentations given at the 2007 Workshop. These summaries were prepared by the author(s) of the presentation; therefore, statements and recommendations do not necessarily represent the views and opinions of the Workshop Steering Committee or NMFS.

The "Current Data Sources and Collection Programs" portion of the workshop included presentations by the NMFS observer, stranding, and disentanglement programs. These programs provide the vast majority of the information used by NMFS staff when evaluating injury events to determine severity. The presentations were designed to describe the types of information that are collected in these programs and the scope (including limitations) on the types of information that could reasonably be expected to be collected. In this way, these presentations provided workshop participants with a background on the information used to distinguish between serious and non-serious injuries. This information was intended to inform discussion and lead to realistic suggestions on the types of additional data needed for distinguishing between serious and non-serious injuries.

Collection of marine mammal data by U.S. observer programs (Amy Van Atten, NMFS NER Observer Program)

Under the MMPA, NMFS has the authority to place observers on board vessels engaged in commercial fishing operations that incidentally take marine mammals. Data collected by NMFS observer programs are used to assess the level of serious injury and mortality of marine mammals, develop marine mammal stock assessments, and identify bycatch reduction measures to ensure the recovery and conservation of these species. NMFS currently conducts ten observer programs, which monitor over 42 fisheries nationwide for incidental take of marine mammals, bycatch of other protected resources, and discards of fish. Not all programs focus on observing marine mammal bycatch.

Fisheries currently monitored under the authority of the MMPA include: Kodiak set-gillnet (Category II), California/Oregon pelagic drift gillnet (Category I), California pelagic longline (Category II), Southern California set gillnet (Category III), Mid-Atlantic gillnet (Category I), New England and Mid-Atlantic small mesh trawl (Category II), New England groundfish trawl and gillnet fisheries (bottom trawls Category II, sink gillnets Category I), Mid-Atlantic *Illex* squid trawl (Category II), Atlantic, Gulf of Mexico, Caribbean pelagic longline (Category I), Southeastern U.S. Atlantic shark gillnet (Category II), and the North Carolina inshore gillnet (Category II).[10]

Marine mammal data are typically collected using the following types of forms:

- Incidental Take Form- for documentation of species, type of marine mammal take, and deterrents used.
- Biological Information Form- for documentation of species, length, weight, sex, and tissue/teeth samples for fisheries permitted under 50 CFR 229.7.

[10] Fishery categories listed in this paragraph are the categories of each fishery on the Final 2007 LOF (72 FR 14466, March 28, 2007).

- Sightings Form- for documentation of species, number of animals, and behavior for animals near or around fishing gear.
- Photos and comments are also recorded to provide further information on marine mammal incidental takes.

Each observer program's training manual contains detailed information on data collection forms and procedures. There is no national standardized format for these manuals. In addition to the information collected on marine mammals, observers also collect a variety of data on other species, gear type, fishing location, estimated weight of retained and discarded catch, species composition of discarded catch, reasons for discard, weight, length, sex, dissections from tagged fish, socioeconomic data, biological samples, and seabird and sea turtle interactions. Data collection on protected species is a priority for all regional observer programs.

When considering changes to current marine mammal data collection procedures, there are a number of inherent tradeoffs. For example, observer programs must balance the collection of more data, the need to provide high quality data for all species of interest, improvements in data management and processing, and cost. Observer programs strive to provide the best data possible to aid in the conservation and protection of marine mammals and other species, and are willing to work with protected resources experts to identify possible improvements in observer data collection.

Marine Mammal Health and Stranding Response Program: data collection (Teri Rowles and Janet Whaley, NMFS Office of Protected Resources)

The Marine Mammal Health and Stranding Response Program (MMHSRP) began in 1992 after the passage of the Marine Mammal Health and Stranding Response Act. The MMHSRP goals are to: collect and disseminate information on the health and health trends of marine mammal populations in the wild; correlate the health and health trends of marine mammal populations in the wild with biological, chemical, and physical environmental parameters; and coordinate effective responses to marine mammal unusual mortality events. The program has developed the following components: response networks, surveillance, research and development, banking, quality assurance, information management, outreach/education, and grant assistance.

Over the last 15 years, the program has conducted the following activities to obtain health information and data to inform health assessments:

- Visual observations.
- Health assessments.
- Physical examinations.
- Analytical results, such as pathology, toxicology, infectious disease, and injuries.
- Necropsies, including cause of death.
- Morphometrics and life history data.

Data sources have included strandings, entanglements, out of habitat animals (e.g., a bottlenose dolphin trapped in a freshwater habitat), by-caught animals, live capture release studies, subsistence hunts, translocations, and free swimming animals. The program collects information and samples to evaluate the cause of stranding, cause of mortality, or cause of morbidity (including infectious and non-infectious causes and human interactions).

Most data collected comes from stranded animals. Over the last 15 years, over 40,000 animals have been reported stranded in the United States. These have included single animal strandings, mass (i.e., multiple animals) strandings, and unusual mortality events. Basic information, such as length, girth, sex, and whether there are signs of human interaction (e.g., fishery gear marks on the animal, propeller cuts) are collected from all stranded animals. The data collection forms and the data fields have changed over the last 15 years and are becoming more specific in the types and manner of information required.

To collect better data on marine mammal injuries and to better assess the role human interactions play in mortality and morbidity, the MMHSRP must use a decision tree matrix, use standardized terminology, evaluate the animal in a consistent and defined manner, and ensure that data are reported in a consistent manner by trained personnel. To determine whether human interactions contributed to the stranding event, the observation data, event history, and experience of the observer are evaluated. To address the question of whether human interactions likely caused the death of the animal, full necropsies, analyses, and interpretation of the complete case must be reviewed. In order to improve the quality of the evaluations on evidence of human interactions, consistent protocols must be used by trained personnel reporting the information in consistent format, and having access to the data to support the interpretations, observations, and findings. The MMHSRP is currently adopting a standardized protocol and database for collecting stranding event information, determining human interactions, determining cause of death, determining whether human interaction contributed to death, and providing training to stranding network personnel.

Large whale disentanglement systems (Dave Mattila, NOS, Hawaiian Islands Humpback Whale National Marine Sanctuary)

Introduction

Responding to reports of entangled whales and releasing them, along with documentation of the animal, can supply data about the causes, extent and severity of the entanglement problem. Using disentanglement techniques developed by Dr. Jon Lien (Memorial University of Newfoundland), the Provincetown Center for Coastal Studies and others, under the supervision and authorization of the National MMHSRP, and in cooperation with many federal, state and NGO entities, response networks are in various stages of development throughout the country. The safe and professional documentation of the whale, specifics of the entanglement event, and gear are becoming an integral part of the disentanglement response. Amongst other management issues, some of these data gathered through the disentanglement response are useful in distinguishing serious from non-serious injuries. Of particular use are identifications and resights of released (i.e., disentangled) individuals in order to determine survivorship through long-term tracking studies, documentation of wounds for ground-truthing scar studies, other newly developed assays of individual health, and the verification of events in order to clarify the reliability of opportunistic reports (Robbins *et al.*, 2007a).

Current Assessment Techniques

Certain aspects of the current assessment criteria used by the disentanglement networks to determine whether an entanglement is potentially life threatening, and therefore warrants intervention, may be of use to this workshop. These criteria have evolved over time as our understanding of which entanglements are life threatening (in the short and long term) and which entanglements are likely to be shed by the animal on their own. They rely on a determination of the species and body part(s) involved, the type and constriction (immediate and the potential to constrict in the future) of the entangling material, as well as the wounds (acute and chronic) and estimated overall health of the animal. In addition, the animal's behavior and geographic location are sometimes factors considered.

Current and Potential Data Collection (with discussion of limitations)

Mattila *et al.* (2007) summarized some of the data that are, or can be, safely collected during large whale disentanglement operations. In this presentation, those aspects which are applicable to helping assess serious injury were summarized, including: the data collected to help understand entanglement impacts on marine mammals and for use in ground-truth scarification studies, the safe collection of visual and physical samples, and some experimental tools being developed (e.g., breath collection to gather ketones to assess stress levels). Certain portions of the event documentation and data collected are currently distributed to members of disentanglement networks through network web sites. In using these data it is important to keep in mind certain caveats, including, but not limited to: there is an absence of negative data (e.g., data does not include what was not seen), and some real time report narratives are assumed to be "incorrect," some of which may be updated but may still include inaccuracies.

Key issues and questions

Since large whale entanglements are cryptic, rarely witnessed events, where the animals often swim off with the entangling gear, determining the actual number of deaths and serious injuries as a result of these events is extremely problematic. Key questions remain:

- What are the respective survival rates of released (vs. non-released) animals?
- What types of data can we safely collect in order to determine the likely fate of individuals?
- What type of data may help to illuminate the overall extent of the problem?
- What are the "trade offs" from the disentanglement process (e.g., injuries from the disentanglement process)?

A Note on Vessel Collisions in Hawaii

Reports of vessel collisions are increasing in Hawaii. Several factors are likely to contribute to this increase in collisions, including: increasing whale population, increasing numbers and speed of vessels, increased outreach, and subsequent reporting. The advent of high-speed ferry transport to the islands has increased public and NOAA's concern about potential collisions. Part of NOAA (NOAA Fisheries and NOAA Sanctuaries) and the State of Hawaii's response is to attempt to more fully document any collisions and their subsequent outcomes.

4.0 Current Systems for Distinguishing Serious from Non-Serious Injuries

This section of the workshop included presentations by NMFS Regional staff responsible for distinguishing between serious and non-serious injuries of marine mammals. Regional representatives responsible for distinguishing serious from non-serious injuries were asked to describe their experiences with the types of interactions and injuries observed in their regions, current methods used for determining the severity of an injury, and key issues and questions they encounter when attempting to distinguish between serious and not-serious injuries. These presentations provided workshop participants with background on the differing approaches for distinguishing serious from non-serious injuries based on region, species, type of injury, and amount of available information on injury events. These presentations also set up breakout group sessions (described in section 4.2 below) discussing what has and has not worked well when attempting to distinguish serious from non-serious injuries, and constraints on data collection affecting serious injury determinations.

Baleen whale serious injury determinations in the Northeast Region over the past 10 years
(Tim Cole, NMFS NEFSC)

<u>Nature of interactions</u>
From 2001 – 2005, 133 large whale entanglement events occurred along the Gulf of Mexico, U.S. east coast and adjacent Canadian Maritimes (Nelson *et al.*, 2007). Of these events, 11 were determined to be serious injuries. In many cases there is insufficient information to make a determination. Live whales have been observed with ship strike injuries, but despite ship strikes being implicated as a leading anthropogenic cause of death for right, humpback, fin and sei whales, the NEFSC has rarely assigned a serious injury to a ship strike event. Blunt trauma injuries show little or no external evidence (bodily or behaviorally), and are likely to be missed by our visual, external examination of living whales.

<u>Cause of injuries</u>
Traps/pots: When entangling gear could be attributed to a particular fishery, lobster trap/pot gear was involved in 8 of 14 right whale entanglements between 1993 and 2002 where the gear type could be reliably identified (Johnson *et al.*, 2005).[11] One or two reports of humpback and/or minke whales anchored by trap gear are received by NMFS each year.

Sink gillnet: Johnson *et al.* (2005) identified sink gillnet gear in 11 of 22 events involving humpbacks and reliably identifiable gear between 1997 and 2002.[12] Sink gillnet gear was identified in 2 of 14 events involving right whales in which the gear could be reliably identified.

Trawls: Since 1989, 5 pilot whales, 5 white-sided and 3 common dolphins were reported to have been released alive or of unknown condition within the Northeast Sea Sampling data.

Ship strikes: Ship strike injuries and deaths have been documented for several cetacean species,

[11] In six additional right whale entanglement cases the gear type could not be identified. In these cases, the gear type involved in the entanglement was categorized as unknown (Johnson *et al.*, 2005).
[12] In three additional humpback whale entanglement cases the gear type could not be identified. In these cases, the gear type involved in the entanglement was categorized as unknown (Johnson *et al.*, 2005).

including right, humpback, blue, and fin whales. Relatively intensive survey effort for right whales each year discovers one or two individuals with lacerations from propellers of small (less than 65 feet (19.8 m)) vessels. The NEFSC currently do not have a means of identifying living whales that have sustained blunt trauma.

Methods of determining serious injury
All small cetaceans recorded as released alive or of unknown condition by the Northeast Sea Sampling program are counted as serious injuries. Large whale entanglement or ship strike events are evaluated using criteria outlined in Cole *et al.,* 2005 (see also Cole *et al.*, 2006; Nelson *et al.,* 2007; and Glass *et al.*, 2008).

Key issues and questions
- There is great disparity in report/data quality, ranging from vague reports from the general public to comprehensive necropsies conducted by field experts.
- Often, there is a lack of external evidence in cases of blunt trauma.
- Accounting for an animal's health prior to injury (already sick? pre- or postpartum?) is an important consideration.
- What behaviors, in conjunction with an entanglement, are likely to cause serious injury?
- Should the size of an injury be used as an indication of its seriousness?
- Should the presence of constricting line always trigger a serious injury determination?
- What are the effects of short, repeated, or chronic injuries?
- Can anecdotal reports provide a means for estimating actual rates of serious injury for a population/stock?

Small cetacean and North Atlantic right whale serious injury determinations in the Southeast Region (Lance Garrison, NMFS SEFSC)

Nature of interactions
Several categories of injuries occur in the Southeast region (SER). These include:
- Injuries to small cetaceans caused by hookings or entanglements with longline gear.
- Injuries to small cetaceans from interactions with other fishing gear, where animal is released alive.
- Injuries to small cetaceans where animal is either hooked externally or ingests gear, including cases of repeated hookings.
- Entanglements and vessel collisions with right whales, with particular attention to very young calves.
- Injuries to small cetaceans from vessel collisions.

Cause of Injuries
Longline gear: The Atlantic pelagic longline fishery operates from the Grand Banks off Canada to the Caribbean and the Gulf of Mexico. The majority of interactions with marine mammals occur in the Mid-Atlantic Bight, which extends from New York south to North Carolina. Fishermen report that pilot whales depredate their catch, and observer data indicates that there is a significant positive correlation between interactions with pilot whales and damage to swordfish catch (Draft PLTRP, 2006). Similarly, observer data show a positive correlation between interactions with Risso's dolphins and damage to swordfish catch (Draft PLTRP, 2006). There

are not enough encounters between longline gear and other marine mammals to determine whether depredation or just chance encounters with the gear are responsible for the interactions. In general, most marine mammals that interact with longline gear are released alive with varying degrees of injury. Interactions take the form of hookings in the mouth and in other areas of the body, as well as entanglements in fishing line.

Entanglements most frequently occur in the mainline. Animals are generally cut free of the gear and not classified as seriously injured on release. Hookings are most often in the mouth and the hook is not removed prior to release. Frequently, the gangion or leader line parts off before the animal can be brought near the boat and the animal is released both hooked in the mouth and trailing significant amounts of entangling gear. When an animal becomes hooked or entangled, the crews typically work rapidly to release the animal, as undue struggling has the potential to further harm the animal as well as the crew. Factors that influence whether the gear can be removed include the size of the animal, the location and severity of the hooking/entanglement, the condition of the seas, and the experience of the crew.

Traps/pots: Dolphins generally become entangled in line around the flukes, pectoral fins, or head. Animals may drown or be seriously injured by dragging crab trap/pot gear for extended periods of time. Dolphins are frequently released alive from these entanglements (8 bottlenose dolphins (*Tursiops truncatus)* in South Carolina alone in the crab trap/pot fishery, with 5 since 2003; McFee *et al.*, 2006). However, the extent of serious injury caused by entanglements has not been assessed. The Atlantic crab trap/pot fishery is included under the Bottlenose Dolphin Take Reduction Plan (BDTRP; 71 FR 24776, April 26, 2006).

Shrimp trawl: Lazy lines[13] on shrimp trawls have caused mortality to bottlenose dolphins throughout the southeast. There are anecdotal accounts of entanglement in which the animal is released alive.

Recreational gear: The range of the coastal stocks of bottlenose dolphins frequently overlaps with recreational activities of people. Illegal feeding of dolphins is prevalent in the southeast. In some areas, this activity is causing behavioral changes of the animals (such as conditioning to people and loss of wariness of people and vessels) which may be contributing to depredation on recreational and commercial gear. Dolphin depredation on bait/catch of recreational gear is increasing, and, in some cases, dolphins are being repeatedly hooked or entangled in gear. Observed and anecdotal reports of depredation show dolphins cleaning the hook of bait or catch or snapping the line.

NMFS SER staff have also observed females teaching begging and depredation behaviors to their calves and other animals. Injuries generally include lures/hooks lodged in the mouth or head region, partial or total ingestion of lures/hooks, and monofilament nests entangled around various parts of the body either in combination with hooks/lures or separately. In 2007, there were increased dolphin strandings with recreational gear attached, ingested, or entangled, especially in Sarasota Bay and Indian River Lagoon, Florida. A review of Florida statewide

[13] A lazy line is a rope that runs from the front of the net (mouth) to the codend (area of the net where the catch is collected), and allows the codend of the net to be hauled on deck to release the catch without dragging the entire trawl net onboard the vessel.

stranding data from 2001-2006, shows 28 cases of tackle ingestion, 15 entanglements, and 5 cases of hooks or lures in the mouth. In some cases, mortality was a direct result of the interaction. The fates of animals that do not strand dead with recreational gear attached but sustain multiple hookings or entanglements are not known, nor is the potential impact of chronic injuries from these interactions. (Case study: female bottlenose dolphin with calf in Panama City, FL, that was hooked on two separate occasions within 6 months).

Ship strikes: The Southeast United States is the only known calving area for North Atlantic right whales. There are several major ports in the Southeast (Canaveral, Jacksonville, Brunswick, Fernandina Beach, Savannah, and Charleston) along the right whale migratory pathway to the Northeast United States. Calves may be particularly vulnerable to ship strikes and entanglements in fishing gear. In 1991, a calf was documented in the Southeast with propeller gashes. In 2005, NMFS staff observed this same animal floating dead off Cumberland Island, the cause of death likely her healed propeller wounds splitting open as her girth expanded with advancing pregnancy.

Vessel collisions with small cetaceans are not documented as frequently as with large whales. However, when a vessel collision occurs, it often results in mortality from blunt trauma or severe propeller wounds. There are cases in which small cetaceans--notably bottlenose dolphins--survive boat strikes but sustain injuries and disfigurement to dorsal fins and other body parts. In Sarasota Bay, Wells and Scott (1997) documented four cases of vessel strikes on bottlenose dolphins in which all four animals survived the strike.

One of the animals struck was a female less than 2 months old. Her wounds consisted of a large gash on the left side of the dorsal fin with trailing yellowish necrotic tissue, which ultimately caused the dorsal fin to curl to the right. She was seen swimming normally alongside her mother with the fresh wounds, but later died at age 4 from a lung infection. It is unknown to what extent her early injuries from the vessel collision may have impacted her overall health. Likewise, the effect on long-term survival in similar cases is unknown. (Case studies: mortality of a striped dolphin (*Stenella coeruleoalba*) in Destin, FL; propeller wounds to dorsal fin from a bottlenose dolphin in the Indian River Lagoon, FL).

<u>Methods of determining serious injury</u>

Serious injury determinations in the SER are made based on the guidelines provided in Angliss and DeMaster (1998). For small cetaceans interacting with the pelagic longline fishery, it was concluded that animals that ingested hooks, were released with significant amounts of trailing fishing gear, were swimming abnormally, or suffered some obvious severe external trauma should be considered seriously injured. Animals that are hooked externally or are released and swim away normally are not considered seriously injured. For large whales, the guidelines indicate that entanglement of young whales in a way that could cause trauma and mortality as the whale grows should be considered a serious injury. However, no further distinction was made in assessing injuries of calves as compared to larger animals.

Serious injury determinations for cetaceans interacting with the longline fishery are made on a case-by-case basis after reviewing the observations, comments, and photographs of fishery observers. These determinations are made and reported annually in technical memoranda that provide estimates of bycatch in the pelagic longline fishery of both marine mammals and sea turtles (Fairfield-Walsh and Garrison, 2006). In general, the NEFSC makes serious injury determinations for large whales. However, recently the SER made a cause-of-death determination for an entangled right whale calf in order to facilitate timely management action. This determination was based on necropsy findings, photographs, and other observations.

Currently, there is no process in place for making serious injury determinations in the SER for small cetaceans that have been reported injured due to vessel collisions or interactions with commercial or recreational gear in fisheries other than the pelagic longline fishery. These injuries are generally not included in estimates of total human-caused serious injury and mortality in SARs.

<u>Key issues and questions</u>
Longline gear- Issues include:

- The observer may or may not be able to see the nature of the injuries if the animal is released far from the boat or in poor visibility. In addition, the report form that has been used did not prompt consistency in observer comments regarding the nature of the injury or the condition of the animal upon release.
- Specific criteria indicating the amount of gear a cetacean would have to trail before it was considered a serious injury was discussed at the previous serious injury workshop, but consensus was not reached.
- The fishery is now required to use circle hooks. More information is needed to determine whether injuries caused by circle hooks are different than those caused by "J" hooks (specifically the degree to which hooks are ingested).
- There has been a lack of consistency and detail in reporting by observers regarding the nature of the injury as well as the condition of the animal upon release (due to factors discussed above).
- Fishermen may be more able (and motivated) to release animals with a minimum of harm if they receive proper training, but almost no effort in establishing such a program has been made.
- Fishermen have also indicated that they would be more motivated to take on the risk of disentangling or dehooking an animal if the animal released without gear was then determined to be only injured (as opposed to seriously injured).

Trap/pot- The ultimate fate of animals released alive from an entanglement is unknown. Questions include:

- How can internal injuries that may have resulted from an entanglement be assessed?
- Is the extent of entanglement injuries more serious depending on location of entanglement (e.g., head, pectoral fins, fluke)?
- Do injuries incurred during such entanglements cause the animals to be more susceptible to other stressors?
- Depending on the extent of the injuries, should entanglements in which dolphins are released alive be included in serious injury and mortality estimates under TRPs?

Recreational gear- Questions include:

- Must an injury be acute to be serious? What about injuries that have latent impacts on an animal’s ability to forage, defend itself against predators, or reproduce?

- What is the fate of small cetaceans released with a hook/lure in their mouth or other body part? With an ingested hook? Could a hook in the mouth lead to death?
- If the hook/lure is shed naturally (e.g., corrodes, gets displaced, or tears out) are there potential longer-term implications of injuries where the hook/lure was lodged? From repeated hookings? From shedding of gear?
- Are calves more susceptible to serious injury than adults from these interactions?

Ship strikes- Objective criteria are also needed for making serious injury determinations for vessel-struck small cetaceans, and a process for including serious injuries of vessel-struck small cetaceans in the estimates of human-caused takes needs to be developed. Questions include:

- Should guidelines differentiate what constitutes serious injury for smaller animals (including right whale calves) considering the size, behavior, and strength of the animal?
- How should we account for potential longer-term implications and effects on survivability if an animal appears to be behaving normally following vessel strike?
- Can we develop serious injury criteria for propeller lacerations?

Serious injury determinations in Hawaii (Karin Forney, NMFS SWFSC, and Bud Antonelis, NMFS PIFSC).

<u>Nature of interactions</u>
Cetaceans: The majority of interactions involve small cetaceans hooked in the mouth or with an ingested hook, presumably because they are taking catch or bait off longline gear. Most of these animals are released when the line breaks or is cut, trailing variable amounts of gear ranging from about 1 meter of line to tens of meters of line and some floats or weights. There were a few cases of animals hooked in the fluke or other body part; some of these died but others were released with trailing line. Humpback and sperm whales were observed entangled in mainline and/or branchline, and all but one were released with some trailing gear (variable lengths of line, at times with floats and weights) wrapped around their bodies or flukes/pectoral fins.

Hawaiian monk seals: The majority of interactions involve monk seals becoming hooked, usually in the mouth, presumably because they are taking bait from the longline gear. NMFS rarely receives reports of the actual hooking event, but later documents seals hauled out with hooks and some trailing line or gear. Most hooked animals are captured by NMFS personnel who then remove the hook. In some instances, hooks fall out without intervention. In one instance, a deeply-ingested hook and attendant gear were removed surgically. Seals also become entangled in near-shore lay nets in the Main Hawaiian Islands (MHI). Finally, seals become entangled in derelict fishing gear and other flotsam, primarily in the Northwestern Hawaiian Islands (NWHI). NMFS field personnel remove the gear whenever possible. Injuries and mortalities have been documented.

<u>Cause of Injuries</u>
Cetaceans- *Pelagic longline*: Includes shallow sets targeting swordfish and deep sets targeting tunas. Cetacean species observed (reported as # killed/ # injured[14]) in this fishery during 1994-

[14] Includes all injuries, both serious and non-serious.

2004 were: False killer whale (1/17), short- finned pilot whale (2/4), Risso's dolphin (0/7), bottlenose dolphin (1/2), short-beaked common dolphin (0/1), pan- tropical spotted dolphin (1/0), spinner dolphin (0/2), Blainville's beaked whale (1/0), humpback whale (0/3), sperm whale (0/2), unidentified cetaceans (0/14). False killer whale takes in this fishery are of the greatest concern because they are a strategic stock (takes exceed PBR under the MMPA).

Hawaiian monk seals:
Near-shore recreational shore-casting: Most interactions have occurred from a type of shore-casting known as slide-rig fishing, which targets primarily carangids (ulua), and 'whipping', which targets scad (akule). From 1994 through July 2007, 42 hooking incidents were reported in the MHI, one resulting in mortality.
Near-shore lay net: This fishery involves setting underwater gill nets on near-shore reefs of the MHI for nonselective catch. From 1994 through July, 2007, 6 entanglement incidents have been documented, with 3 mortalities.
Debris entanglement: Entangling debris comprises items of fishery and non-fishery origins, and occurs primarily in the NWHI. During 1982-2006, 268 entanglements occurred, with 36 injuries and 8 mortalities.

<u>Methods of determining serious injury</u>
Based on the guidelines developed at the 1997 Serious Injury Workshop (Angliss and DeMaster, 1998), cetaceans are considered seriously injured if one or both of the following applies: 1) they are hooked in the mouth/head or have ingested a hook; and/or 2) they are released with trailing gear that is likely to impair feeding or locomotion. Serious injury determinations are made on a case-by-case basis using the observer's description of the interaction, the behavior and body size of the animal, the amount and types of gear attached when the animal was released, and where on the body the animal was hooked/entangled. Monk seals are considered seriously injured if one or more of the following conditions apply: 1) they are hooked in the mouth deeper than the lip (i.e. inside the mandible, at base of tongue, or having swallowed the hook); 2) they are entangled in an actively fishing lay net; 3) they are entangled in debris which has cut through the skin of the animal; 4) they are entangled in debris and are subsequently disentangled, and the intervener(s) specifically state in a field report that the animal could not have escaped unaided; and/or 5) they are entangled in debris which is in turn caught on shallow substrate, effectively immobilizing the animal.

<u>Key issues and questions</u>
Cetaceans: Hooked cetaceans are often very active, complicating an assessment of where and how the animals are hooked. Many animals break the line and swim away with varying amounts of gear attached before they are close enough for the observer to see details. Tuna sets (the majority) are hauled after dark, making it difficult for observers to identify species and observe details of the interaction events. To increase the collection of data relevant to serious injury determinations, new forms are currently being tested that have check boxes allowing observers to quickly record information on location and type of hook or entangled gear, amount and types of gear left attached to the animal, and the animal's behavior. Questions include:

- What is fate of small cetaceans released with a hook in their mouth (lip? jaw? skull?) or with an ingested hook?
- Is there any evidence they shed the hook on their own? Would a hook in the mouth

significantly impair feeding, cause infection, or lead to death?

- At what point does trailing gear become a problem likely to cause death for small cetaceans (how much and what type of gear)?
- How does the impact of trailing gear differ:
  - when an animal is hooked in the mouth, head, body, pectoral fin, fluke?
  - when an animal has line entangled around the head, body, pectoral fins, fluke?
- What types of additional data would be useful to try to collect regarding the nature of the injury or the types and amounts of gear involved?
- Can any behaviors appropriately be used to indicate that an animal has sustained a serious injury (e.g., swimming abnormally, 'squealing', active/lethargic)?

Hawaiian monk seals: Seals are presumed to become hooked by taking bait rather than catch, but additional data need to be collected to confirm this sequence of events. Moreover, interviews with fishermen who have inadvertently hooked and released seals can provide information on what types of bait may be more or less likely to be taken by seals. A key issue is that the subpopulation of seals in the MHI is increasing, so fishery interactions are likely to increase. Some steps have been taken to mitigate the effects of hookings. PIFSC personnel have been advocating the use of barbless hooks in the shorecasting fishery, a practice which would not diminish hookings, but would lead to a hooked animal more likely to lose the hook without human intervention.

In determining serious injuries, the effect of human intervention has not been considered, and perhaps this warrants further discussion, at least on the management side. If humans remove a deeply embedded (or ingested) hook, or release an animal from a lay net, and the animal survives, should the event still be considered a serious injury?

Cetacean serious injury determinations off the U.S. Western Contiguous Coast (Karin Forney, NMFS SWFSC)

<u>Nature of interactions</u>

Most cetacean-fishery interactions on the U.S. West coast involve small cetaceans, and the interaction generally leads to the death of the animal. Large whales, however, may swim away with gear attached. Between 1999 and May 2007, at least ten humpback whales off the U.S. West Coast were observed entangled in fishing gear, including line from crab pots, traps, and nets. In some cases, the animals were freed or subsequently stranded dead, but in most cases, the fate of the animal is unknown. Ship strikes have also been implicated in the deaths of humpback, blue, and fin whales. Additional whales have been observed with ship strike injuries (e.g., propeller gashes), but their fate is not generally known. A few humpback whales have been observed with healed scars from apparent ship strikes.

<u>Cause of Injuries</u>

Pelagic drift gillnet fishery (~20 inch mesh): Large whales are occasionally entangled and released with a portion of the net, or they may swim through the net and continue with or without gear attached. Pingers (i.e., acoustical deterrent devices) may be attached.

Traps/pots: Humpback whales occasionally get entangled in traps/pots set for spot prawns or crabs, and may swim away with lines, traps and/or floats attached. They may also become anchored.

Ship strikes: Ship strike injuries and deaths have been documented for several cetacean species, including humpback, blue, and fin whales.

Methods of determining serious injury

Carretta *et al.* (2004) summarized the approach used to determine serious injury in marine mammals entangled in driftnet fishing gear:

"Occasionally, entangled animals were released with injuries that made future survival doubtful. These cases of "serious injuries" were defined by reviewing observer notes and comparing the extent of the injuries with the serious injury guidelines used by NMFS (Angliss and DeMaster, 1998). … Serious injuries may include--but are not limited to--the following: animals released with trailing gear that would impair the animal's mobility or ability to feed, ingested hooks, visible blood flow, loss or damage to an appendage, listless appearance or inability to defend itself, inability to swim or dive upon release from fishing gear, signs of equilibrium imbalance, perforation of any part of the body by fishing gear, and animals that swim abnormally after release."

Ship strike injuries are evaluated on a case-by-case basis, but serious injury determinations are not always possible.

Key issues and questions

- How much and what type of trailing gear is likely to cause the mortality of large whales?
- How does the impact differ:
  - when an animal has gear entangled around the head, body, pectoral fins, fluke?
  - if the animal is entangled in bottom-anchored gear and struggles for a period of time?
  - by type of gear (monofilament line, multifilament line, netting, pots, floats attached, etc.)?
- What types of entanglement injuries are whales known to have survived (or not)?
- What types of ship strike injuries are whales known to have survived (or not)?

Large whale and pinniped serious injury determinations in Alaska (Robyn Angliss, NMFS AFSC)

Nature of interactions

Injuries to several different marine mammal stocks in Alaska result from vessel strikes and incidental entanglement in a variety of fishing gear. Most of the federally-regulated fisheries (groundfish trawl, longline, and pot fisheries) have some level of observer coverage. There are occasional reports of marine mammal incidental mortalities reported for some of these fisheries, but very few reported injuries. However, because most fisheries that may cause incidental injury or mortality of marine mammals in Alaska are not observed, information on the entanglements can be collected only through opportunistic accounts from commercial fishers, researchers, and the general public.

Due to the opportunistic nature of the reporting, many entanglement/injury reports are received in areas where there is substantial research effort, public boating, and public awareness of entanglements, such as in Southeast Alaska. Far fewer reports of injury or entanglement are available in less populated areas, such as Bristol Bay. The extent of entanglement ranges from loose loops of line around the body and/or pectoral fins with no apparent wounds, to gear that has cut deeply into the flesh, to gear that is so tightly wound around the animal that the head and flukes were bound together. In many cases, the entangling line cannot be identified to a fishery. A disentanglement program in Southeast Alaska aids some of the entangled humpback whales and thus reduces the total number of animals that would otherwise be considered injured. A few injuries of bowhead whales and fin whales due to entanglement or ship strikes have been reported, but the frequency of these reports is under one animal per year.

Cause of Injuries

Traps/pots: Large whales—primarily humpback and gray whales--are entangled in a variety of pot fisheries. Types of pot fisheries include commercial crab pot, commercial shrimp pot, personal use pot, subsistence use pot, or unspecified. In many cases, it is not possible to determine from the records what type of pot fishery was responsible for the entanglement.

Salmon gillnet: Ranks second in entanglement rates for humpback and gray whales.

Salmon purse seine: Infrequent entanglement of humpback and gray whales.

Troll gear: Steller sea lions have been reported with hooks and flashers in their mouths. Reports are currently infrequent, but occurrence of this type of event is also known to be underreported.

Ship strikes: Collisions between humpback whales and pleasure craft in Southeast Alaska occur at a rate of ~1/year.

Methods of determining serious injury

Until 2004, the method to assess whether an injury should be considered "serious" involved one individual who reviewed a stranding report summary. Entanglements or other injuries reported through the observer program or through stranding reports were considered serious if they were deemed to be likely to impede movement or feeding, per the serious injury guidelines (Angliss and DeMaster, 1998). Entanglements that clearly bound an animal's appendages sufficiently to prevent movement or that wrapped around an animals' mouth were considered to be likely to impede movement or feeding. Entanglement in or dragging of large quantities of gear were considered to be likely to impede movement, and were considered serious injuries. If the report of the entanglement/injury was poor, a best guess was made; the assessment erred on the conservative side and designated an injury as "serious."

Due to concerns about how the serious injury designation was being made for humpback whales, the Alaska SRG (AKSRG) convened a subcommittee to review the raw data for each entanglement and make recommendations regarding whether each entanglement should be considered "serious," "not serious," or "cannot be determined (CBD)" (Wynne *et al*., 2003). The 2005 draft SAR included the majority opinion of the AKSRG for each humpback whale entanglement event. In 2006, the AFSC and Alaska Region (AKR) reviewed the AKSRG's assessment of each entanglement event for consistency with the serious injury guidelines (Angliss and DeMaster, 1998), and with the exception of three records, accepted the AKSRG's advice. For the 2006 draft SARs, of the 38 injuries of humpback whales between 2001-05, 9 (24%) were considered seriously injured, 18 (47%) were considered not seriously injured, and the information on the remaining interactions was insufficient to make a determination.

Key issues and questions

- It would be helpful to learn how some types of entanglements directly affect survival of an individual large whale in the short-term (days to weeks) and long-term (a year). Entanglement types include: single or multiple wraps of line, line through the mouth or restricted to other parts of the body, trailing small or large amounts of pot gear, and trailing small or large amounts of gillnet gear.
- There are a variety of opinions as to whether a hook in a pinniped's mouth should be considered a serious injury. Whether this does, in fact, commonly cause mortality of the pinniped should be explored.
- The Wynne *et al.* (2003) white paper documented a remarkable lack of consensus among several experts as to whether many different types of humpback whale entanglements or injuries should be considered serious or not serious. It would be helpful to develop a set of guidelines or a process that can be used to reduce this variability.

The AKSRG has suggested that "serious injury" be assessed in a probabilistic manner (e.g., stating that there is a 50% chance the animal would die as a result of the injury) instead of simply using the terms "injured" or "seriously injured."

4.1 Evaluation

The last two presentations in this section of the workshop provided a synthesis of all the regional approaches to distinguishing serious from non-serious injuries (described above), followed by a non-NMFS evaluation of the serious injury determination process in Alaska. The purpose of the first presentation was to present similarities, differences, needs, and common operational constraints across regions, as well as to discuss inconsistencies in serious injury determinations nationwide. The second presentation presented an exercise performed by the AKSRG in which AKSRG members were asked to review NMFS data on injury events and make a serious injury vs. death determination (as discussed by Angliss in section 4.0 above). This presentation served to show participants a model or case study for assessing the serious injury determination processes.

Synthesis of regional approaches to serious injury determinations (Tim Cole, NMFS NEFSC)

Across the regions, the *species groups* involved in interactions with humans potentially leading to serious injury include: mysticetes (baleen whales), odontocetes (toothed cetaceans), otariids (eared seals/sea lions), phocids (true, or earless, seals), and sirenians (manatees and dugongs).

Primary *data sources* for making determinations include: fisheries observer programs, stranding and disentanglement networks, and opportunistic reports from researchers and the public.
Key *causes of injury* include: hooking (longline, troll, recreational), entanglement (trap/pot,

gillnet, monofilament, longline), entrapment (trawl, seine), and collisions (vessel hull, propeller).

Key *variables contributing to whether an injury should be considered serious* include:

- Animal age.
- Animal health.
- Animal behavior.
- Injury type (e.g., puncture, laceration, blunt trauma, compression).
- Injury location (e.g., mouth, head, body, flipper, tail, internal).
- Injury size.
- Injury duration (e.g., short, repeated or chronic).
- Entanglement type (e.g., hooked, constricting line, loose line, anchored, entrapment).
- Entanglement size (e.g., size, length and number of branches of line; number of buoys, traps or anchors; volume of netting).
- Entanglement constriction (e.g., tight, loose, multiple wraps).
- Entanglement duration.

The task of making serious injury determinations consistent across regions is characterized by the following key issues and challenges:

- The amount and quality of primary data varies.
- Assessing internal injuries on free-swimming animals is a challenge.
- Behavior has limited reliability as an indicator of serious injury.
- Susceptibility of animals to other health threats or complications following injury.
- Accounting for serious injury in stock assessments (whether to use procedures that are either absolute or probabilistic, e.g., 50% chance the animal would die as a result of the injury; anecdotal data for smaller species).
- Estimating populations' actual rate of serious injury from opportunistic data is difficult.

Report from the Serious Injury Subcommittee of the Alaska Scientific Review Group (Kate Wynne, University of Alaska)

In 2003, the AKSRG was asked by NMFS staff to review a table of humpback whale entanglements planned for inclusion in the 2005 Alaska SAR. The group was provided with a scoring grid, and for each event, the group was asked to determine those events that would result in "serious injury or death" and those that would not.

No category was provided for outcomes that "cannot be determined" and the scoring grid did not provide a place to code "criteria used" in making the determination. Members of the SRG submitted divergent responses, which raised issues for discussion at the November 2003 meeting. AKSRG members raised concerns that, while dichotomous outcome determinations (will die *vs.* won't die) are ideally suited for MMPA implementation, they were difficult to make based on the data provided (Wynne *et al.*, 2003).

AKSRG participants discussed several sources of uncertainty and interpretational discrepancies that led to differences among AKSRG responses. Given the management implications of this ambiguity, the AKSRG suggested that the definition and determination of lethal entanglement should be a NMFS priority, warranting a joint discussion among the AKSRG and formal advice to NMFS.

To address this issue, AKSRG formed a subcommittee to provide more detailed response to NMFS regarding serious injury determinations. The subcommittee included five experienced Alaskan marine mammalogists (Wynne *et al.*, 2003), three of whom have received NMFS training in whale disentanglement assessment and response. The subcommittee agreed to reassess the outcome of humpback whale entanglement events reported in the SAR Table and to identify the criteria they used to determine which events likely represented lethal interactions. While completing this task, the subcommittee encountered inconsistencies in information provided in the SAR Table that could alter their outcome determinations.

The scoring grid enabled the reporting of the level of agreement for coding the set of entanglement and collision events. The group of mammalogists reached complete agreement on the anticipated outcome of entanglement or collision less than 18% of the cases presented (Wynne *et al.*, 2003). Committee members' comments indicated their difficulties making objective outcome determinations were due to insufficient information and/or sources of subjectivity. In more than 80% of cases, at least one member believed the information provided was inadequate to determine the likely outcome of the incident (Wynne *et al.*, 2003). As a result of this exercise, three sources of subjectivity (original event descriptions by observers, distillation of original information into tables and reports, and at the reviewer level when determining the outcome) were identified by subcommittee members with suggestions for their minimization (Wynne *et al.*, 2003).

4.2 Breakout Group Discussion on Evaluation of Current Data and Systems for Distinguishing Serious from Non-Serious Injuries

Following the presentations under session 4.0, participants discussed the issues in plenary then split into 3 breakout groups. Each breakout group was comprised of an equal number of participants from each region and field of expertise, in order to prompt discussions that were national in scope and considered each marine mammal taxonomic group. Each group discussed the following questions:

1) What has worked well with serious injury determinations?
2) What has not worked well?
3) How have constraints on data collection affected serious injury determinations?

The most common comment from participants was that the process for distinguishing serious from non-serious injuries lacks consistency (between regions and individual serious injury determinations) and communication. Participants pointed out inconsistencies between regions in making determinations (e.g., for different species, using a risk-averse vs. risk-prone approach, using inclusive vs. conservative criteria) and interpreting the data and serious injury guidance. Participants also pointed out the need for increased communication between data collectors, stranding networks, and the staff responsible for distinguishing between serious and non-serious injuries.

Additional participant comments and suggestions provided during plenary and breakout group discussions included needs for:

- Movement from a qualitative approach for distinguishing between serious and non-serious injuries to a quantitative approach. Need to develop a mechanism to increase national consistency and standardization, which incorporates the flexibility to adapt to new information and applies to different species without subjectivity. Components of such a mechanism include:
    - Standardized data collections and interpretation of data.
    - Relatively simple nationwide criteria for use in a decision tree approach to distinguishing serious from non-serious injuries (similar to the process currently in use by the NEFSC described in section 2.4).
    - Movement away from a dichotomous process for distinguishing serious from non-serious injuries (i.e., injured animal is either “seriously” or “not seriously” injured). Include a “CBD” option to ensure that injury events without clear outcomes (e.g., death) do not default to the “non-serious” category.
    - Incorporation of external expertise and review into the criteria and process for distinguishing serious from non-serious injuries (e.g., the AKSRG serious injury determination exercise, Wynne *et al.*, 2003). The responsibility for a serious injury determination should not rest on a single person, which leads to inconsistency in the determinations because of differing interpretations of the data or serious injury guidance.
- Increased communication:
    - Between NMFS, stranding networks, and the public to raise awareness of how to report an injured or stranded animal, which will lead to better data collection and reporting. Participants considered that current communication needs are greatest along the U.S. West coast.
    - Within NMFS between the observer program, stranding program, take reduction team (TRT) members, and staff responsible for distinguishing serious from non-serious injuries, to better understand how data are used by each program and what data needs exist. Increasing coordination can lead to more consistent reporting and interpretation of the data.
- Continued training for observers and stranding network participants on the physiology of marine mammals and encouragement of efforts to obtain digital images of animals, when possible.
- Development of incentives for fishermen to collect and enable data collection.
- Identification and mining of the existing data to determine whether or not connections exist between necropsy findings and visual observations. By determining the types and characteristics of injuries that have led to the deaths of marine mammals, it may be possible to distinguish between serious and non-serious injuries based on similar case studies, removing the need to resight all animals observed injured. For example, if an animal is observed with a type of injury that is known to have caused death in other individuals of the same species, then it might be considered dead in the absence of a subsequent live-sighting. The NEFSC has gone through this process qualitatively over the last 10 years.
- Increased data collection on offshore species and populations, including at-sea necropsies and increased effort to tow ashore carcasses found at sea.

- Increased focus on ship strikes and the resulting injuries.
- Development of databases and websites with real-time data, similar to the ship strike, stranding, and disentanglement databases.
- Increased research through longitudinal studies of marine mammal populations. Documenting and tracking the fates of injured animals has provided significant information.
- Investigate novel tools for monitoring injuries and mortalities in unobserved fisheries.

5.0 New Information on the Survival of Injured Marine Mammals

This section of the workshop included presentations on new information on the survival of injured marine mammals. The presentations were designed to present information gathered since the 1997 workshop from longitudinal studies of various cetacean populations (showing the fate/survival of injured individuals) and scar-based analyses (as a way to document the impacts of injuries as they heal). The presentations were split by taxonomic group (large cetaceans, small cetaceans, and manatees), each followed by a facilitated plenary discussion. The large cetacean presentations discussed information on injuries observed in humpback, right, blue, and gray whales; the small cetacean and manatee presentations discussed information on injuries observed in common dolphins, bottlenose dolphins, spinner dolphins, Risso's dolphins, harbor porpoise, pilot whales, false killer whales, and manatees. The presentations informed the plenary discussions and subsequent Day 3 breakout group sessions, which considered if and how the information presented could be incorporated into the system for distinguishing serious from non-serious injuries. A review of the facilitated plenary discussions from the large cetaceans, and small cetaceans and manatees sections is combined in section 5.3 review of the discussion for pinnipeds is included in the pathobiology presentations and discussions in section 6.1.

5.1 Large Cetaceans

***Serious injury determinations for right whales: What's missing?* (**Richard Pace, NMFS NEFSC, with contributions from A. Knowlton, New England Aquarium, Boston, MA)

The linkage between serious injury determinations and the stock assessment process is guided by the Guidelines for Assessing Marine Mammal Stocks (GAMMS; Wade and Angliss, 1997). Stock assessments require an accounting of human-caused mortality incurred by any marine mammal stock in order to assess the stock's status. Unlike most small cetacean and pinniped stocks for which fishing-related mortality is estimated from a potentially unbiased sampling process, large whale human-caused mortality assessments are direct counts of dead whales that are almost surely biased strongly downward due to low recovery rates of carcasses and fate determination rates of discovered carcasses (Number dying >[15] Number detected > Number of necropsies > Number causes determined). Historically, assigning mortality causes to large whale deaths required significant (nearly irrefutable) pathological evidence. Similarly, the criteria for labeling an observed injury of a large whale as serious (*sensu* MMPA) required there to be little doubt among experts that said injury would result in mortality.

Serious injury evaluations produce one of three outcomes: 1) no error when the determination matches the outcome, 2) an error of commission when an injury is declared serious but does not result in mortality, or 3) an error of omission when a fatal injury is not labeled as serious (which also occurs in the case of insufficient information). The longitudinal resighting data of individually recognized North Atlantic right whales were compared to the record of serious injury determinations for 1991-2004. During that period, 12 catalogued individual right whales had serious injuries. All but 2 of these individual whales had significant sighting histories prior to their injuries and were documented as seen more than 1 year post injury. One whale had a relatively sparse sighting history, but has not been seen during the 10 years post injury. The

[15] The symbol ">" means "more than."

remaining whale was seen 2 years post injury during which sightings noted declines in apparent health status, and it has not been seen since. Additionally, 5 right whales sustained injuries that met the NEFSC criteria for serious injury but died and were thus reported as mortalities in the SAR. Therefore, NEFSC made no obvious errors of commission in right whale serious injury determinations reported for 1991-2004.

A set of serious injury determinations were also examined from an "alternative knowledgebase" that resulted from well-defined criteria applied to entanglement related injuries to right whales. The alternative knowledgebase declared 48 injuries as serious including 11 declared by NEFSC, 5 that would have been declared by NEFSC had they not been ultimately reported as deaths, and 5 others for which their sightings histories end soon after their injuries were reported. Thus, NEFSC made a minimum of 5 errors of omission (rate= 5/21 x 100 = 24%). Further, the alternative knowledgebase had a moderately high commission to correct serious injury declaration ratio (27:21 or 1.3 errors of commission per correct serious injury declaration).

Any refinement of the process to determine serious injury will continue to miss the assessment gap in counting human caused mortality of right whales. The addition of the 5 apparent omissions over a 14 year periods amounts to <0.4/yr additional fishing related deaths. This hardly adjusts for the estimated/reasoned difference of 4 human caused mortalities per year not accounted for in recent SARs. A suggested conclusion is that staff developing serious injury criteria for large whales need not fear that errors of commission will result in inflated human caused mortality assessments.

Scar-based inference into entanglement and serious injury for humpback whales (Jooke Robbins, Provincetown Center for Coastal Studies)

Entanglement in fishing gear is a documented source of injury and mortality to humpback whales and other cetaceans. Although any body part can be involved, at least 53% of humpback whale entanglements involve the flukes and caudal peduncle (Johnson *et al.*, 2005). Even short-term, mitigated events produce scars at this location that persist from one year to the next (Robbins and Mattila, 2001). These injuries generally take the form of wrapping linear scars and abrasions, notches and other penetrating injuries, and occasionally substantial deformation.

Since 1997, systematic photographic sampling and scar analysis have been used to study entanglement scarring on free-ranging Gulf of Maine humpback whales (Robbins and Mattila, 2001, 2004). More recently, the same techniques have been applied to humpback whales in other U.S. areas, including Hawaii (Robbins and Mattila, 2004; Robbins *et al.*, 2007b), Southeast Alaska (Neilson, 2006; Robbins *et al.*, 2007b), and areas of the U.S. West Coast (Robbins *et al.*, 2007b). Entanglement-related scarring has been detected in all of the areas in which research has been conducted to date. For example, more than half of the Gulf of Maine population has experienced at least one entanglement, and annual acquisition rates range from 8% to 25%. Yet, even where public awareness is high and a formal reporting network exists, fewer than 10% of new entanglement injuries correspond to successfully reported and adequately documented events.

Serious injury determinations presently depend on evidence that an event has occurred and that it is likely to lead to death. Scar analysis indicates that the vast majority of entanglement events of humpback whales are not witnessed.

Nearly all of the types of physical injuries observed in documented entanglements have also been observed among free-ranging (surviving) humpback whales. However, animals that die from entanglement do not necessarily have injuries as severe as those observed on free-ranging animals. Thus, external (i.e., externally visible) injuries alone may not be predictive of whether or not an entanglement will result in a serious injury. The mouth is involved in at least 43% of humpback whale entanglements, including cases known to have led to death (Johnson *et al.*, 2005). However, significant injuries at the head, such as those observed among North Atlantic right whales, are not common among free-ranging Gulf of Maine humpback whales.

Scar research has also provided insight into the fate of injuries over time. It is not uncommon for entanglement injuries of humpback whales to persist in a "raw" state from one year to the next, depending on the size of the original injury. In more rare cases, entanglement injuries appear not to ever heal. However, humpback whales also appear to tolerate persistent raw wounds from other sources, such as jaw scuffing acquired during bottom feeding. Therefore, it is unclear what the impact these persistent wounds might have on the health of the animal.

Occurrence of injuries on humpback, blue, and gray whales along the U.S. West coast and in the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) Project (John Calambokidis, Erin Falcone, Lisa Schlender, and Jessie Huggins, Cascadia Research)

Along the U.S. West coast, long-term studies of three species, blue, humpback, and seasonal resident gray whales, have provided information on the fate of seriously injured animals. Blue and humpback whales have been individually identified annually since 1986, and the catalog for each species numbers just under 2,000 individuals. For both species, the majority of the group using this region has been identified. For gray whales, photographic identification from northern California to British Columbia has tracked a group about 250 regularly-returning seasonal residents as well as stragglers from the larger overall gray whale population. In each of these populations, animals with severe injuries have been documented. Although the exact causes of these injuries are not always clear, some appear to be ship strikes, propeller scars, and entanglement. While it is difficult to measure survival rates for these injured animals, it is clear that many with fairly severe injuries are surviving and continuing to be observed over the course of multiple years. While some individuals have been directly observed entangled, in most cases identification photographs allowing long-term tracking of survival of these individuals have not been available.

One special case that occurred in 2007 was a mother and calf, both severely injured from a possible collision, swimming far up the Sacramento River to the Port of Sacramento and becoming the focus of a major rescue effort. While the ultimate fate of these two animals after they left San Francisco Bay is not known, it did provide an opportunity to closely examine short-term changes in their injuries and their reaction to a prolonged period in fresh water.

SPLASH represents an extensive collaborative effort (more than 50 research groups) to examine the abundance, trends, and structure of the entire North Pacific population of humpback whales, including occurrence of injuries. A key strength of this dataset is the comparison if affords of different locations. The dataset contains data collected in a consistent manner for all known feeding and wintering areas for humpback whales in the North Pacific. Entanglement rates have been computed and will be summarized separately. Both entanglement and other types of injuries, including killer whale rake marks, are shown to vary by geographic region. The dataset identifies specific regions where certain types of injuries are more likely to occur.

A description of severe injuries on humpback whales in southeastern Alaska (Jan Straley, University of Alaska)

Humpback whales in southeastern Alaska have been studied since the late 1960s. These longitudinal studies have provided useful information on life history parameters, including reproduction and survival. Another useful outcome of these long term sighting histories of individual whales is health assessment, although this was not a consideration when these studies began. As such, determining when specific injuries are received remains difficult. Using photography, initially 35mm slides and black and white film and now digital, 35 humpback whales have been documented with an injury, 18 classified as severe. A severe injury was defined as penetrating the blubber layer. The source of these injuries was not determined for certain; however, over half (10) of the injuries were most likely caused by a collision with a motorized vessel propeller (two were seen with fresh injuries). Three whales have injuries caused by probable entanglements with a line wrapped around the body. One whale has had an unhealed injury at the base of the tailstock for at least 20 years, possibly resulting from a line entanglement. The source of four injuries is unknown; two of these, which involved injuries to the flukes or tailstock, have not healed. All but two of the 18 whales seen with injuries have been sighted in two or more years. Six whales are known females, two are males, and 10 are of unknown sex. Of the six females, five have been seen with calves after the first sighting with the injury. It is apparent that humpback whales can sustain severe injuries, survive, and continue to reproduce. However, some whales with no visible outside injury do not survive, as evidenced by a humpback whale found dying with an inflated tongue and no obvious external severe injuries during the summer of 2007. The draft necropsy report concluded the probable cause of death was trauma, but this is not definitive. It is suspected that there was a blow to the chest/neck that caused a rupture of part of the respiratory tract with air exhaled into the tissues of the tongue, causing it to inflate.

Survival and fecundity rates of entangled humpback whales (Jooke Robbins, Provincetown Center for Coastal Studies)

Case studies show that individual humpback whales can survive severe injuries and that females with such injuries can go on to reproduce. However, the likelihood that a given type or level of injury will have a positive outcome is harder to determine. Humpback whales without outwardly severe injuries can die after exposure to human activities, and mitigation efforts like disentanglement do not ensure animal survival.

In the Gulf of Maine, a well-established reporting network exists to detect and respond to entangled humpbacks. There has also been annually intensive photo-identification research on the free-ranging population since the 1970s. Provided that an entangled individual is sufficiently documented, there is a possibility of resighting the animal should it survive. In such cases, mark-recapture statistical analyses can provide a framework for comparing apparent survival among individuals. They can also provide a means of estimating and comparing other vital rates, such as reproductive rates. This talk described an on-going study using multi-state statistical models to model the survival and fecundity of entangled Gulf of Maine humpback whales (Robbins, in prep.).

In this study, apparent survival is being estimated for 865 Gulf of Maine humpback whales seen at least once between 1997 and 2006. Individuals are classified as either juveniles or adults and can occupy one of three entanglement states in a given year: 1) never reported entangled, 2) entangled in that year or 3) entangled in any previous year. When an individual was entangled in a given year and also had a previous history, priority is being given to the current case. This model structure allows juveniles to be assessed separately from adults and for immediate survival impacts to be differentiated from chronic effects. Other factors considered include the initial assessment of the disentanglement team, the disentanglement action (if any) and the final "serious injury" determination.

In a second, on-going multi-state statistical analysis, annual calving probabilities are being estimated for 203 mature Gulf of Maine females, including those reported to have been entangled. Each year that a mature female was documented, she can be placed into one of four states depending on her calving status (accompanied by a calf or not) and her documented entanglement history. This model structure allows the annual calving probabilities to be compared among females with and without an entanglement history.

Multi-state statistical models are data intensive, but can provide unique insight into the effects of discrete events in the lifetime of an animal. Mark-recapture statistical approaches like these should be preferred in studies of survival and fecundity in species in which individuals are free-ranging and can be uniquely identified. Preliminary results of these analyses and potential sources of bias were presented.

5.2 Small Cetaceans and Manatees

Evidence of fishery interactions in small cetaceans in the mid-Atlantic (Aleta Hohn, NMFS SEFSC)

In North Carolina, records of stranded marine mammals with signs of interactions with fisheries date to 1992, when a database of strandings was established. Since 1997, strandings have been routinely and systematically examined for signs of interactions with fisheries. Since 1992, there have been six species of small cetaceans identified with signs of fishery interactions (common dolphin [*Delphinus delphis]*, short-finned pilot whale *[Globicephala macrorhynchus*], Risso's dolphin *[Grampus griseus]*, harbor porpoise [*Phocoena phocoena]*, striped dolphin *[Stenella coeruleoalba]*, and bottlenose dolphin [*Tursiops truncatus]*), comprising 237 animals. Of these, 88% were bottlenose dolphins. Most of the identified marks were fresh rather than healed. Both harbor porpoises (n=1) and bottlenose dolphins (n=35) have been found with gear still attached. Marks found on carcasses are primarily from monofilament line, including recreational line and monofilament gillnet. Other gear types include braided line from unidentified sources, crab pot line, and trawl lines. Along other mid-Atlantic states, the primary gear types associated with strandings are gillnets and crab pot lines.

Four species of whale (minke [*Balaenoptera acutorostrata]*, Bryde's *[Balaenoptera edeni],* North Atlantic right [*Eubalaena glacialis],* and humpback [*Megaptera novaeangliae]*) have been identified with marks or gear from fishery interactions. The majority (13 of 17 events) have been humpback whales.

In January 2005, there was a mass stranding on 33 short-finned pilot whales north of Cape Hatteras, NC. Of those, 27 were examined for signs of human interaction. Nine had well-healed scars (8 deep, 1 superficial) indicative of possible interactions with longline gear, including five of the 21 (23.8%) females and four of six (66.7%) males. All of the females with scars were adults (16 of the 21 female were adults) while males of all age classes had scars (1 adult, 2 juveniles, 1 calf with scars, and one calf and one juvenile without). With one exception, the scars were limited to areas around the mouth, including broken teeth for three animals. The exception was a large female with healed scars around the leading and trailing edges of the dorsal fin. It is possible there were other healed scars post-cranially; however, conditions during the stranding response prevented full evaluation of the animals for fishery interactions.

The mass stranding of pilot whales in January 2005 was the first in North Carolina in 10 years; three prior mass strandings occurred in 1994-1995, albeit comprising only 2-3 animals during each event. Thus, there is no comparative record for evaluating possible longline entanglements. None of the individually stranded pilot whales were noted to have healed scars; therefore, it is reasonable to suggest that they were not examined for scars. However, including individual strandings, there has been a seasonal component to the strandings, with pilot whale strandings occurring in January – March. This finding is consistent with when the highest levels of take in the Atlantic pelagic longline fishery off of North Carolina have occurred.

Healed line marks are rare. A bottlenose dolphin and a striped dolphin were identified with deep, healed scars around the mouth, including broken teeth. A Risso's dolphin showed a healed lesion on the right side of dorsal fin, cut through 1.5 cm deep at the deepest point and thought to have been caused by trailing gear. This case also showed a partially healed 1-2 mm (0.4-0.8 in) lesion at the insertion of its flukes.

The paucity of healed scars due to monofilament from gillnets suggests low survival of animals entangled in that gear, while the 2005 mass stranding of pilot whales indicates that some interactions in, presumably, longline gear can be survived. The current sample size is too low and earlier observations are not sufficiently detailed to draw conclusions about rates.

Consequences of injuries on survival and reproduction of bottlenose dolphins in Sarasota Bay, Florida (Randy Wells, Chicago Zoological Society/Mote Marine Laboratory; Wells *et al.*, In Press, Marine Mammal Science)

Research initiated in 1970 and continuing today on bottlenose dolphins along the central west coast of Florida has led to the development of several long-term datasets of relevance to examining the effects of serious injuries. Data have come from photographic identification studies, capture-release operations, and from Mote Marine Laboratory's Stranding Investigations Program. The sighting database compiled since 1975 includes 32,347 dolphin group sightings, with 91,059 identifications of distinctive individual dolphins, derived from a photographic identification catalog of 3,958 individually-identifiable dolphins.

The capture-release database, compiled since 1984, includes veterinary examination records and health data in 676 sets of measurements from 214 individuals (some sampled up to 14 times). Exams include examination of the oral cavity, and in some cases stomach tubing. The stranding program, operating since 1985, responds in three counties including and extending beyond the Sarasota Bay dolphin range.

To date, basic information and data have been obtained from 413 bottlenose dolphins, with 319 necropsies. Sixty-seven of the examined dolphins have sighting histories in our database. Data from these sources have been used to investigate the effects of gear ingestion, entanglement, vessel strikes, and amputations from unknown causes. Details of specific cases were presented.

<u>Gear Ingestion:</u> Records include 12 cases in which gear or severe scarring from gear were related to ingestion. One dolphin is still alive, with extensive healed scarring at the angle of the gape; she has produced multiple calves subsequent to the injury. Seven apparently died directly from gear: 4 with embedded hooks in the mouth, throat, or goosebeak, and 3 with line wrapped around the goosebeak (perhaps from regurgitation). In 2 cases, gear was considered to have contributed to mortality, but shark attack or a stingray barb were identified as the primary causes of death. In 4 cases, non-embedded small hooks were found in the stomach, but these were not identified as the cause of death. Embedded gear has only been found in carcasses, never during more than 600 health assessment examinations of live animals, suggesting that embedded hooks are frequently fatal. In cases when embedded hooks were implicated as cause of death, the animals had lost 22-36% of their body weight, suggesting that mortality was delayed following hooking.

<u>Gear Entanglement:</u> Of 49 cases of entanglement in gear by well-known dolphins, most were based on scars, but 12 dolphins were observed with gear, including 8 in monofilament, 3 in crab trap float lines, and one in a bathing suit. Two of these died from entanglement, one died as a probable complication of entanglement, 7 others might have died without intervention, and two shed the gear on their own and survived. Most injuries involved lines cutting through appendages, a process that occurred over periods of weeks to months. Nine of 10 adult females observed with entanglement wounds or scars subsequently produced calves.

<u>Vessel Strikes:</u> Ten cases of apparent vessel strikes have been recorded, involving mothers with calves, dependent calves, independent juveniles, and a compromised adult. Only two of these

have resulted in death, and one of these involved an already-compromised juvenile. Propeller cuts on the backs or dorsal fins have been observed to heal in most cases, although permanent disfigurement is common. The surviving mother has produced and successfully reared 3 calves since the injury.

Amputations of Unknown Origin: Cases involving major disfigurement or loss of significant dorsal fin (n=34) or fluke (n=3) tissue were monitored over time. On average, individuals survived a minimum of 8 years with these wounds. All identified females with these injuries (n=8) produced calves.

Limited information on interaction outcomes for Pacific false killer whales (Karin Forney, NMFS SWFSC)

False killer whales are the most frequently caught cetacean in the Hawaii-based tuna longline fishery, and the Hawaii Pelagic stock is considered strategic under the MMPA. Observer data suggest that false killer whales primarily become hooked while depredating tuna and other catch from the gear. Most of the false killer whales that have been observed caught by on-board observers were released alive with hooks in their mouth, esophagus, or ingested, and with varying amounts of gear still attached. In some cases, false killer whales broke free before the on-board observer could ascertain the nature of the hooking/entanglement, because the line parted or was cut by vessel crew. The fate of false killer whales injured by longline fishing gear is unknown, but animals hooked in the mouth/head or having ingested gear are considered seriously injured based on previous serious injury determination guidelines (Angliss and DeMaster, 1998).

The presentation summarized limited photographic evidence of potential outcomes of interactions between false killer whales and fishing gear. It is difficult to put these observations into a broader context because of their opportunistic and circumstantial nature, but the information nonetheless may be useful to increase our understanding of injury outcomes.

In a study conducted by Baird, R. W. and A. M. Gorgone (2005), the authors review rates of major dorsal fin disfigurements from photo-identification studies of false killer whales around the main Hawaiian Islands. Three of 80 distinctive individuals (3.75%) were photographically documented to have major dorsal fin disfigurements that appear to be to be most consistent with fishing line injuries. This rate of severe dorsal fin disfigurement is higher than in any other odontocete population for which published data are available worldwide. Two of the three false killer whales with disfigured dorsal fins were seen with calves, suggesting they were adult females and reproductively active despite their injuries.

The 2005 Pacific Islands Cetacean and Ecosystem Assessment Survey (PICEAS), conducted by SWFSC/NOAA, was designed to obtain abundance estimates of false killer whales and other cetaceans in an area between Hawaii, Johnston Atoll, and Palmyra Atoll. This is the region where the majority of takes of false killer whales in the Hawaii-based longline fishery have been documented. The survey included visual search effort and acoustic monitoring using a towed hydrophone array. Fourteen groups of false killer whales were sighted and approached by the vessel (8 were detected visually, 6 were detected acoustically and later confirmed visually). In one of these groups, a severely emaciated individual was photographed. The animal may have had line around the head, but it was too distant to determine unequivocally whether gear was present. It is possible that this observation represented an animal injured by fishing gear and no longer able to feed itself.

Serious injury to Florida manatees[16] (Alexander Costidis, University of Florida, Florida Fish & Wildlife Conservation Commission)

Florida manatees (*Trichechus manatus latirostris*) are a subtropical subspecies of the West Indian manatee (*Trichechus manatus*). The Florida manatee ranges from the coastal and inshore waters of Florida in the winter months, to the southeastern United States in summer months. The coastal range of the manatee population has led to an inevitable interaction with human activities such as fishing and boating. In Florida, approximately 24% of annual Florida manatee mortality is due to collisions with watercraft (Lightsey *et al.*, 2006).

While propeller lacerations (sharp-force trauma) are quite often cited as the cause of death of manatees struck by boats, impact injuries (blunt-force trauma) account for more deaths than do propeller injuries. There is a wide range of watercraft injuries sustained by manatees, some of which can be explained by some relatively unique behavioral, anatomical, and morphological features. Watercraft injuries can be separated into three categories based on the physical characteristics of the injury and the inciting structure. Impact injuries are most common, accounting for 58% of all watercraft-related mortality and can be caused by blunt objects such as keels, hulls, and gear casings, or sharper objects such as propellers, rudders, and skegs (Lightsey *et al.*, 2006; Rommel *et al.*, 2007). Sequalae of impact injuries typically involve subdermal contusions, muscle/tissue shredding, bone fractures, vertebral separations, and inertial organ tears. The second most common type of injury accounts for 32% of all watercraft-related mortality and involves open propeller lacerations that expose muscle and bone, or open the pleural and/or abdominal cavities to the environment (Lightsey *et al.*, 2006).

Common findings from such injuries include lacerated organs and bones, exsanguinations, severed vertebral columns, and partial or complete body transection. Finally, approximately 10% of watercraft related mortality is caused by a combination of blunt- and sharp-force trauma which can present with any number of the afore-mentioned sequalae of each respective category (Lightsey *et al.*, 2006). Empirical and anecdotal evidence suggests that certain anatomical and physiological traits possessed by manatees allow them to survive injuries that would be considered fatal to most other mammals. As such, throughout their lives most manatees obtain numerous sublethal injuries that lead to substantial exostoses and bone remodeling as well as other chronic conditions such as pyothorax and abscessation.

Over 90% of adult Florida manatees have evidence of at least one sublethal interaction with a

[16] Management responsibility for manatees is the jurisdiction of the FWS. The Steering Committee included a presentation on manatees at the workshop because the FWS and its partners have a large amount of resight data of individual manatees (injured and otherwise), and the Steering Committee considered that these resight data might serve as a reasonable model for other marine mammal species. However, in his presentation, Costidis noted peculiarities about manatee anatomy and physiology that would prevent the use of manatees as a model for pinnipeds and cetaceans.

watercraft (pers. comm. S. Rommel, University of Florida). To date, little is known about the types and sizes of watercraft that injure manatees, or the activity (recreational vs. commercial) the vessels were conducting at the time of collision (Rommel *et al.*, 2007). Finally, two other causes of death seen in Florida manatees involve other human activities and include such things as entanglement and floodgate or water control structure deaths. Entanglements seen in manatees usually involve either monofilament or crab pot rope around one or both pectoral flippers; however, occasional entanglements with anchor or mooring lines do occur. The most common sequalae of entanglement are either complete or partial amputation of one or both pectoral flippers, with the manatee usually surviving the injury long after amputation. Some exceptions have occurred where an infectious or septic event was established. However, in most cases the flippers appear to necrotize gradually due to ischemic necrosis, thereby allowing the manatee to slowly isolate the flipper and any infections occurring within it.

A small number of manatees have been found with rope entanglements around the pectoral flippers and cranial thoracic region. These cases are relatively rare. A small percentage of manatees in Florida are also killed by crushing and/or drowning in floodgates and canal locks found in intercoastal bodies of water such as channels and canals. These types of injuries have only been documented when resulting in fatal interactions and therefore nothing is known about whether sublethal interactions of this type occur. Water control structure-related deaths frequently involve rectangular or symmetrically shaped, often-bilateral impressions on the dermis and epidermis, with substantial subdermal contusions, internal hemorrhage, muscle and organ shredding, and occasionally evidence of wet drowning (water entering the lungs).

5.3 Plenary Discussion

Following the presentations on reviewing new information on survival of injured marine mammals, participants discussed the following question in plenary: "What elements from these analyses could be incorporated into a new (national) system for distinguishing between serious and non-serious injuries?"

Participants identified the following elements to consider in distinguishing serious from non-serious injury:

- A system for distinguishing serious from non-serious injuries must allow for parsimonious decisions in the absence of data.
- NMFS must determine how far into the future to look to predict the survival of an injured animal before it is considered a serious injury (i.e., an animal dies one week/one month/one year/10 years as the result of an injury, the injury is considered "serious"). This will have implications for management measures, such as TRPs.
- Need to develop a mechanism for distinguishing serious from non-serious injuries that balances errors of omission (not assigning a serious injury when an injury was actually serious) and errors of commission (falsely calling an injury serious when it was actually not serious).
- Cumulative impacts are an important consideration when distinguishing serious from non-serious injuries (e.g., how one type of injury may predispose an animal to another type or more severe injury).

- Depth of an injury (i.e., penetrating injury into the blubber layer vs. into the muscle or body cavity) is a key determinant of whether an injury should be considered serious.
- Key factors affecting the severity of an injury in small cetaceans include: location of the hook in the body of an animal, existence of any gear trailing from the mouth, and depth of penetrating injuries.
- Need to provide incentives to fishermen to remove gear and hooks from caught marine mammals, when possible.
- The existing guidance, which suggests that an animal is not seriously injured when it swims away strongly after a capture-release scenario, may not be supported by more recent evidence regarding capture myopathy and other hidden injuries. Therefore, this guideline should be revised.
- The presentations demonstrate that terminology (e.g., laceration, sharp trauma, incision) should be more specific or precise when describing injuries.

Participants identified the following research needs:

- Continue work on mark-recapture (longitudinal) studies, especially for large whale and offshore species. While a statistically valid sample size does exist for determining probabilities of survival for most large whale species, opportunistic resighting data leads to a bias because resighting data considers only survivors.
- Determine the ability of different fishing hooks (based on strength, size, and shape) to retain catch while allowing marine mammals to escape, taking into consideration large animals are more able to straighten hooks than smaller animals.

6.0 Pathobiology of Injuries

This section of the workshop included presentations on the pathobiology of injuries. The presentations were designed to describe how pathobiology may be used to determine whether an injury caused or contributed to the death of an animal, information which could serve to help predict the lethality of injuries incurred by marine mammals. The presentations discussed peracute (instantaneous death), acute (death within a short period), and chronic (death over time or significant debilitation that affects feeding, mobility, or reproduction) injuries, including hidden injuries and the potential effects of capture myopathy. The presentations informed the plenary discussions and subsequent Day 3 breakout group sessions, which considered if and how the information presented could be used by staff evaluating injury events to help distinguish between serious and non-serious injuries.

Predicting lethality from vessel and gear trauma in North Atlantic right whales (Michael Moore, Woods Hole Oceanographic Institute)

Human-induced traumas in North Atlantic right whales (*Eubalaena glacialis*) fall in to three categories (Campbell-Malone *et al.* In press; Moore *et al.*, 2004): sharp propeller incisions, blunt vessel impacts, and constrictive laceration by fishing gear. Accurate prognoses from field observations of live but impacted animals are essential for triage of entanglements and accurate prognostication of the likelihood of a particular case being fatal. These forecasts are an essential part of governmental regulatory process. Data were synthesized from management records of persistent entanglement cases, photo-identification of live sightings of entangled or vessel struck whales, and from necropsy reports. Vessel interactions tend to be peracute to acute whereas entanglement in animals that are unable to immediately shed the gear is typically very chronic with fatal cases having an average duration of 5 months, and persistent non-lethal cases up to many years (Moore *et al.*, 2006).

Out of 77 mortalities recorded since 1970, a necropsy was performed on 45 cases (Campbell-Malone, 2007; Moore *et al.*, 2004): vessel collision has been the cause of death in 24 of them. Of the ship-strike related mortalities, the cause of death in 56% (15) of the cases was acute sharp trauma alone, while 20% (9) were attributed to blunt trauma. Other cases were more complex.

A scoring matrix was established to characterize and evaluate propeller wounds: a sum of the product of cut depth (0 to 4) and number of cuts for each of head, upper and lower back, peduncle and fluke. Results were (mean +/- SD (N): Alive 7.4+/- 4.5 (24) and Dead 16.0 +/- 15.2 (15). Cuts in the upper back and head were more likely to be lethal than in the caudal part of the body, although lethal cuts were observed in all body regions. External evidence was absent in 44% (4/9) of blunt trauma cases. Thus the extent of non-lethal blunt trauma is not known. Skeletal fractures were observed in 89% (8/9) of the lethal blunt trauma cases and a broken mandible was observed in 33% (3/9) of all lethal blunt trauma cases examined by necropsy. As a fully healed mandibular fracture has never been observed in a right whale, a fractured mandible is believed to represent a fatal injury. The apparent density and mechanical properties of bone tissue from the mandible were determined experimentally. These data were then used as inputs for a finite element model capable of predicting the stress sufficient to induce fatal fracture of a mandible (Campbell-Malone, 2007). On-going work will compare such stresses with the forces produced by vessels to determine the vessel speed and size combinations capable of fracturing a mandible.

From 1970 to July 2007, there have been 47 reported cases of significant entanglement, 15 entanglement related deaths, and 6% of the cases are presumed to be dead given an absence from the sighting record for 6 or more years. For entanglement trauma, significant parameters were scored subjectively in terms of severity. For 18 persistent entanglement cases where a full data set were available, scores on a scale of 0-35, were lethal above 17 and non lethal below 14, and of mixed outcome between those numbers. We are still refining the model to deal with cases where data are missing. We hope to rank cases in terms of severity, and compare the ultimate outcome.

Ongoing development of the biomechanical model and a simple scoring system to evaluate entanglement and propeller cut cases should enhance our prognostic capacity.

***Consequences of injury* (**David Rotstein, University of Tennessee/NMFS)

Serious injury can be defined as that which results in death instantaneously (peracute), within a short period (acute), or over time (chronic) or in significant debilitation that affects feeding, mobility, or reproduction. For marine mammals, sources of injury include gunshot/projectiles/arrows, entanglements and ingestions, and sharp and blunt force trauma. While these injuries may have grossly observable changes such as lacerations, amputations, and hemorrhage, internal changes may be less evident and could be of incredible significance to survival.

Pathologic consequences of injury fall into two categories: anatomic and physiologic. The anatomic location of an injury could lead to peracute to acute death (e.g., head trauma) or chronic debilitation (e.g., fracture of mandible and starvation). Physiologic consequences of injury include shock, pain, or blood loss leading to an inflammatory cascade, activation of the sympathetic nervous system, hormone release (epinephrine and norepinephrine) and vascular changes with potential end results of hypothermia, coagulation defects, organ failure, and death. However, these may not be readily determinable in an animal surviving a traumatic event, and in animals that die, tissue autolysis or loss may prevent a complete assessment.

Factoring into all of this are the signalment (species, gender, age class) and history (nutritional status, body condition), reproductive status, natural history (indigenous, migratory), and pre-existing disease states that may adversely affect healing or ability to avoid an insult. If the sources of trauma and animal factors are considered, then these could provide components of a categorization of injury and possible response to injury similar to human traumatic insult categorization.

Capture myopathy in mammals and how this condition may apply to marine mammals (Terry Spraker, Colorado State University)

Capture myopathy is a condition that has been described in terrestrial mammals and birds following capture, handling, and/or transportation, but it appears to be rare in marine mammals and carnivores. There are numerous names for capture myopathy, including muscular dystrophy, capture disease, degenerative polymyopathy, overstraining disease, white muscle disease, leg paralysis, muscle necrosis, idiopathic muscle necrosis, and exertional rhabdomyolysis.

The pathophysiology associated with capture, handling and transportation of animals is extremely complex and associated with the sex, body condition, health of the animal, length of time of chase/pursuit, method/roughness of handling, the environmental condition (heat/cold), and other factors. The primary pathophysiological changes are characterized by intra- and intercellular lactic acidosis and regional ischemia that predispose to rhabdomyolysis and necrosis of various internal organs especially in the cortex of the kidneys. Hyperthermia or hypothermia can play a vital role in the outcome of capture myopathy.

There are at least four stages or forms of capture myopathy: capture shock syndrome, ataxic myoglobinuric form, ruptured muscle form, and the delayed-peracute form. The most likely scenarios in which capture myopathy may be a problem in marine mammals would be in dolphins that have been caught several times in tuna fisheries in a short period of time (perhaps a week), and perhaps in eared seals following capture (acute shock) or during recapture on the second or third day following the initial capture (peracute form).

Hidden Trauma in pinnipeds

Trauma is a common cause of death in pinnipeds. There are two primary types of trauma: sharp and blunt trauma. Gunshot is a third condition that may be placed under the category of sharp trauma (e.g., bullets, arrows, etc.). Usually sharp trauma can be observed on external examination, but blunt trauma is often missed. Primary causes of sharp trauma include bite wounds, boat propellers, entanglement by netting, and perhaps gun shot/arrows.

Causes of blunt trauma are most common in young animals and are usually caused by crushing type wounds. Pups are commonly crushed by older animals, especially in crowded conditions and during territorial fighting by the males. Other scenarios include being hit by boats, falling off of cliffs during times of excitement, etc. An important type of blunt trauma to the head and abdomen is not uncommon in northern fur seals that is associated with dystocia. The most common types of hidden trauma are caused by blunt trauma. Necropsy of pinnipeds is of utmost importance to confirm trauma, especially blunt trauma. A tremendous degree of internal damage (e.g., fractured liver, kidney, skull) can follow blunt trauma and be totally missed following external exanimation.

6.1 Plenary Discussion

Following the presentations on pathobiology, participants again discussed, “What elements from these analyses could be incorporated into a new (national) system for distinguishing between serious and non-serious injuries?”

Participants reiterated multiple necessary considerations for a serious injury determination system presented in section 5.3:

- The analyses demonstrate that terminology (e.g., laceration, sharp trauma, incision) or precision of terminology needs to be more specific when describing injuries.

- The existing guidance, which suggests that an animal is not seriously injured when it swims away strongly after a capture-release scenario, may not be supported by more recent evidence regarding capture myopathy and other hidden injuries.
- Cumulative impacts need to be considered when distinguishing serious from non-serious injuries (e.g., how one type of injury may predispose an animal to another type or more severe injury). For example, while there is no simple predictor(s) of capture myopathy, the chance of capture myopathy occurring increases with the number of captures.

7.0 Day 3 Breakout Group Discussions on Key Topics

Day 3 of the workshop was devoted to morning and afternoon breakout session discussions, organized to address the following six topics:

Morning concurrent breakout groups
1) Longitudinal/survival rates from a modeling perspective (7.1).
2) Categorization of injuries and pathological consequences: Gear-related injuries (7.2).
3) Categorization of injuries and pathological consequences: Sharp, blunt force, and penetrating injuries (7.3).

Afternoon concurrent breakout groups
4) Large cetaceans (7.4).
5) Small cetaceans (7.5).
6) Pinnipeds and other species (7.6).

The workshop Steering Committee designed the morning breakout group questions (7.1-7.3) to gather participant input on the data used and the data needed to predict survival rates of injured animals, and suggestions for how to categorize and address injuries in serious injury determinations. Afternoon breakout group questions (7.4-7.6) were designed to gather input on how to categorize injuries, address data needs, and account for scientific uncertainty specific to each species group based on differences between each taxonomic group.

During the morning session, participants were grouped according to expertise on the subjects listed as 1-3 above. Participants addressing topics 2 and 3 were posed identical questions, developed by the Steering Committee prior to the workshop. For the afternoon session, participants were grouped according to species expertise, thus providing participant overlap across the morning and afternoon sessions. Each afternoon breakout group was presented with an identical set of questions to address, developed by the Steering Committee prior to the workshop. In some cases, breakout groups presented with identical questions provided similar or identical comments and suggestions as the other groups. This is evident in the redundant statements reported in sections 7.2-7.3 (groups 2 and 3 morning breakout groups) and 7.4-7.6 (afternoon breakout groups). While the majority of the comments and suggestions presented in sections 7.1-7.6 represent responses agreed upon by all participants in a given breakout group, the intent of these sessions was not to reach consensus recommendations. The intent was to gather input from each individual participant on the questions based on his or her expertise and/or regional experience. Where disagreement occurred, it is noted.

7.1 Longitudinal/survival rates from a modeling perspective

Question 1: What needs to be in a model to accurately predict long-term survival?

- Factors that are potentially important when predicting survival include:
    - Individual animal level: life stage (e.g., adult or juvenile), sex, body condition, and detection probability.
    - Population level: level of sampling effort (i.e., heavily monitored populations vs. unmonitored populations), natural survival rate.

  - Injury specific: injury timing and classification.
- Basic data collection should be standardized, while retaining the flexibility for innovation in data collection.
- The various sources of information available for each population (e.g., sighting, observer, and stranding data) should be connected and coordinated, thereby increasing the available mark-recapture data. Individual animals not detected in one data set may be detected in another data set, increasing resighting instances for certain individuals.
- Longitudinal studies provide valuable data on the survival of individual animals. Many are already established for many cetacean populations and their continuation is important. In populations without long-term data sets, individuals may not be reliably re-encountered or re-identified, posing a challenge for studies of survival of animals within that population. Satellite or VHF tagging is one possible option for filling data gaps when longitudinal resighting studies are not possible.
- A tiered approach may be necessary given the different state of knowledge among populations and species. Well-studied populations may allow a different level or type of analysis than for those which only opportunistic data are available. Well-studied populations might provide a foundation for developing approaches to be used to assess data-poor populations.
- Performance testing should be conducted to quantify uncertainties in model-based survival rate estimates.

Question 2: What is the most viable model currently available? What types of models, if any, need to be developed taking into account new information?

- Experimental designs using control vs. experimental (i.e., treatment) individuals or groups (e.g., experiments involving the deliberate injury, to various extents, of marine mammals and monitoring their survival) would be the most informative. However, such experimental studies are not generally viewed as appropriate for megafauna such as marine mammals.
- Mark recapture models are informative, provided that individuals are resighted and recognized. While mark-recapture models may work well for well-monitored populations, other approaches (e.g., reviewing stranding data) are needed for less known populations and because some injured animals are never detected and/or resighted.
- Analyses of stranding data have been used in the absence of experimental manipulation and mark-recapture modeling. However, stranding data can be problematic because sightings of stranded animals are opportunistic and often have no sighting history from which to determine body condition, and other factors, prior to an injury or mortality event. There are also biases from a modeling perspective on which animals will strand and be sighted by humans, or sink into the ocean.

Question 3: Are sufficient data (quantity and types) available for testing?

- Well-documented injury events are only a subset of the total number of injury events, and this reduces the data available for study.
- Longitudinal data exist for a variety of species, such as North Atlantic right whales, humpback whales in the North Atlantic and Pacific, and some well-studied small cetaceans (e.g., bottlenose dolphins in Florida), which can be used to predict survival of injured individuals of these species.

- Where analyses are still data-limited, injury types and outcomes could potentially be studied across populations with similar characteristics, such as with humpback whales in the Gulf of Maine and humpback whales in southeast Alaska.

Question 4: Are the predictors (or signs that are known to indicate the severity of an injury) applicable across taxa?

- Some predictors of the severity of an injury may be applicable across species or taxa with similar life histories to make assumptions about survival, but these do not account for variation in the environmental conditions encountered by each species or individual animal.
- Capture myopathy of the most vulnerable species (i.e., those species that are less able to cope with or survive stressful situations) could be used until more is known about a given species.

7.2 Categorization of injuries and pathological consequences: gear-related injuries (e.g., entanglements, hookings, and ingestions)

Question 1: What type of nationally consistent categorization of injuries and outcomes will be functional for classification of injuries using data collected by various methods?

- A risk assessment/decision analysis framework should be developed to assign mortality risks to individuals based on factors affecting survival for each taxonomic group and injury type. This type of framework will require examination of current data and the collection of additional data in the future. The decision analysis framework should be developed by a panel of marine mammal and veterinary experts in cooperation with risk assessment experts.

Question 2: Are there categories of injuries that are: a) likely to have a serious outcome (i.e., mortality or reproductive impairment), b) unlikely to have a serious outcome; or c) not clearly determinable? How do we evaluate uncertainites?:

a) Injuries likely to have a serious outcome (based on the information provided in the workshop presentations):

- Ingestion of gear.
- Hook in mouth or head (especially for small cetaceans).
- Gear attached on body with potential to wrap around pectoral fins, peduncle or head, or to be ingested (e.g., hook with line that might be ingested).
- Foreign bodies penetrating into body cavity.
- Multiple wraps of line around pectoral fin, peduncle, head, abdomen, or chest.
- Deep external injuries (depth criteria to be determined (TBD), e.g., penetrating muscles, bones, or organs vs. penetrating the skin or blubber).
- Partially severed flukes, especially when midline is affected.
- Small cetaceans brought on the deck of a vessel following an interaction.

b) Injuries unlikely to have a serious outcome:

- For small cetaceans, a hook in the fluke with minimal trailing gear that does not have the potential to wrap around any body part or to accumulate drag (e.g., algal growth or marine debris).

c) Injuries for which the outcome cannot clearly be determined:

- For small cetaceans, the loss or severe disfigurement of the dorsal fin. There is evidence that small cetaceans can survive and reproduce without the dorsal fin, but these observations include information only on the survivors, and it is unknown what proportion of animals may die as a result of the loss of the dorsal fin. The nature of the injury causing the loss of the dorsal fin will affect the likelihood of surviving.
- For large whales, entanglement with line or gear in the mouth. Some large whales may survive a mouth entanglement, but the proportion is unknown.
- Animals released without gear following entanglement. Some regions previously considered disentangled animals not seriously injured, but capture myopathy considerations suggest some of these animals may subsequently die. The health of the animal may be comprised to a greater extent the longer it is immobilized by an entanglement.

Question 3a: What factors play a role in an animal's response to traumatic injuries and how would we evaluate them in the field?

- The condition of the animal (e.g., did the injury take place during a time of physiological stress, such as the fasting part of the animal's life cycle?).
- The duration of the stressor (e.g., the duration of an entanglement).
- The animal's age, sex, and reproductive status (e.g., juveniles may 'grow into' wrapped gear, increasing the severity of the entanglement due to the penetration of constricting lines).
- Environmental factors (e.g., individuals out of their normal habitat [such as dolphins in freshwater], climate stressors).
- Social stressors (e.g., separation of individuals from the group, cow/calf separation).
- The cumulative effects of repeated exposures.
- The susceptibility of the species to capture myopathy (e.g., pelagic dolphins are potentially more susceptible than coastal bottlenose dolphins or pinnipeds; North Atlantic right whales may be more susceptible than humpback whales).

Question 3b: How do we address hidden factors that may affect the risk of serious injury over time?

- Whenever possible, conduct follow-up tracking (i.e., gather resighting data) to help identify additional causal factors and injury outcomes.
- Conduct real-time communications between the disentanglement, observer, and stranding programs about ongoing entanglements to raise awareness among stranding network participants and increase information exchange about potential factors affecting the animal's survival.
- Researchers doing at-sea surveys should document and report any injuries or other relevant observations on marine mammal injuries.

Question 4: Based on the information we have from longitudinal studies, what is the most appropriate way to evaluate or score severity of injury and response of the animal?

- See answer to question 1 in this section (7.2) above.

7.3 Categorization of injuries and pathological consequences: sharp, blunt force, and penetrating injuries

Question 1: What type of nationally consistent categorization of injuries and outcomes will be functional for classification of injuries using data collected by various methods?

- A risk assessment matrix/approach would assist in developing a nationally consistent categorization of injuries and outcomes. Key variables to consider in developing a risk assessment matrix may include:
  - Geographic location.
  - Species.
  - Type of injury (e.g., blunt or sharp trauma, penetrating wound, or appendage loss). The type of injury could be further organized into subcategories, such as percent of body covered by wounds, the number of wounds, amount of blood loss, etc.
  - Location of wound on body.
  - Level of experience of observer documenting the injury event.
  - Previous history of the animal (e.g., previous injuries or entanglement events, individual sighting history).
  - Environmental events (e.g., times and areas of high fishing activity, marine mammal unusual mortality events, harmful algal blooms).
  - Environmental conditions (e.g., water temperature and salinity).
  - Overall body condition of animal (e.g., skin color, emaciated vs. robust, cyamid loads) and changes in body condition over time after the injury.
  - Behavior changes (e.g., how the animal reacted to the interaction that caused the injury).
  - Size and speed of a vessel involved in a ship strike or propeller injury event.
  - Life history characteristics of animal (e.g., lactating or pregnant female, fasting vs. feeding, juvenile vs. adult, healthy vs. diseased).
- The risk assessment matrix should be tested with data from North Atlantic right whale injury cases, because the longitudinal data on individual right whales is the most robust. Also, the matrix should be tested against injury cases where the animal is known to have died to assess whether the serious injury determinations coincide with the animal's actual fate.
- The injuries that are not clearly determinable may need to have some regional and species specific flexibility to account for differences in the impact of a given injury on difference individual animals and/or species.
- An interdisciplinary, national panel should also be convened to assist NMFS in distinguishing serious from non-serious injuries and case-by-case consultations on injuries that are not clearly determinable. This panel should include experts with combined expertise in forensics, animal health, and risk assessment.

Question 2: Are there categories of injuries that are: a) likely to have a serious outcome (i.e., mortality or reproductive impairment), b) unlikely to have a serious outcome; or c) not clearly determinable? How do we evaluate uncertainties?

Participants in this breakout group prefaced their responses to question 2 with several general comments:

- Key terms used to describe injuries need rephrasing. Rather than using the terms sharp, blunt force, or penetrating to describe injuries, the terminology should be based on physical injuries that can be objectively described, such as incision, laceration, and swelling.
- The New England Aquarium considered a wound of 4 cm depth or greater as serious for North Atlantic right whales (Knowlton and Kraus, 2001).
- Determining when an animal received a wound may be important. If the injured animal has been able to survive with the injury for a given period of time, the animal may be more likely to continue to live with the injury into the future. It is also important to consider the cumulative effects of previous wounds or injuries incurred by an animal.

a) Injuries likely to have a serious outcome:

- Head trauma.
- Vertebral transection.
- Body cavity penetration or exposure.
- Direct hit by a vessel of a certain size (TBD).

b) Injuries unlikely to have a serious outcome:

- For large whales, wounds penetrating into blubber but no deeper.
- Shallow wounds (excluding wounds to the head, chest or penetrating into the body cavity).

c) Injuries for which the outcome cannot clearly be determined:

- Wounds penetrating into the muscle may require additional descriptors from the observer to determine severity (e.g., age, history of previous wounds).

Question 3a: What factors play a role in an animal's response to traumatic injuries and how would we evaluate them in the field?

- Life history of animal (e.g., pregnant or lactating female, fasting vs. feeding, age).
- Species. Different species respond differently to similar injuries.
- Movement patterns of the animal (e.g., highly migratory vs. remain local).
- Environmental conditions (e.g., different temperatures and salinities may affect healing rates, harmful algal blooms may impact an animal's susceptibility to an injury and recovery from an injury).

Question 3b: How do we address hidden factors that may affect the risk for serious injury over time?

- Not specifically addressed.

Question 4: Based on the information we have from longitudinal studies, what is the most appropriate way to evaluate or score severity of injury and response of the animal?

- Data from longitudinal studies can inform a revised process for distinguishing serious from non-serious injuries.

7.4 Large Cetaceans

Question 1: Given the data we have, do the categorizations and classifications of injuries identified in the preceding breakout groups fit this taxonomic group? What are the unique characteristics in this taxonomic group that would change the categorization and classification of injuries? How does age, type of injury, location of injury, species, etc., impact the classification of an injury?

Participants suggested the following ideas would help improve serious injury classifications:

- The majority of participants stated that NMFS should move away from the binary threshold of "serious injury" or "not serious injury," by developing a matrix to provide more room to handle injury cases that are difficult to categorize. The developed criteria should be applicable to a wide range of taxa and regions (i.e., criteria should lead to nationally consistent results when distinguishing serious from non-serious injuries). One participant warned that a subjective scoring system analogous to triage evaluation may provide false precision.
- A revised classification scheme should include the following considerations: (1) any changes should be an improvement over the current system, (2) the system should be as simple as possible, and (3) the system should be scientifically and legally defensible.
- NMFS should not shy away from adding criteria to those currently outlined in Angliss and DeMaster (1998) and the NEFSC mortality and serious injury determination reports (Cole *et al.*, 2005; Cole *et al.*, 2006; Nelson *et al.*, 2007), or from asking for more data to be collected to inform serious injury determinations. More data may provide a better opportunity to evaluate an injury case.
- There are varying levels of information available for different marine mammal populations, providing opportunities for different levels of analysis (e.g., estimating mortality rates for injuries using mark-recapture studies is possible for well-studied populations, but not for less-studied populations).
- Data from longitudinal case studies indicating which types of injuries are serious should be used to make determinations in injury cases of individuals of the same species where fate of that individual is unknown. It could be useful to consider extrapolating data on the survival of injured animals from well-monitored populations to animals with similar injuries from other populations or similar species.
- Any resighted animal that is clearly in poor condition and has evidence of human interactions (e.g., entanglement or ship strike) should be classified as "seriously injured," even if it was not initially considered a serious injury at the time of the injury event (e.g., observed at the time of the interaction and then observed again in worse condition, or observed in poor condition with evidence of previous interaction).
- Serious injury determinations can be informed by the manner in which the gear is located on the animal (e.g., fishing lines are hanging vertically (indicating heavy gear) vs. horizontally off the animal, or the fishing lines are cutting into the animal).

- Anchoring or immobilizing whales in gear may increase risk of death from hidden injuries, stress, or capture myopathy.

Question 2: What are our data needs, and how do we address these?

Field data:

- Conduct follow-up research on observed injuries, such as through photo-identification and tagging efforts, and develop long-term longitudinal databases.
- Investigate wounds that do not appear to heal over time.
- Researchers should obtain photos to document injuries, not just for the purposes of photo-identification.
- Improve data collection of entangled humpback whales in the Alaska region by increasing staffing and enhancing awareness of stranding and injured marine mammals. Many parts of Alaska are underrepresented due to limited staff available for detecting and monitoring humpback whale entanglements.

Communication and coordination:

- Improve communication and coordination between stranding networks, regional offices, researchers, disentanglement networks, Canadian colleagues, and NMFS staff responsible for distinguishing serious from non-serious injuries.
- Develop more consistent terminology for describing injuries, including injury categories (e.g., serious, moderate, severe).

Health assessments:

- Continue efforts to develop tools and techniques for conducting visual and remote health assessments on marine mammals.

Necropsy:

- Increase support for necropsy response, including responses to dead whales observed at sea, whether or not there is external evidence of human interactions. Increase forensic expert involvement in necropsy analyses.

Review of existing data:

- Review cases and case histories of disentangled marine mammals to better understand the nature of the interactions. Involve fishermen and veterinarians in this review to improve the ability to recreate the entanglement.
- Model survival based on different injury categories.

Specific research topics to address:

- Increase investigation of the physical indications of capture myopathy. This could be done by collecting new data (e.g., ketones in breath samples of disentangled animals), and reviewing sighting and disentanglement databases for animals that exhibited suspicious symptoms (e.g., animal remained in place once disentangled instead of swimming away) and see whether or not those animals survived the interaction.
- Continue biomechanical testing on the manner in which gear interacts with animals, and how different parts of gear interact with different parts of an animal's body.

- Investigate whether rope in the mouth decreases survivorship by increasing muscular expenditure while swimming (i.e., mouth suction theory).

Question 3: How can the scientific uncertainty concerning the impact of an injury (short- or long-term) be handled in making serious injury determinations?

- Extrapolating data on the survival of injured animals from well-monitored populations to animals with similar injuries from other populations or similar species.
- Use a Bayesian approach to help distinguish serious from non-serious injuries in a decision tree matrix with priors for parameters where values are unknown.
- Start with the assumption that every injury is a serious injury.
- Create a CBD category to address cases where uncertainty exists in distinguishing between serious and non-serious injuries. Develop a risk-assessment matrix to remove cases from the CBD category.
- Pro-rate CBD cases based on what is known about specific injury cases in certain species (as shown in Forney and Kobayashi, 2007).
- Shift from a base count of injuries to an extrapolation to account for unobserved injuries and mortalities.
- Address other uncertainties, such as the size of vessels and which fisheries are causing interactions. Also, address uncertainties for attributing serious injury to a given marine mammal when the stock to which the individual belongs is unknown.

7.5 Small Cetaceans

Note: This breakout group defined small cetaceans as all odontocetes excluding sperm whales.

Question 1: Given the data we have, do the categorizations and classifications of injuries identified in the preceding breakout groups fit this taxonomic group? What are the unique characteristics in this taxonomic group that would change the categorization and classification of injuries? How does age, type of injury, location of injury, species, etc., impact the classification of an injury?

The breakout group considered key findings presented from the morning breakout session discussions, attempted to clarify points that were vague, and folded into their discussions the issues that may be specific to small cetaceans. The response to question 1 is both a fleshing-out of the morning discussions as well as an expansion. The breakout group focused its deliberations on the topics of fishing gear-related injuries and traumatic injury, but also noted some unresolved issues.

<u>Gear-related injuries:</u>

- The severity of certain injuries is similar across all taxa (e.g., multiple wraps of fishing line causing constriction, ingestion of gear), and there may not always be a distinction in the severity of a given injury between small and large whales. However, some injuries that are not serious in large cetaceans are serious for small cetaceans. For example:
    - A hook in mouth is serious in small cetaceans because of the potential for ingestion.

  - The duration of entrapment becomes an issue with small cetaceans. After a given amount of time, large animals may be more apt to free themselves, while small cetaceans may have increased difficulty reaching the surface.
  - Stress response may be more "urgent" in small cetaceans than in larger cetaceans.
- The ability to differentiate robustness between species and taxonomic groups is important for determining the severity of an injury (i.e., species respond differently to stress, potentially increasing the severity of a given injury for certain species). The response of a given species to stress should be included in a risk assessment/decision framework.
- The type and amount of gear remaining on an animal after it swims away from the vessel should be recorded. This information provides an indication of the potential for the animal to ingest the gear, for the gear to wrap and constrict, or for the gear to accumulate drag as the animal swims.
- Cleanness of a cut and the depth of a wound made by gear are also important. A clean, one-time wound is not as serious as constricting fishing line cutting into the animal over time.
- Visible blood does not mean an injury is serious. Observers and other data recorders should record the presence or absence of visible blood, instead of using subjectivity to describe the amount of blood present (i.e., lots of blood, a small amount of blood).
- Observers should attempt to distinguish between actively fishing gear interacting with the animal vs. derelict fishing gear. In the case of actively fishing gear, observers will have a better idea of the maximum amount of time the gear has been on the animal, whereas opportunistic sightings of stranded animals or animals swimming with passive (ghost) gear do not give an indication of how long the animal has been entangled.
- An entanglement that immobilizes or significantly impairs the movement of a species that must eat every day may be more serious than for a species that is in the fasting portion of its annual feast/fast cycle (e.g., bottlenose dolphins must eat every day vs. humpback whales that fast during migration to breeding grounds).
- Social structure of the species and age of the individual animal are key factors in determining the severity of an injury (e.g., a social or dependant animal released alone may be subject to additional stress and reduced survival).
- Any small cetacean that is brought on the deck of a vessel is subject to a high risk of death due to hidden injuries or some other factor (an thus could be designated as seriously injured).

<u>Traumatic injuries:</u>

- The location of propeller wounds on the body is an important factor in distinguishing a serious from a non-serious injury. For example, propeller wounds on the head or neck are more likely to be serious injuries than wounds behind the animal's midsection.
- Resighting data may be more difficult to obtain with small cetaceans, but observers should document all resighting data possible.
- The size and speed of a vessel involved in a vessel-strike event are important factors in distinguish between a serious or non-serious injury.

<u>Unresolved issues/questions:</u>

- Is a serious injury to a pregnant cetacean or a cetacean with a calf a serious injury to the cow, the fetus or calf, or both?

- How should the effects of whale-watching and chasing of dolphins by people engaged in other recreational activities (e.g., boating, kayaking, swimming) be incorporated into serious injury determinations? Would these cases be included in the SARs?
- How should research-related serious injuries be incorporated into serious injury determinations?

Question 2: What are our data needs, and how do we address these?

- Collect additional data on post-release survival. Additional comments here included:
  - Tools exist for collecting data on post-release survival (e.g., telemetry, tagging), but telemetry or tagging would need strict experimental boundaries and designs to include studies using control and experimental groups.
  - The reality of tagging and telemetry studies is such that we would need to balance the cost, effort involved, stress on the animal, tag failure rate, and small sample size, with the difficulties in interpreting the data collected.
  - Before determining how best to gather data on the survival of an injured animals, the survival window (amount of time the animal survives with an injury to be considered seriously injured) would have to be defined.
  - Consider chartering vessels to gather the data that observers may not able to gather, and/or to perform the follow-up studies.
  - When a tag stops recording data, it is often difficult to determine whether a mortality has occurred or the tag has failed or been lost. Creating a redundant tagging system could provide confirmation of mortalities.
- Biopsies should be taken by all observer programs, when possible, to increase the number of genetic tags available for analysis. Pair genetic and photo-identification, whenever possible.
- The stranding network should increase photo-identification work on stranded animals for comparisons between data sets.
- Provide improved support and resources for stranding networks. Encourage thorough necropsies on every animal possible.
- Focus on improving the data collected by the observer program.
  - Provide observers with better tools and resources at sea, including a consistent set of questions to answer, and training to allow identification and recording of the characteristics of a dying animal (e.g., arching of the back in small cetaceans is indicative of imminent death).
  - Encourage observers to bring carcasses back to shore, whenever possible.
  - Train observers in safe release techniques for entangled marine mammals.

Specific analyses and studies:

- Propeller scar studies for small cetaceans, similar to scar studies on large whales (such as those described in presentations by Robbins and Calambokidis).
- Data-mining of existing observer data, especially for fisheries which lack key drivers for data gathering, such as TRTs or interactions with strategic stocks.
- Examine existing robust databases of health assessments for cases of injuries that will increase the sample size (e.g., the Sarasota Dolphin Research Program, killer whales in the Pacific Northwest, or Hector’s dolphins).

- Investigate stress responses in marine mammals to better characterize the impact of stress on the survival of an animal.
- Develop better identification for beaked whales and collect more biopsies from these species.
- Investigate the effect of noise on marine mammals as a potential serious injury.[17]

Question 3: How can the scientific uncertainty concerning the impact of an injury (short- or long-term) be handled in making serious injury determinations?)

- Develop a risk analysis/decision framework. Potential alternative approaches:
    - Bring the staff responsible for distinguishing serious from non-serious injuries together with policy staff and decision analysis experts to develop a decision tree for distinguishing serious from non-serious injuries based on a set of criteria.[18]
    - Convene a small group of experts to work on a white paper to be reviewed by the SRGs.
- Modify the process for distinguishing serious from non-serious injuries so that determinations are made by a national group rather than by individuals.
- Institute a training or certification process for staff responsible for distinguishing between serious and non-serious injuries to increase national consistency.
- Consider a policy decision that shifts the burden of proof. That is, recognizing that there is a continuum of injury severities; create a system that makes the working assumption that an injury is serious unless contradicted by empirical evidence or a consensus of professional judgment to the contrary. When there is uncertainty, determine that the injury is a serious injury.
    - This would cause a fundamental change in how determinations are made and would have management implications (e.g., additional TRTs).

7.6 Pinnipeds and other species

Question 1: Given the data we have, do the categorizations and classifications of injuries identified in the preceding breakout groups fit this taxonomic group? What are the unique characteristics in this taxonomic group that would change the categorization and classification of injuries? How does age, type of injury, location of injury, species, etc., impact the classification of an injury?

<u>Gear-related injuries:</u>
Injuries likely to have a serious outcome:

- Ingestion of gear (although not generally observed in pinnipeds).
- Gear attached to body with trailing gear that has the potential to anchor or drag, or to wrap around flippers, body, or head.
- Foreign objects penetrating into a body cavity.
- Multiple wraps of line or netting around the body.
- Missing a front or back flipper(s), for both otariids and phocids.

[17] The impacts of sound/noise on marine mammals were not specifically addressed at this Workshop.
[18] This bullet outlines the process followed on Day 4 of the workshop.

- Deep external injuries (e.g., severe wounds extending through the skin and blubber, well into the muscle, or puncturing the body cavity).

Injuries unlikely to have a serious outcome:
- Confirmed hooked in the lip (soft tissue only).
- Hooked in flipper or other party of the body (excluding the head) with minimal trailing gear that does not have the potential to wrap around body or appendage(s).

Injuries for which the outcome cannot clearly be determined:
- Hooked in the head. The severity depends on several factors, including the hooking location on head, the depth of penetration, and the type of hook.
- Animals stressed from being encircled or trapped (e.g., purse seine).
- Animals released without gear following an entanglement. The severity depends on the extent of the injury, the duration of time the animal was submerged, the duration of time the animal was entangled in the gear, and the degree of restraint.
- Pinnipeds brought on vessel. Unlike with small cetaceans, this is typically not considered to be a serious injury. However, the severity of the injury also depends on the manner in which the animal was brought onboard (e.g., in net, over a roller, or through the power block).

<u>Injuries caused by blunt trauma and penetration:</u>
Injuries likely to have a serious outcome:
- Head trauma (including broken jaw or the eye popped out), vertebral transection, and cavity penetration or exposure (includes bullets).
- Any detectable fractures, which will lead the animal to eventually strand or die due to thrombosis (a blood clot in the heart or blood vessel) or a secondary infection.

Injuries for which the outcome cannot clearly be determined:
- Feral, wild or domestic carnivore bites (i.e., dog or coyote bites), the severity of which depends on the extent of the injury.
- Direct hit by a vessel is a serious injury depending on the size, speed, and inertia of the vessel relative to the size of the animal, the depth of propeller wound (into the blubber or muscle), and the type of vessel (e.g., water ski, car, boat).
- Direct hit by blunt object (e.g., baseball bat), the severity of which depends on the extent of the impact.

<u>Unique characteristics of pinnipeds that affect the categorization and classification of injuries:</u>
- Sea lions and seals can be examined relatively closely by an observer or stranding program participant. Therefore, it is possible in many cases to get an accurate description of an injury and assess its severity.
- Some pinnipeds have adapted to fishing operations or other human activities and do not appear to experience the same level of stress as other marine mammal taxa.
- Certain pinniped behaviors may predispose them to serious injuries. For instance, those likely to repeatedly interact with fishing operations/gear are more likely to be shot (e.g., California sea lions).

Key contextual features that affect the classification of an injury:

- Factors contributing to the severity of an injury in cetaceans also generally apply to pinnipeds and other marine mammal species. Juveniles, pups and young-of-the-year animals have soft craniums and are therefore more vulnerable to blunt trauma. Dependent animals are generally more at risk.

Question 2: What are our data needs and how do we address these?

- In general there is good reporting and follow-up (including resight data) of injured pinnipeds from stranding and response networks (especially in Hawaii). Specific suggestions for addressing data needs:
  - Standardize data collection nationally and between the data collection programs (stranding, disentanglement, and observer programs).
  - Conduct more studies on post-injury survival in pinnipeds.
  - Increase efforts to capture and rehabilitate pinnipeds that are observed entangled or with human-caused injuries. When this is not possible, document the observation and mark the animal (e.g., with paint) to allow for follow-up observations.
  - Identify existing databases to work on risk assessment and probability of survival.
  - Emphasize the use of high quality photos to document injuries, body condition, healing, and entanglement events. Photos provide better information to staff responsible for distinguishing between serious and non-serious injuries, when that person has not personally seen the injured animal.

Question 3: How can the scientific uncertainty concerning the impact of an injury (short or longterm) be handled in making serious injury determinations?

- A greater level of precaution may be warranted for strategic stocks, endangered, or declining species (such as monk seals) compared to species with increasing populations (such as California sea lions). The importance of including scientific uncertainty into the decision-making process is heightened when dealing with strategic stocks, or endangered and threatened species.
- Include confidence levels (codes) for reliance of data in the determination process.
- As a starting point, assume serious injury for cases marked by insufficient data until the data supports a non-serious determination.

7.7 Summary of Day 3 Breakout Group Sessions

Many common themes and suggestions emerged from the Day 3 breakout groups, presented above as each group separately. While rare, diverging views were stated at times. This section summarized the common suggestions and needs identified by all of the breakout groups.

Similar suggestions related to serious injury criteria and the determination process:

- NMFS is likely underestimating serious injuries through the current determination processes. Therefore, NMFS should develop a risk assessment/matrix approach for use in distinguishing serious from non-serious injuries. This approach should be:
  - Nationally consistent. The matrix should incorporate flexibility, while limiting subjectivity in the determinations. The matrix should be developed in such a way

as to avoid circumstances that exist under the current determination process where a given injury is considered "serious" in one region and "not serious" in another.
    - Based on factors affecting survival for each marine mammal species and taxonomic group.
    - Sufficiently flexible to include additional relevant factors when there is uncertainty in the outcome of an injury event
- NMFS should gather a national panel annually, including staff responsible for distinguishing serious from non-serious injuries from each region, decision analysis, and other external experts (veterinarians, pathobiologists, marine mammal researchers) to review serious injury determinations. This panel review will help to decrease individual subjectivity in the determinations, leading to increased national consistency.
- NMFS should revise (and/or develop) and use consistent terminology to objectively describe injuries. The terminology should be based on the observable physical injuries (i.e., laceration, incision, swelling).

<u>Diverging views to suggestions related to serious injury criteria and the determination process:</u>

- Aside from assuming all injuries are mortal unless proven otherwise, a new approach is unlikely to significantly increase the number of injuries classified as "serious injuries" for large whales if it relies on anecdotal reports, as the current large whale systems do. Even in well-documented populations, individuals are under observation by researchers for a tiny fraction of their lives. For example, for North Atlantic right whales—one of the most thoroughly studied species—only the most prolonged entanglements are longer than the average period between detections of individuals. Most mortalities are never observed.
- We must differentiate between means for improving the accuracy of injury assessment and prognosis when injuries are observed, and means for improving the accuracy of estimates of all (observed and unobserved) human-caused mortality and serious injury. The reliance on anecdotal reports makes these distinctly different for large whales.

<u>Similar suggestions related to data needs:</u>

- The observer, stranding, and disentanglement programs are collecting useful data and have improved over the past decade. Participants indicated that further improvements could be made by:
    - Standardizing data between all regions, for all species and taxonomic groups, and between data collection programs.
    - Increasing communication and coordination between the data collection programs and the staff responsible for distinguishing serious from non-serious injuries, and between each region.
- NMFS should examine data collected by the observer, stranding, and disentanglement programs, and external partners, to determine whether injured animals documented in one data set are resighted in another data set. This could increase the data available on a given injury case.
- Longitudinal studies provide valuable information on individuals and populations, including the survival of injured animals. Longitudinal studies should be continued for currently well-monitored populations and started (or expanded) for lesser or unmonitored populations.

Similar suggestions related to the categorization of injuries:

- Participants in each breakout group identified the following injuries as serious injuries for all marine mammals (in addition to other injuries identified by individual breakout groups), including:
  - Ingestion of gear.
  - Constricting lines or lines with the potential to constrict as an animal grows.
  - Head trauma.
  - Body cavity penetration.
- Physiological and behavioral differences exist between species and taxonomic groups, which cause differences in the severity of certain injuries for different species. For example, a hook in the mouth is a serious injury for small cetaceans and pinnipeds, but not a serious injury for large cetaceans.
- Vessel size and speed "source" information should be included in the serious injury matrix because the severity of the injury resulting from a vessel strike depends on the size and speed of the vessel.

8.0 Recommendations of Government Staff

The final day of the workshop was a closed federal session. Thirty-six federal participants with expertise in marine mammal biology, pathobiology, veterinary medicine and management attended from NMFS, NOS, FWS, the U.S. Navy Marine Mammal Program, and the Marine Mammal Commission. The primary purpose of the closed federal session was to draw on presentations and discussions from Days 1-3 of the workshop, consider what has worked well in distinguishing serious from non-serious injuries since 1997, what has not worked well, and recommend potential changes to the existing serious injury guidance, as outlined in Angliss and DeMaster (1998) and as adapted for use by the NEFSC (Cole *et al.*, 2005; Cole *et al.*, 2006; Nelson *et al.*, 2007; Glass *et al.*, 2008). Information from Day 4 discussions is presented in sections 8.0-8.4.

Most participants expressed the view that the current serious injury guidance should be revised and updated to capture current knowledge about impacts of injury on marine mammals and to improve national consistency in distinguishing serious from non-serious injuries. Nearly all the participants recognized that NMFS is close to where it should be in the assessments of detected animals. However, undetected injuries exist that are not being incorporated into population assessments; therefore, NMFS needs to devise a mechanism to better account for undetected injuries. One participant suggested that serious injury guidelines are not the appropriate mechanism for accounting for undetected injuries. This participant noted that the 1997 workshop report presented recommendations but did not identify a single set of criteria for determinations; instead, researchers from each region worked to adapt and refine the recommendations for distinguishing serious from non-serious injuries, building on experience since the first workshop.

Participants expressed nearly unanimous support for the development and publication of an official NMFS policy to strive for nationally consistent criteria to use when distinguishing serious from non-serious injuries, while allowing for flexibility in data-rich situations. This policy should also include what is meant by the term “likely” in the definition for serious injury, “injury that will *likely* result in mortality,” because different working definitions are currently in use for different stocks nation-wide. One participant noted that creating a legal definition for the term *likely* in the serious injury definition could have far-reaching implications beyond the realm of serious injury determinations. Participants concluded that rulemaking or a change to the regulatory definition of "serious injury" was not necessary to improve serious injury determinations.

The section below describes recommended revisions to the process and criteria for distinguishing between serious and non-serious injuries, developed by federal participants present on Day 4 of the workshop.

8.1 Recommended Revisions and Updates to the Process and Guidance for Distinguishing Serious from Non-Serious Injury

The workshop Steering Committee reviewed the guidance for distinguishing between serious and non-serious injuries provided in Angliss and DeMaster (1998) and the various NEFSC publications (see Section 2.3 above), and recommended revisions and additions based on the Day 1-3 presentations and discussions. Federal participants subsequently discussed the Steering Committee's recommendations and constructed a matrix containing a revised set of criteria for distinguishing serious from non-serious injuries (Table 1).[19] Table 1 incorporates a synthesis of new information presented and discussed at the workshop and is a first step towards creating guidance that attempts to improve national consistency in serious injury determinations across regions.

Table 1 is meant to serve as a starting point for distinguishing serious from non-serious injuries. In addition, Table 1 is meant to provide guidance in situations where there are little data and/or resighting of an injured animal is unlikely. Participants recognized that alternate guidance may be available in data-rich situations where an injured animal has a higher likelihood of being resighted (as with baleen whales in the NER). In this manner, Table 1 provides a means by which to strive for national consistency while retaining flexibility for situations where better information is available. Table 1 is intended as a precursor for developing future NMFS policy for distinguishing serious from non-serious injuries.

In addition to specific revisions and updates, Table 1 outlines two substantial recommended changes to the current process for distinguishing between serious and non-serious injuries as a whole:

1) Expands the dichotomous determination process (all injuries are "serious" or "not serious") to include a third category representing uncertain cases (injuries can now be classified as "serious," "not serious" or "CBD/case specific"). Currently, cases with insufficient information are often (but not consistently) considered "not serious," likely leading to an underestimate of the actual number of serious injuries. The recommended addition of a "CBD/case specific" category takes into account two circumstances: 1) there is insufficient information about the impact of a particular injury to determine whether it is a serious or non-serious injury; and/or 2) it is possible to determine whether a particular injury is a serious or non-serious injury, but additional factors must be considered on a case-by-case basis.

2) Creates guidance with separate serious, non-serious, or CBD/case specific determinations criteria for different marine mammal taxonomic groups (i.e., large cetacean, small cetacean, and pinnipeds), to allow for differences in the severity of an injury based on the animal's physiology and the amount and type of data that are available.

Participants added definition to Table 1 by making the following clarifications:

- Table 1 addresses most of the injuries likely to be observed in marine mammals. Capture myopathy was not explicitly included in the list of injuries because it is difficult to observe as a phenomenon. However, some participants considered the potential impacts of capture myopathy as a factor to be considered when an injury determination falls into

[19] The recommended matrix does not consider criteria for determining serious injuries for FWS trust marine mammal species (manatee, sea otter, polar bear, dugong, marine otter and walrus). Recommended serious injury criteria for pinnipeds may be applicable to walrus; however, due to physiological differences, each of the criteria in the matrix would need to be assessed separately for a serious injury determination for the remaining FWS trust species.

the “CBD/case specific” category. Also, participants noted that not all categories will have externally visible injuries.

- A major goal in developing Table 1 was to identify the types of injuries that would clearly be considered serious injuries.
- The injury categories established in Table 1 cover most types of injury regardless of the source. However, there were a few source-dependent injuries that participants considered necessary (e.g., collision with vessel of a certain size or speed).
- Injury determinations that are “CBD/case specific” may vary by region (e.g., because of the types and quality of data that are available) or species (e.g., because a given injury may be more severe for some species than for others).
- Participants offered distinctly divergent advice for just two of the 33 injury categories, identified with gray shading in Table 1:
    - Criterion 10 in Table 1, “Gear attached to free-swimming animal with potential to 1) wrap around pectoral fins/flippers, peduncle, or head; 2) be ingested; or 3) accumulate drag,” for large cetaceans could be considered either a “serious injury” or “CBD/case specific.” In a straw poll (with several abstentions), about 2/3 of the participants present voted for the injury determination to be included as “CBD/case specific” and about 1/3 voted for “serious injury.” Participants agreed that this injury event is “serious” for both small cetaceans and pinnipeds.
    - Whether the injury “dog bite” should have its own unique category, or whether it should be subsumed as part of any of the following categories in Table 1: Head trauma (including eye injuries) (criterion 6); Deep, external cut or laceration to body (criterion 15); Body cavity penetration by foreign object or body cavity exposure (criterion 16); or body trauma not covered by cases 6, 15, or 16 above (e.g., broken appendages, hemorrhaging” (criterion 24). In a straw poll (with several abstentions), about ¾ of the participants preferred including dog bites within these categories. The pinniped experts present generally preferred to include dog bites in a separate category, because of the additional potential for inter-species disease transmission. For this reason, the workshop Steering Committee modified Table 1 finalized on Day 4 of the workshop to include dog bites as a separate criterion (criterion 33). The lack of agreement by workshop participants is indicated by the gray highlighting on this criterion in Table 1.

Table 1: Recommended Serious Injury Criteria for Different Taxonomic Groups *

SI = Serious Injury; **NSI** = Not Serious Injury; **CBD/case specific** = Potential SI, but either 1) insufficient information about the impact of a particular injury, or 2) additional factors must be considered on a case-by-case basis to determine the severity; **n/a** = not applicable; **TBD**= To Be Determined; __ = areas lacking near-complete agreement among Day 4 participants.

Criterion	Injury/Information Categories	Large Cetaceans	Small Cetaceans	Pinnipeds
Pre-Existing Guidance (included in Angliss and DeMaster (1998) and/or NEFSC publications, retained with no changes)				
1	Ingestion of gear or hook	SI	SI	SI
Modified Criteria (some aspects retained from guidance provided in Angliss and DeMaster (1998) and/or NEFSC publications, with some changes or additions)				
2	A free-swimming animal observed at a date later than its human interaction, exhibiting a marked change in skin discoloration, lesions near the nares, fat loss, or increased cyamid loads, etc.	SI	SI	SI
3	Gear constricted on any body part, or likely to become constricting as the animal grows	SI	SI	SI
4	Uncertain whether gear is constricting, but appendages near the entanglement's point of attachment are discolored	SI	SI	SI
5	Anchored/immobilized (not freed)	SI	SI	SI
6	Head trauma (including eye injuries)	SI	SI	SI
7	Hook in mouth (excluding case 9 below), no trailing gear	CBD/case specific	SI	SI
8	Hook confirmed in head (excluding mouth), no trailing gear	NSI	SI	CBD/case specific
9	Hook confirmed in lip only, no trailing gear	n/a	CBD/case specific	CBD/case specific
10	Gear attached to free-swimming animal with potential to 1) wrap around pectoral fins/flippers, peduncle, or head; 2) be ingested; or 3) accumulate drag	CBD/case specific	SI	SI
11	Animal freed from gear and released without gear	CBD/case specific	CBD/case specific	CBD/case specific
12	Social animal separated from group or released alone	CBD/case specific	CBD/case specific	CBD/case specific
13	Dependent animal (e.g., calf, pup) alone post-interaction	SI	SI	SI
14	Wrap(s) of gear around pectoral fin/flippers, peduncle, head, abdomen, or chest	CBD/case specific	SI	SI
New Criteria				
15	Deep, external cut or laceration to body	CBD/case specific	CBD/case specific	CBD/case specific
16	Body cavity penetration by foreign object or body cavity exposure	SI	SI	SI

Criterion	Injury/Information Categories	Large Cetaceans	Small Cetaceans	Pinnipeds
17	Visible blood loss	CBD/case specific	CBD/case specific	CBD/case specific
18	Loss or disfigurement of dorsal fin	CBD/case specific	CBD/case specific	n/a
19	Partially severed flukes (transecting midline)	SI	SI	n/a
20	Partially severed flukes (not transecting midline)	CBD/case specific	CBD/case specific	n/a
21	Partially severed pectoral fins or flippers	CBD/case specific	CBD/case specific	CBD/case specific
22	Severed pectoral fins or flippers	CBD/case specific	CBD/case specific	SI
23	Entanglement, immobilization or entrapment of a certain duration before being freed (TBD, species-dependent)	SI	SI	SI
24	Body trauma not covered by cases 6, 15, and 16 above (e.g., broken appendages, hemorrhaging)	CBD/case specific	CBD/case specific	CBD/case specific
25	Detectable fractures	SI	SI	SI
26	Hook in appendage, without trailing gear or with trailing gear that does not have the potential to wrap, be ingested, or accumulate drag	NSI	NSI	NSI
27	Animal brought on vessel deck following entanglement/entrapment	n/a	SI	CBD/case specific
28	Vertebral transection	SI	SI	SI
29	Collision with vessel of certain minimum size (TBD, species-specific)	SI	SI	CBD/case specific
30	Collision with vessel traveling at a certain minimum speed (TBD, species-specific)	SI	SI	CBD/case specific
31	Collision with vessel below a certain size threshold (TBD, species-specific)	CBD/case specific	CBD/case specific	CBD/case specific
32	Collision with vessel traveling below a certain speed threshold (TBD, species-specific)	CBD/case specific	CBD/case specific	CBD/case specific
33	Dog Bites°	n/a	n/a	CBD/case specific

***** See section 8.1 for additional details on the intent and purpose of Table 1.

° This criterion was not included by the Day 4 Participants. The workshop Steering Committee added this criterion for clarity. About ¾ of the Day 4 participants preferred subsuming dog bites under criteria 6, 15, 16, or 24 (depending on the injury inflicted by the dog bite). The pinniped experts generally preferred to include dog bites in a separate category, because of the additional potential for inter-species disease transmission.

8.2 Changes from Existing Guidance Represented in Table 1

The initial elements of Table 1 were derived from the existing guidance established at the 1997 workshop (Angliss and DeMaster, 1998) and from published documents on serious injury determination for baleen whales in the NEFSC (Cole *et al.*, 2005; Cole *et al.*, 2006; Nelson *et al.*, 2007; Glass *et al.*, 2008). Participants then made specific changes based on the Days 1-3 presentations and discussions.

All of the guidance provided in Angliss and DeMaster (1998) was incorporated into Table 1, some with changes or additional details (as described below). All of the NEFSC criteria for what constitutes a serious injury for baleen whales were incorporated unchanged into Table 1. In addition, Table 1 incorporates many of Angliss and DeMaster's considerations for distinguishing between serious and non-serious injuries on a case-by-case basis into the "CBD/case specific" category (see section 2.4 in this document).

The information below, describing the similarities between Table 1 and the existing serious injury guidance, was not explicitly discussed during Day 4 of the workshop. The workshop Steering Committee developed this information for this Technical Memorandum to facilitate the readers' review of the proposed serious injury criteria presented in Table 1.

Unchanged criteria between existing guidance and Table 1

Criterion 1: "Ingestion of gear or hook"

- *Large cetaceans, small cetaceans, and pinnipeds:* Only one criterion in Table 1 was retained from existing guidance (in this case from Angliss and DeMaster) without changes to any of the taxonomic groups. Angliss and DeMaster considered "Ingestion of gear or hook" a serious injury for all taxonomic groups, and it is also considered a serious injury for all taxonomic groups in Table 1.

Changes to, or differences from, existing guidance

The following discussion reflects where guidance provided in Angliss and DeMaster and/or in NEFSC documents were modified in Table 1 for: 1) added clarity; 2) to distinguish a serious from a non-serious injury for a species group not included in either Angliss and DeMaster or NEFSC documents; or 3) participants at the 2007 workshop considered the serious injury determination for a given injury scenario to be different than existing guidance. (Numbers correspond with the criteria numbers in Table 1.)

Criterion 2: "A free-swimming animal observed at a date later than its human interaction, exhibited a marked change in skin discoloration, lesions near the nares, fat loss, or increased cyamid loads, etc."

- *Large cetaceans:* Considered a "serious injury" in NEFSC documents. Remains a "serious injury" in Table 1.
- *Small cetaceans and pinnipeds:* Not discussed in existing guidance. Included as a "serious injury" in Table 1.

Criterion 3: "Gear constricted on any body part, or likely to become constricting as the animal grows."

- *Large cetaceans:* Considered a "serious injury" in NEFSC documents. Remains a "serious injury" in Table 1.
- *Small cetaceans and pinnipeds:* Not discussed in existing guidance. Included as a "serious injury" in Table 1.

Criterion 4: "Uncertain whether gear is constricting, but appendages near the entanglement's point of attachment discolored and likely compromised."

- *Large cetaceans:* Considered a "serious injury" in NEFSC documents. Remains a "serious injury" in Table 1.
- *Small cetaceans and pinnipeds:* Not discussed in existing guidance. Included as a "serious injury" in Table 1.

Criterion 5: "Anchored/immobilized (not freed)."

- *Large cetaceans:* Considered a "serious injury" in NEFSC documents. Remains a "serious injury" in Table 1.
- *Small cetaceans and pinnipeds:* Not discussed in existing guidance. Included as a "serious injury" in Table 1.

Criterion 6: "Head trauma (including eye injuries)."

- *Large cetaceans:* Not discussed in existing guidance. Included as a "serious injury" in Table 1.
- *Small cetaceans*: Small cetaceans hooked near the eyes or the head were considered "seriously injured" in Angliss and DeMaster. Participants at the 2007 workshop broadened this criterion to include any head trauma, including eye injuries, retaining it as a "serious injury" in Table 1.
- *Pinnipeds:* Not discussed in existing guidance. Included as a "serious injury" in Table 1.

Criteria 7: "Hook in mouth (excluding case 9 below), no trailing gear."

- *Large cetaceans:* Existing guidance does not address hooking injuries for large cetaceans. Participants at the 2007 workshop noted that hooking injuries are unlikely to occur with baleen whales. Therefore, Table 1 lists a hook in the mouth as "CBD/case specific" for large cetaceans.
- *Small cetaceans:* Angliss and DeMaster list a hook in the head (near the eyes) as "serious" for small cetaceans. Table 1 includes additional detail to this guidance by also including a hook in the mouth as "serious" for small cetaceans.
- *Pinnipeds:* Angliss and DeMaster list a hook in the mouth (internally) as "serious" for pinnipeds. Table 1 includes additional detail to this guidance by also including a hook in the mouth as "serious" for pinnipeds.

Criterion 8: "Hook in head (excluding mouth), no trailing gear."

- *Large cetaceans:* Existing guidance does not address hooking injuries for large cetaceans. Participants at the 2007 workshop noted that hooking injuries are unlikely to occur with baleen whales. Therefore, Table 1 lists a hook confirmed in the head, but not the mouth as "not serious" for large cetaceans.

- *Small cetaceans:* Angliss and DeMaster list a hook in the head (near the eyes) as "serious" for small cetaceans. Table 1 includes additional detail to this guidance by also including a hook confirmed in the head, but not the mouth, as "serious" for small cetaceans.
- *Pinnipeds:* Angliss and DeMaster list a hook in the mouth (internally) as "serious" for pinnipeds. Table 1 includes additional detail to this guidance by also including a hook confirmed in the head, but not the mouth, as "CBD/case specific" for pinnipeds.

Criterion 9: "Hook confirmed in lip only, no trailing gear."

- *Large cetaceans:* Existing guidance does not address hooking injuries for large cetaceans. Participants at the 2007 workshop noted that hooking injuries are unlikely to occur with baleen whales. Therefore, Table 1 lists a hook confirmed in the lip only as "not applicable/not observed" for large cetaceans.
- *Small cetaceans:* Angliss and DeMaster list a hook in the head (near the eyes) as "serious" for small cetaceans. Table 1 includes additional detail to this guidance by also including a hook confirmed in the lip only as "CBD/case specific" for small cetaceans.
- *Pinnipeds:* Angliss and DeMaster list a hook in the mouth (internally) as "serious" for pinnipeds. Table 1 includes additional detail to this guidance by also including a hook confirmed in the lip only as "not serious" for pinnipeds.

Criterion 10: "Gear attached to free-swimming animal with potential to 1) wrap round pectoral fins/flippers, peduncle, or head; 2) be ingested; or 3) accumulate drag."

- *Large cetaceans:* Existing guidance does not specifically address this injury scenario for large cetaceans. While participants at the 2007 workshop included this injury scenario in Table 1, they disagreed on the severity of such events for large cetaceans. During a straw vote at the workshop to get an idea of how many of the participants considered the injury "serious" for large cetaceans, about 2/3 of the participants stated that they consider the injury determination "CBD/case specific," and about 1/3 consider it "serious." This disagreement is highlighted in Table 1 by shading in the box under large cetaceans.
- *Small cetaceans and pinnipeds:* Angliss and DeMaster consider small cetaceans and pinnipeds entangled with trailing gear to be "seriously injured." Participants at the 2007 workshop agreed with Angliss and DeMaster, and listed this injury as "serious" in Table 1 for small cetaceans and pinnipeds. Participants added details to the guidance listed in Angliss and DeMaster to specify that the injury is "serious" not only if the animal is released with trailing gear, but if that trailing gear has the potential to wrap, be ingested or accumulate drag.

Criterion 11: "Animal freed from gear and released without gear."

- *Large cetaceans:* The NEFSC technical memorandums state that a baleen whale is typically not considered seriously injured if all constricting lines are removed or shed, and the whale has no other injuries that would otherwise be considered serious. Participants at the 2007 workshop agreed that additional factors need to be assessed in order to determine whether an animal released free of gear after an entanglement is seriously injured (e.g., length of time the animal was immobilized). Therefore, participants classified these injury determinations as "CBD/case specific" for large cetaceans.

- *Small cetaceans:* Angliss and DeMaster consider this injury scenario to be "not serious" for small cetaceans if the animal was swimming normally after begin freed from the gear. Participants at the 2007 workshop agreed that an animal swimming normally after an interaction does not always mean the animal is not seriously injured. Participants agreed that additional factors need to be assessed in order to determine whether an animal released free of gear after an entanglement is seriously injured (e.g., length of time the animal was immobilized, risk of myopathy and renal failure). Therefore, participants classified these injury determinations as "CBD/case specific" for small cetaceans. This represents a change from the guidance in Angliss and DeMaster.
- *Pinnipeds:* Angliss and DeMaster consider that this injury scenario should be assessed on a case-by-case basis for pinnipeds. Participants at the 2007 workshop retained this injury scenario as "CBD/case specific" for pinnipeds.

Criterion 12: "Social animal separated from group or released alone."

- *Large cetaceans:* Existing guidance does not specifically discuss this situation for large cetaceans. Participants at the 2007 workshop listed the separation of a social animal from its group as "CBD/case specific" for large cetaceans.
- *Small cetaceans:* Angliss and DeMaster state that and entanglement that results in an animal being separated from its pod is a serious injury for small cetaceans. Participants at the 2007 workshop agreed that additional factors needed to be assessed to determine whether a small cetacean separated from its pod is a serious injury to that individual. Therefore, participants classified these injury scenarios as "CBD/case specific" for small cetaceans. This represents a change from the guidance in Angliss and DeMaster.
- *Pinnipeds:* Existing guidance does not specifically discuss this situation for pinnipeds. Participants at the 2007 workshop listed the separation of a social animal from its group as "CBD/case specific" for pinnipeds.

Criterion 13: "Dependent animal (e.g., calf, pup) alone post–interaction"

- *Large cetaceans, small cetaceans, and pinnipeds:* Existing guidance does not specifically discuss this situation for a dependent animal. Participants at the 2007 workshop included this criterion in addition to criterion 12 to specifically address dependent animals separate from its mother or pod, considered a "serious injury" for all taxonomic groups.

Criterion 14: "Wrap(s) of gear around pectoral fin/flippers, peduncle, head, abdomen, or chest."

- *Large cetaceans:* Angliss and DeMaster list constricting wraps of gear that anchors the animal or leads to the inability to use an appendage for locomotion or feeding as "serious" for large cetaceans (although participants at the 1997 workshop did not agree at *what point* an entanglement impedes locomotion). Participants at the 2007 workshop modified the guidance, listing this injury scenario as "CBD/case specific" for large cetaceans because of known cases of large whales surviving for extended periods of time with gear wrapped around appendages or the body, including cases of such animals reproducing successfully. Therefore, the severity of the injury depends on the specifics of the entanglement.
- *Small cetaceans and pinnipeds:* Not discussed in existing guidance. Participants at the 2007 agreed that this injury scenario is "serious" for both small cetaceans and pinnipeds.

New Criteria Included in Table 1

Participants recommended entirely new criteria for those cases not explicitly covered by existing guidance, but deemed necessary based on the information provided in the Days 1-3 presentations and discussions. (Numbers correspond with criterion numbers in Table 1.)

Criterion 15: "Deep, external cut or laceration to body."

- *Large cetaceans, small cetaceans, and pinnipeds:* Participants at the 2007 workshop considered this injury scenario to be "CBD/case specific" for all taxonomic groups.

Criterion 16: "Body cavity penetration by foreign object or body cavity exposure."

- *Large cetaceans, small cetaceans, and pinnipeds:* Participants at the 2007 workshop considered this injury scenario to be "serious" for all taxonomic groups.

Criterion 17: "Visible blood loss."

- *Large cetaceans, small cetaceans, and pinnipeds:* Participants at the 2007 workshop considered this injury scenario to be "CBD/case specific" for all taxonomic groups.

Criteria 18-22 (details below): Existing guidance does not specifically address damage, or the degree of damage, to fins/flippers and flukes. Participants at the 2007 workshop stated that the severity of the injury depended on which appendage is lost or compromised, and the extent of the compromise. This detail is reflected in Table 1 by separating the criteria for damaged appendages into five separate criteria.

Criterion 18: "Loss or disfigurement of dorsal fin."

- *Large cetaceans and small cetaceans:* Participants at the 2007 workshop viewed the loss of the dorsal fin as "CBD/case specific" for large and small cetaceans. In the case of small cetaceans, information presented during Days 1-3 of the workshop showed that small cetaceans have been documented living for some time and reproducing after the loss or disfigurement of the dorsal fin.
- *Pinnipeds:* This injury scenario is not applicable to pinnipeds.

Criterion 19: "Partially severed flukes (transecting midline)."

- *Large cetaceans and, small cetaceans:* Participants at the 2007 workshop viewed partially severed flukes, where the injury transects the midline, as a "serious injury" for large and small cetaceans.
- *Pinnipeds:* This injury scenario is not applicable to pinnipeds.

Criterion 20: "Partially severed flukes (not transecting midline)."

- *Large cetaceans and small cetaceans:* Participants at the 2007 workshop viewed partially severed flukes, where the injury does not transect the midline, as "CBD/case specific" for large and small cetaceans.
- *Pinnipeds:* This injury scenario is not applicable to pinnipeds.

Criterion 21: "Partially severed pectoral fins/flippers."

- *Large cetacean, small cetaceans, and pinnipeds:* Participants at the 2007 workshop viewed partially severed pectoral fins/flippers as "CBD/case specific" for each group.

Criterion 22: "Severed pectoral fins/flippers."

- *Large cetaceans and small cetaceans:* Participants at the 2007 workshop viewed fully severed pectoral fins as "CBD/case specific" for large and small cetaceans.
- *Pinnipeds:* Participants at the 2007 workshop viewed fully severed pectoral fins as "serious" for pinnipeds.

Criterion 23: "Entanglement, immobilization or entrapment of a certain duration before being freed (TBD, species-dependent)."

- *Large cetaceans, small cetaceans and pinnipeds:* While anchoring and immobilization is considered a serious injury for large cetaceans in existing guidance, participants at the 2007 workshop considered Dr. Spraker's presentation on capture myopathy (section 6.0) and added this criterion to include animals from each taxonomic group that were immobilized or entangled for a certain duration before being disentangled. Immobilization for a significant period of time may impact an animal's ability to survive, even after disentanglement. Participants did not discuss or agree upon the length of time an animal must be immobilized prior to disentanglement for the injury to be considered "serious." Also, while participants considered this to be a "serious injury" for all taxonomic groups, they noted that the duration of immobilization leading to a "serious injury" was species-dependent.

Criterion 24: "Body trauma not covered by cases 6, 15, and 16 above (e.g., broken appendages, hemorrhaging)."

- *Large cetaceans, small cetaceans and pinnipeds:* While head trauma is discussed generally in existing guidance (see criterion 6 above), participants at the 2007 workshop stated that a criterion was needed to address trauma specifically to the body. This injury scenario was included in Table 1 to distinguish body trauma other than lacerations or body cavity penetration (criteria 15 and 16). Participants listed this injury scenario as "CBD/case specific" for all taxonomic groups because various other factors about the injury need to be considered before making a determination of severity. All participants agreed that, regardless of the type of body trauma, the injury determination was "CBD/case specific" for all species.

Criterion 25: "Detectable fractures."

- *Large cetaceans, small cetaceans, and pinnipeds:* Participants at the 2007 workshop considered this injury scenario to be "serious" for all taxonomic groups.

Criterion 26: "Hook in appendage, without trailing gear or with trailing gear that does not have the potential to wrap, be ingested, or accumulate drag."

- *Large cetaceans, small cetaceans, and pinnipeds:* Participants at the 2007 workshop considered this injury scenario to be "not serious" for all taxonomic groups.

Criterion 27: "Animal brought on vessel deck following entanglement/entrapment."

- *Large cetaceans:* This injury scenario is not applicable to large cetaceans.
- *Small cetaceans:* Participants at the 2007 workshop considered a small cetacean brought onto the deck of a vessel following entanglement as "seriously injured" because such handling causes substantial stress and injury to small cetaceans.

- *Pinnipeds:* Participants at the 2007 workshop considered a pinniped brought onto the deck of a vessel following entanglement as "CBD/case specific," because their physiology allows them to stay out of the water for extended periods of time. Also, the severity of the injury depends on the manner in which the pinniped is brought onto the deck (e.g., in net, over roller, through power block).

Criterion 28: "Vertebral transection."

- *Large cetaceans, small cetaceans, and pinnipeds:* Participants at the 2007 workshop considered this injury scenario to be "serious" for all taxonomic groups. However, vertebral transection injuries are most commonly reported as mortalities (especially in large whales), as an internal examination is often necessary to observe the injury.

Criteria 29 and 31: "Collision with vessel of certain minimum size (TBD, species-specific)" and "Collision with vessel below a certain size threshold (TBD, species-specific)."

- *Large cetaceans and small cetaceans:* Participants at the 2007 workshop considered an injury "serious" when a large or small cetacean is hit by a vessel above a certain size (criterion 29). The large whale breakout group considered that a whale hit by a commercial transport ship (e.g., container ship or tanker) is likely to die regardless of vessel speed. When any cetacean is hit by a vessel smaller than a certain size (criterion 31), the injury determination is in "CBD/case specific." Participants did not discuss where to set this size threshold, and recommended that such a threshold be determined based on further veterinary and technical input prior to the publication of an official NMFS policy.
- *Pinnipeds:* Participants considered an injury "CBD/case specific" when a pinniped is hit by a vessel above a certain size (criterion 29) or below a certain size (criterion 31). Participants did not discuss where to set this size threshold, and recommended that such a threshold be determined based on further veterinary and technical input prior to the publication of an official NMFS policy.

Criteria 30 and 32: "Collision with vessel traveling at a certain minimum speed (TBD, species-specific)" and "Collision with vessel traveling below a certain speed threshold (TBD, species-specific)."

- *Large cetaceans and small cetaceans:* As with vessel size, participants at the 2007 workshop considered an injury "serious" when a large or small cetacean is hit by a vessel traveling at or above a certain minimum speed (criterion 30). When any cetacean is hit by a vessel traveling below a certain speed (criterion 32), the injury determination is in "CBD/case specific." Participants did not discuss where to set this speed threshold, and recommended that such a threshold be determined based on further veterinary and technical input prior to the publication of an official NMFS policy.
- *Pinnipeds:* Participants considered an injury "CBD/case specific" when a pinniped is hit by a vessel traveling at or above (criterion 30) or below a certain speed (criterion 32). Participants did not discuss where to set this speed threshold, and recommended that such a threshold be determined based on further veterinary and technical input prior to the publication of an official NMFS policy.

Criterion 33: "Dog bites" (this criterion was not specifically indentified by the Day 4 participants, but was added by the workshop Steering Committee for this Technical Memorandum to fully capture the discussion surrounding dog bite injuries to pinnipeds).

- *Large cetaceans and small cetaceans:* This injury scenario is not applicable for large or small cetaceans.
- *Pinnipeds:* Criterion 33 is highlighted in Table 1, indicating lack of consensus on this criterion. The majority of Day 4 participants viewed dog bites as a form of head trauma, body trauma, or laceration (and therefore to be subsumed under criteria 6, 15, 16, or 24), but the pinniped experts recommended that dog bites be listed as a separate injury criterion due to the added potential for disease transmission. The pinniped experts considered an injury "CBD/case specific" when a pinniped is bitten by a dog. However, the pinniped experts did not discuss what types (e.g., penetrating, trauma, laceration, etc.) of injuries resulting from dog bites would be considered serious.

8.3 Addressing Areas of Uncertainty

After developing Table 1, Day 4 workshop participants discussed how to address the many "CBD/case specific" situations that appear in the table. Participants identified two main reasons why a particular type or cause of injury would be classified as "CBD/case specific":

- There is insufficient information about the general type of injury and its longer-term impacts on marine mammals to distinguish between a serious and a non-serious injury no matter how much information is available on conditions surrounding the injury event; and/or
- Distinguishing between a serious and a non-serious injury is possible, but additional factors must be considered on a case-by-case basis to determine the severity of such an injury on a given animal. Important factors for a given case may include, but are not limited to:
  - Age.
  - Sex.
  - Location of the injury.
  - Body condition of the animal at the time the injury is sustained and when/if the animal is resighted at a future date.
  - State of the animal upon release.
  - Past injuries incurred by the animal (i.e., cumulative impacts).

Participants outlined the following general approach to address and reduce the areas of uncertainty inherent in the "CBD/case specific" situations:

1) Convene key NMFS staff from each region responsible for distinguishing serious from non-serious injuries along with veterinarians and risk assessment experts on a periodic basis, perhaps annually. The purpose would be to discuss and attempt to reach consensus on how to assess particular cases. There was also strong support for establishing a peer review process (such as the AKSRG process, as described by Wynne in section 4.1) to support future serious injury determinations.
2) Begin developing a probabilistic/risk assessment framework that addresses the varying amounts of information available for different species and the corresponding levels or

shades of gray in each case. There was particular support for pursuing a risk assessment approach with relevant risk analysis experts.

3) Use injury determinations considered “CBD/case specific” to identify priority research needs and inform future research proposals. Participants also suggested that the research recommendations from the 1997 workshop be reviewed to see whether they have been addressed.
4) Evaluate and refine the framework (i.e., Table 1 and the associated process for distinguishing serious from non-serious injuries) over time in an adaptive process.

8.4 Burden of Proof in the Face of Uncertainty

Day 4 workshop participants discussed the ambiguity of the term “likely” contained in the regulatory definition of serious injury (i.e., “any injury that will likely result in mortality,” 50 CFR 229.2). At one extreme, likely could mean any probability greater than 0.50 (the chance of occurring is greater than not occurring). At the other extreme, likely means just short of being certain that death would occur; that is, a very high probability that death would occur.

Participants noted that the current regulatory definition was inadequate due to the broad range of interpretations that may be applied to the term “likely.” Furthermore, the descriptions of NMFS’ application of the current guidance (see sections 4.0 and 4.1 above) suggested there was a degree of region-to-region inconsistency in which end of this range (greater than 0.50 chance of death, to being just short of certain that death would occur) is being applied currently when distinguishing serious from non-serious injuries.

Participants noted potential consequences of interpretations from either extreme of the range of interpretations of “likely,” from the potential for over-regulation to inadequate marine mammal conservation. As indicated by Pace’s presentation (section 5.1), there are errors of omission and errors of commission, and there are clearly some animals that are injured and subsequently die of those injuries but are not observed (therefore not included in the existing data sets). In current use, any injury not specifically labeled as “serious” (i.e., those considered “not serious” and “CBD/case specific”) is not included in estimates of human-caused mortality and serious injury; thus, these cases are not included in assessing the status of marine mammal stocks.

After stating there was no explicit guidance in the text of the MMPA to provide guidance in making these interpretations, participants briefly discussed the MMPA’s legislative history. Committee reports from the House (U.S. House of Representatives Report 92-707, December 4, 1971) and Senate (U.S. Senate Report 92-863, June 15, 1972) from the initial passage of the MMPA addressed the issue burden of proof. These reports both noted that people who requested authorization to take marine mammals carried the burden to show that the requested taking must not be to the disadvantage of marine mammal populations or species. The House report emphasized that the burden was, indeed, a heavy one. Furthermore, these reports noted that NMFS and the FWS should not authorize such take if the burden was not met.

There was agreement among workshop participants (with the exception of a few) that the term “likely” within the definition of serious injury should not be toward the “certain death” end of the range of interpretations and should be more risk-averse for marine mammal conservation.

There was, however, no agreement on what chance of death would be an appropriate threshold value. Participants agreed that interpreting "likely" in the definition of serious injury to be more risk-averse (i.e., not to only mean certain death) would constitute a change in the way many serious injury determinations are currently made. For example, this change would impact the current categorization of some fisheries on the MMPA List of Fisheries (LOF), and potentially qualify additional fisheries for management under a TRT. However, participants agreed that the outcome should not drive the decision. Participants suggested evaluating which stocks would benefit, and how the LOF might change if a more risk-averse approach were applied. Participants recommended that this be examined during the development of an official NOAA policy on distinguishing serious from non-serious injuries.

The participants discussed alternatives to achieve a more risk-averse approach. One of these was to consider an injury as "serious" unless there was sufficient information to conclude that death would not likely occur. Another mechanism included modeling the effects of various injuries on marine mammals to predict the likelihood of death. If the predicted likelihood of death for a given injury is higher than a threshold established as policy, then the injury would be considered "serious." However, not all participants agreed with this approach. One participant noted that a scoring system or similar modeling method may give false precision, especially since NMFS is expected to make a binary decision (an injury is "serious" or not). This participant considered the use of well-defined data fields when distinguishing serious from non-serious injuries.

Participants discussed various consequences of likelihood thresholds, including the potential for over-regulation of human activities and under-protection of marine mammals. However, there were no additional conclusions or recommendations resulting from these discussions.

Workshop participants also discussed other uncertainties involved in evaluating the effects of injuries to marine mammals and the need for NMFS to establish guidance to account for human-caused injuries determined to be serious, a management responsibility required by the MMPA.[20] This guidance should account for cases where insufficient information is available to assign the serious injury to a specific fishery (for classification of fisheries on the MMPA LOF) or to a specific vessel (for ship-strike injuries). These serious injuries and mortalities could be included in a general category of fishery-related or ship strike-related mortality and serious injury. These discussions are not included in this report because they do not relate directly to the purpose of the workshop: distinguishing serious from non-serious injury.

[20] MMPA section 117(a)(3): "estimate the annual human-caused mortality and serious injury of the stock by source…"

9.0 Concluding Comments

Information and suggestions/recommendations made by participants of this workshop will form the basis for a NMFS policy on distinguishing serious from non-serious injuries. The next step from this workshop is to publish a proposed policy for distinguishing serious from non-serious injuries in the *Federal Register* for public comment, with a final policy published after public comments are reviewed, addressed and incorporated.

10.0 Acknowledgements

The workshop objectives were successfully met in part due to Scott McCreary and Eric Poncelet of CONCUR, Inc., by their assistance prior to and during the workshop. Their expertise, professionalism, and diligence were key assets to the success of the workshop. The Days 1-3 and Day 4 Workshop Summaries prepared by CONCUR, Inc., along with meeting minutes from plenary and breakout group discussions, were used as the basis in writing this Technical Memorandum.

The Steering Committee appreciates contributions from each of the invited presenters and participants. Their time and effort in offering updated scientific information and recommendations contributed to the achievement of the workshop goals.

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12.0 Appendixes

Appendix A: Agenda (Day 1-3)

SERIOUS INJURY TECHNICAL WORKSHOP
September 10-12, 2007
Seattle, WA

MEETING OBJECTIVES

1) Review information obtained since 1997 workshop
   a. Types and frequencies of observed injuries
   b. Evidence of survival of marine mammals sustaining such injuries

2) Discuss the use of, and needed changes to, existing guidance in making serious injury determinations
   a. Identify when information is insufficient to determine the severity of the injury
   b. Identify data needs for making serious injury determinations
   c. Review existing data sources for making serious injury determinations, and identify constraints

3) Discuss potential implications of the workshop

DAY 1, MONDAY, SEPTEMBER 10, 2007 (8:30 AM-5:30 PM)
Review and Discuss Existing Processes for Making Serious Injury Determinations
Register through https://reefshark.nmfs.noaa.gov/pr/siw/

8:00 AM **Late Registration**

8:30 AM **Welcome, Introductions, and Getting Organized**
- Welcome and opening (John Bengtson, AFSC; David Cottingham, NMFS Headquarters)
- Participant introductions (CONCUR, Inc.)
- Objectives of the workshop (Tom Eagle, NMFS Headquarters)
- Process for the workshop (CONCUR, Inc.)
  - Ground rules
  - Agenda overview

9:00 AM **Review of Existing Guidelines to Distinguish Serious from Non-Serious Injuries (1997 workshop report) (**Robyn Angliss- AFSC)

9:15 AM **Evaluate Current Data and Determination Systems** (*Session Chair: Tim Cole)*
Current Data Sources
- National Observer Program (Amy Van Atten, NER Observer Program)
- Health and Stranding Program (Teri Rowles, HQ MMHSRP)

9:45 AM Current Determination Systems

- Baleen whale serious injury determinations in the Atlantic and Gulf of Mexico (Tim Cole- NEFSC)
- Small cetacean serious injury determinations in the Atlantic and Gulf of Mexico (Lance Garrison- SEFSC)

10:25 AM **BREAK**

10:40 AM

- Serious injury determinations in Hawaii (Karin Forney- SWFSC and Bud Antonelis- PIFSC)
- Cetacean serious injury determinations off the U.S. Western Contiguous Coast (Karin Forney- SWFSC)
- Large whale and pinniped serious injury determinations in Alaska (Robyn Angliss- AFSC)

Synthesis

- Synthesis of regional case studies (Tim Cole- NEFSC)

11:40 PM

- Non-NMFS evaluation of serious injury determination processes: White Paper of the AK Scientific Review Group (Kate Wynne- AK SRG)

LUNCH (On Your Own)

12:20 PM

- Large whale disentanglement systems (David Mattila- NOS, Humpback Whale National Marine Sanctuary)

1:45 PM

- Introduction to breakout group session (Melissa Andersen- NMFS Headquarters)

2:05 PM

Facilitated Breakout Group Discussion on the Evaluation of Current Data and Serious Injury Determination Systems

2:15 PM

Breakout group structure and questions TBD

Breakout group leaders and reporters summarize breakout group discussions

4:15 PM

Breakout groups present summary statements

4:30 PM

ADJOURN DAY 1

5:30 PM

Please join fellow workshop participants at "forty-two," a unique wine bar in the lobby of the Watertown Hotel.

6:30

DAY 2, TUESDAY, SEPTEMBER 11, 2007 (8:30 AM-5:30 PM)
Review and Discuss New Information from Survival Evaluations and the Pathobiology of Injuries

8:30 AM **Overview: Questions from Day 1 and Review Day 2 Agenda**

8:45 AM **Overview of New Information on Survival of Injured Marine Mammals**
Large Whales (*Session Chair: Tom Eagle)*

- Survival of injured North Atlantic right whales based on photo-id data and longitudinal tracking (Richard Pace- NEFSC)
- Survival of injured humpback whales, and other large whales, in the Atlantic and Pacific (Jooke Robbins- Center for Coastal Studies; John Calambokidis- Cascadia Research; Jan Straley- University of Alaska)
  1) Scar-based insight into entanglement and serious injury (Jooke Robbins)
  2) Case studies of injuries and survival along the U.S. west coast (John Calambokidis)
  3) Case studies of injuries and survival in Southeast Alaska (Jan Straley)
  4) Statistical analysis of survival (Jooke Robbins)

9:50 AM **BREAK**

10:05 AM Facilitated Discussion on Large Whales

11:05 AM Small Cetaceans and Manatees (*Session Chair: Karin Forney)*

- Fishery interactions in small cetaceans in the mid-Atlantic (Aleta Hohn- SEFSC)
- Bottlenose dolphins in Sarasota Bay, FL (Randy Wells- Chicago Zoological Society/Mote Marine Lab)
- Limited information on interaction outcomes for Pacific false killer whales (Karin Forney to present Baird *et al.* scarring study and other photos)
- Injuries and outcomes in manatees (Alexander Costidis- FL Fish & Wildlife Conservation Commission)

12:35 PM **LUNCH (On Your Own)**

1:45 PM Facilitated Discussion on Small Cetaceans and Manatees

2:45 PM **Pathobiology of Injuries** (*Session Chair: Teri Rowles)*

- Predicting lethality from vessel and gear trauma in North Atlantic right whales (Michael Moore- Woods Hole Oceanographic Inst.*)*
- Categories and consequences of injuries (David Rotstein- University of Tennessee/NMFS)

3:45 PM **BREAK**

4:00 PM

- Injuries observed in pinnipeds (CA sea lions, Northern Fur seals, and monk seals) (Terry Spraker- Colorado State University)

4:30 PM Facilitated Discussion on the Pathobiology of Injuries

5:30 PM **ADJOURN DAY 2**

DAY 3, WEDNESDAY, SEPTEMBER 12, 2007 (9:00 AM-5:00 PM)
Breakout Groups Sessions

9:00 AM **Overview: Questions from Day 2 and Review Day 3 Agenda**
- Outline breakout group sessions (CONCUR, Inc.)
  - Group composition (TBD)
  - Questions for discussion (TBD)

9:30 AM **Breakouts Group Activity**
Session One
Group 1: Longitudinal/survival rates from a modeling perspective
Group 2: Categorization of injuries and pathological consequences: Gear-related injuries (i.e., entanglements, hookings, and ingestions)
Group 3: Categorization of injuries and pathological consequences: Sharp, blunt force, and penetrating injuries

11:30 AM Breakout group leaders and reporters summarize breakout group discussions

11:45 AM Breakout groups present summary statements

12:30 PM **LUNCH (On Your Own)**

1:45 PM Session Two
Group 1: Large cetaceans
Group 2: Small cetaceans
Group 3: Pinnipeds and other species

3:45 PM Breakout group leaders and reporters summarize breakout group discussions

4:00 PM Breakout groups present summary statement/ Plenary Discussion

5:00 PM **ADJOURN DAY 3**

Appendix B: Background Documents Provided to Participants

In addition to the presentation summaries provided in this Technical Memo, workshop participants received the following background documents prior to the Workshop:

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