Gross Evidence of Human-Induced Mortality in Small Cetaceans

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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This report was designed to assist stranding network members in the identification of evidence of adverse human interactions in stranded small cetaceans. Careful documentation of entanglement, gunshot wounds, vessel collisions, blast injury, and other human interactions may facilitate the diagnosis of a cause of death of a stranded dolphin or porpoise. Therefore, it is critical to establish physical criteria diagnostic of various sources of mortality. This manual describes external and internal evidence associated with entanglement in fishing gear, gunshot wounds, vessel collisions, and blast injury in small cetaceans. This report was prepared by the Nicholas School of the Environment at Duke University Marine Laboratory in fulfillment of reference order 43AANF501263.

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1.0 INTRODUCTION

One can document evidence of anthropogenic trauma such as entanglement in fishing gear, vessel collisions, and gunshot wounds by careful evaluation of stranded marine mammals. Identification of such human-induced mortality and serious injury is an important function of the regional marine mammal stranding networks. Currently, several reference manuals exist to assist marine mammal network members in responding to stranding events, perform necropsies, and collect samples (Bonde et al., 1983; Hare and Mead, 1987; Geraci and Lounsbury, 1993). However without proper training and experience, it can be difficult to identify some of the more subtle indications of anthropogenic trauma. **This manual was designed to assist marine mammal researchers and stranding network members in the identification of evidence of adverse human interactions impacting stranded small cetaceans.**

Careful documentation of entanglement, gunshot wounds, vessel collisions, and blast injury may facilitate in the determination of a cause of death of a stranded small cetacea (i.e., dolphins or porpoises). Determining the cause of death is often difficult because postmortem autolysis or scavenger damage may obscure the physical evidence of these interactions. Therefore, it is critical to establish physical criteria diagnostic of various sources of mortality (Garcia-Hartmann et al., 1996; Kuiken, 1996). Such observations complement other methods of post-mortem examination, such as gross pathology and histopathology.

Based on our extensive experience examining many injured dolphins and porpoises and on the observations from our colleagues, we have described in detail the gross evidence associated with fishing gear entanglement, gunshot wounds, vessel collisions, and blast injury. **It is our hope that this report will assist marine mammal researchers and stranding network members with distinguishing between fatal injury due to human activities from those of natural causes.** To this end, we have restricted our observations to gross evidence that can be documented by field workers familiar with basic marine mammal anatomy, but without any special knowledge of pathology.

We have presented this information in three sections:
- Physical evidence associated with entanglement in fishing gear
- Physical evidence associated with other forms of human activity
- Procedures for examination of stranded small cetaceans and data documentation

2.0 PHYSICAL EVIDENCE ASSOCIATED WITH ENTANGLEMENT IN FISHING GEAR

Entanglement in fishing gear is the most common anthropogenic source of mortality for small cetaceans (Forney et al., 1999; Hill and DeMaster, 1999; Waring et al., 1999). The physical evidence associated with entanglement is specific to each combination of cetacean and fishing gear. Porpoises and dolphins killed in fine-mesh seine nets, for example, become trapped in the folds of the seine rather than entangled in the net itself and may not exhibit any external evidence of entanglement. In contrast, almost all dolphins and porpoises entangled in gill nets exhibit lacerations or indentations from the net material. Thus, the lesions caused by interactions with various types of fishing gear are very different. In this section, we will briefly describe gross evidence associated with entanglement in various types of fishing gear.

2.1 Evidence Diagnostic of Entanglement in Gill Nets

Over the past decade, we have examined over 100 carcasses of small cetaceans known to have died in gill net fisheries. In all but one of these specimens, from five species and three families, we found clear external evidence of entanglement, primarily in the form of lacerations and indentations left from the net material. The type of laceration varies with the net material. Marks from monofilament nets usually appear as thin, distinct indentations in the skin of the animal (Figure 1). In contrast, multifilament gill nets often leave impressions of the braided nylon in the skin (Figure 2).

Figure 1. Net marks around the rostrum of a harbor porpoise entangled in a sink gill net in the Bay of Fundy, Canada.

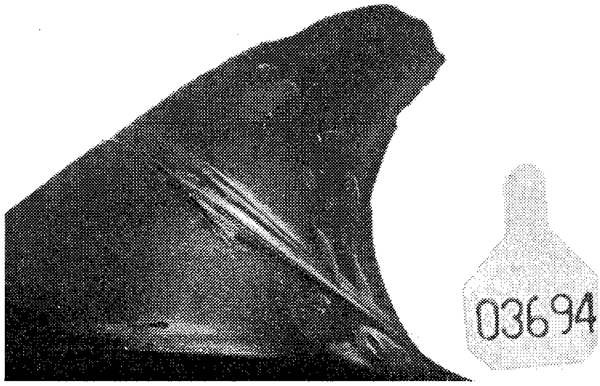

Figure 2. Braided multifilament net marks around the dorsal fin of a common dolphin entangled in a pelagic drift net on the continental shelf break of the northeastern U.S.

2.1.1 Evidence of Entanglement

We consider the presence of unhealed, narrow, linear lacerations or indentations in the epidermis, most commonly around the head, dorsal fin, flukes and flippers, to be diagnostic of entanglement in gill nets. Any carcass exhibiting such lacerations or indentations should be assumed to have died as a result of an interaction with fishing gear. These lesions have also been identified by other researchers as diagnostic of incidental mortality of cetaceans in commercial fisheries (Kuiken et al., 1994; Kuiken 1996; Siebert et al., 1996). Careful examination of the nature of these lesions may indicate in which type of net the animal was entangled (i.e., monofilament or multifilament) and perhaps some indication of the size of the mesh. The degree of entanglement and, consequently, the severity of associated lesions can vary with the species and the type of net. Large animals, such as pilot and beaked whales, killed in large-mesh nets are often severely entangled and exhibit clear net marks over much of their body (Figure 3). Lacerations around the mouth of these larger animals may be associated with bro-

Figure 3. Net marks around the head of a long-finned pilot whale entangled in a pelagic drift net on the continental shelf break of the northeastern U.S.

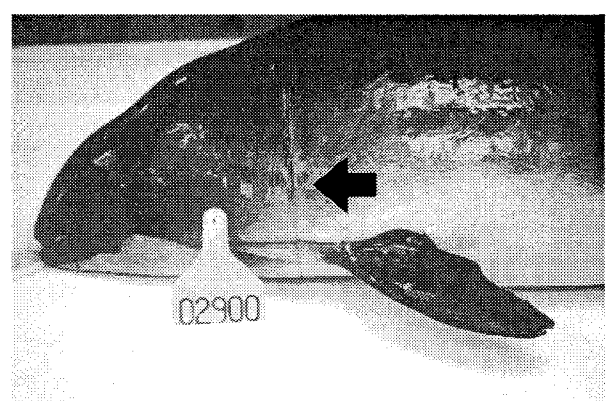

Figure 4. Net marks encircling the cervical region of a harbor porpoise entangled in a sink gill net in the Gulf of Maine.

ken or missing teeth caused by the net. Smaller animals, such as porpoises, may be caught in the net by a flipper or fluke lobe and exhibit only subtle signs of entanglement. Nevertheless, it is our experience that the vast majority of small cetaceans killed in gill nets exhibit external signs of entanglement in the form of net marks and, as noted above, we consider these lacerations and indentations to be diagnostic of entanglement.

Lacerations and indentations left by net material are often deepest when present around the entire head (Figure 4) or thorax (Figure 5) of an animal, indicating that the animal may have

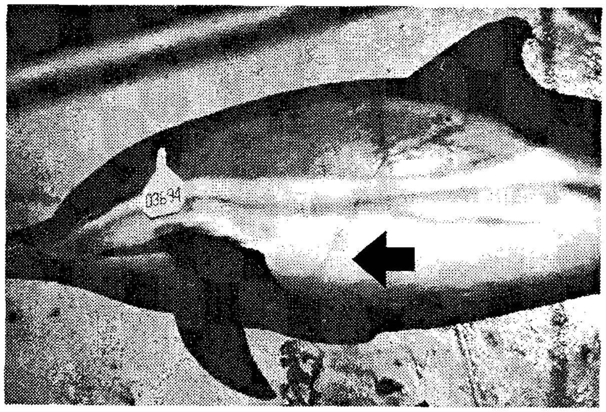

Figure 5. Net marks around the thorax of a common dolphin entangled in a pelagic drift net on the continental shelf break of the northeastern U.S.

Figure 6. Braided multifilament net marks encircling the flipper of a common dolphin entangled in a pelagic drift net on the continental shelf break of the northeastern U.S.

broken through several meshes of the net before becoming completely entangled. Lacerations are common on the leading edges of flippers (Figure

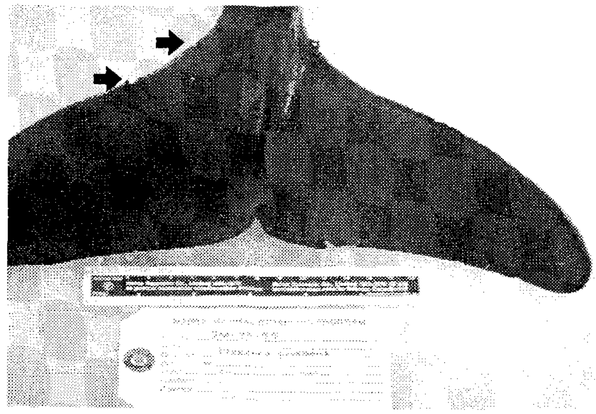

Figure 7. Net marks on the leading edge of the flukes of a harbor porpoise entangled in a sink gill net in the Bay of Fundy, Canada.

6), flukes (Figure 7) and dorsal fin (Figure 8) and are usually manifested as straight, narrow cuts into the epidermis. On the head, net marks often encircle the rostrum, or the head posterior to the eye. Net marks on the dorsal fin and flippers appear most commonly on the leading or trailing edges of the fins as thin, short lacerations, often breaking the skin. These lacerations may or may not be evenly spaced. These lacerations usually extend around both sides of the leading edge of the appendage, unlike other marks (such as gull pecks) which are typically found only on one side. Similar lacerations may appear around the

Figure 8. Net marks on the leading and trailing edges of the dorsal fin of a harbor porpoise entangled in a sink gill net in the Bay of Fundy, Canada.

leading and trailing edges of the flukes, and may encircle the entire fluke lobes (Figure 9). Even when the net marks do not encircle the entire fluke lobe, it is often possible to match individual cuts, caused by individual strands of the net, on

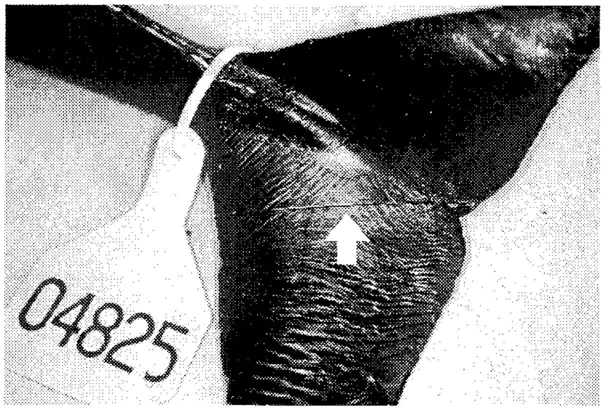

Figure 9. Net marks encircling the left fluke lobes of a harbor porpoise entangled in a sink gill net in the Gulf of Maine.

both the leading and trailing edge of the flukes. Cracks in the skin caused by damage from freezing and thawing may be distinguished from net marks as the former tend to be jagged while the latter are sharp and clean. However, differentiation of lacerations caused by nets and cracks in the skin caused by desiccation in the freezer, or from repeated thawing and freezing, may be dif-

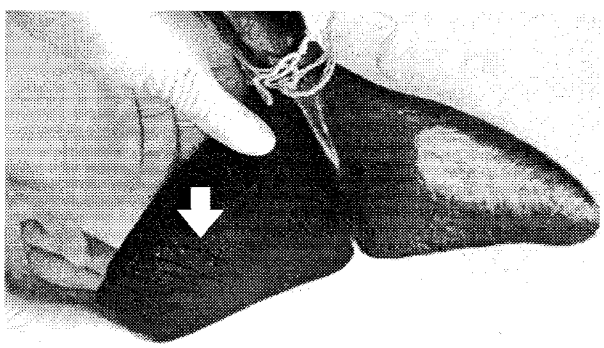

Figure 10. Cracks in the epidermis caused by freezer desiccation on the dorsal surface of the flukes of a harbor porpoise stranded in Virginia.

ficult (Figure 10). Therefore, it is important to conduct the external examination of a carcass prior to storage in a freezer.

2.1.2 Postmortem/Antemortem Injuries

Carcasses are often towed, moved or secured after death by ropes or lines tied around the tailstock or flippers; impressions and abrasions from these lines are usually quite clear. Again, it is important to differentiate between physical evidence of entanglement and that associated with post-mortem events. It is also important to distinguish evidence of recent trauma from healed scars of past events. For example, a common dolphin killed in a pelagic drift net had healed line wounds around the rostrum and insertion of both flippers in addition to fresh lacerations, suggesting a previous, non-fatal entanglement. Many delphinids and ziphiids also bear fresh or healed lesions caused by social interactions with conspecifics. Tooth rakes are the most common form of these lesions, and these occasionally occur in a pattern similar to the marks left by the multifilament net material.

2.2 Non-Diagnostic Evidence of Entanglement in Gill Nets

Other forms of injuries are consistent with, but not diagnostic of entanglement in gill nets. These include penetrating wounds, missing appendages, sub-dermal hemorrhage, broken bones, and froth in the bronchi. We do not consider these features to be diagnostic of entanglement because they can originate from other types of trauma.

2.2.1 Body Condition

Most of the entangled specimens we have examined have been in good physical condition, with no evidence of emaciation (Figure 11a). However, emaciated animals that have suffered

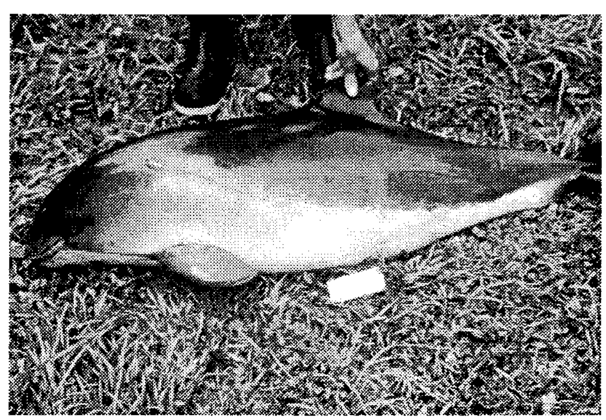

Figure 11a. A robust harbor porpoise killed in a sink gill net in the Bay of Fundy, Canada. Note the convex dorsal surfaces and the lack of any external neck.

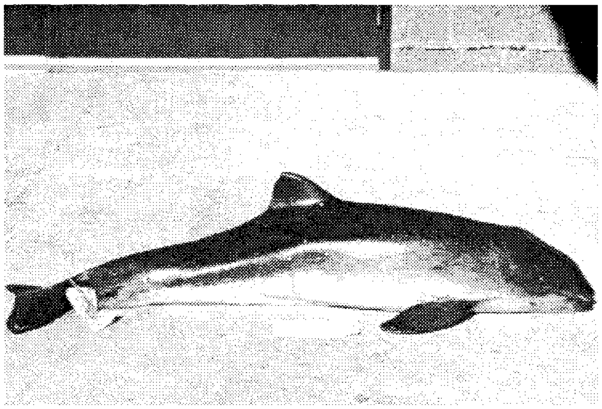

Figure 11b. An emaciated harbor porpoise stranded in virginia. Note the concave dorsal surfaces and pronounced neck, the sunken area just posterior to the skull.

and/or died from a chronic medical problem may become entangled in fishing gear. An unusually thin blubber layer and atrophied neck or epaxial musculature (i.e., external depression posterior to the nuchal crest of the skull - pronounced neckline) are indicative of poor physical condition and may indicate the existence of chronic disease (Figure 11b).

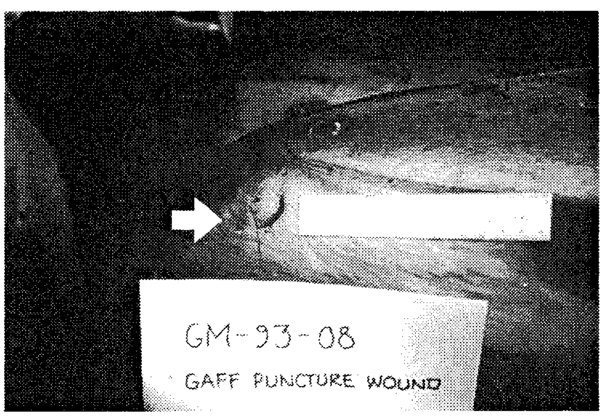

Figure 12. Puncture wound made post-mortem by a fisherman's gaff on the lower jaw of a harbor porpoise entangled in a sink gill net in the Bay of Fundy, Canada.

2.2.2 Penetrating Wounds

Many porpoises and dolphins killed in fisheries exhibit small penetrating wounds caused by the gaffs used by fishermen to retrieve the animals from the water (Figure 12). These wounds usually occur around the head and cervical regions, as the animal hangs tail down alongside

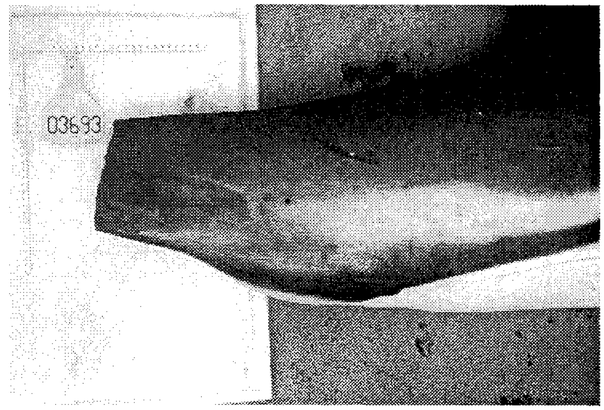

Figure 13. Severed caudal peduncle of a common dolphin entangled in a pelagic drift net on the continental shelf break of the northeastern U.S.

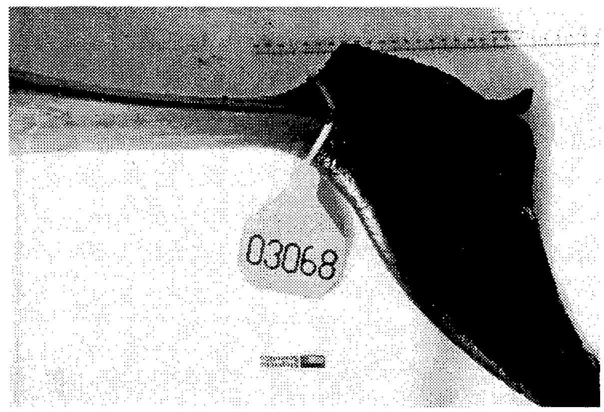

Figure 14. Severed fluke blade of a common dolphin entangled in a pelagic drift net on the continental shelf break of the northeastern U.S.

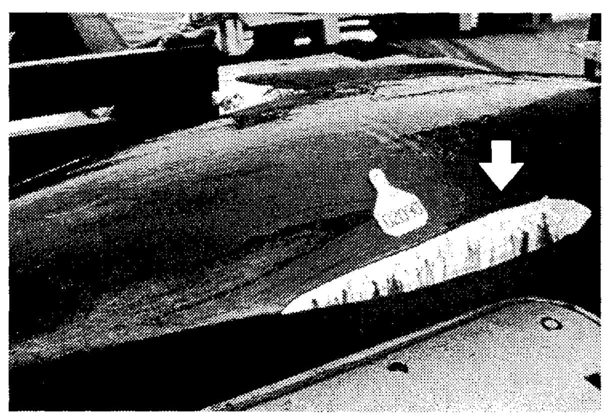

Figure 15. Severed dorsal fin of a long-finned pilot whale entangled in a pelagic drift net on the continental shelf break of the northeastern U.S.

the vessel. Other penetrating wounds are made by stab probes used by fisheries observers to measure core body temperatures in the epaxial musculature near the dorsal fin. Any small cetacean carcass examined and discarded overboard by a NMFS fisheries observer should be readily identified by a plastic, numbered, tail tag (Figure 9).

2.2.3 Mutilation

Fishermen often mutilate the carcasses of small cetaceans to facilitate disentanglement. This is particularly true for large animals that are severely entangled. In such cases, the flukes, flippers, or dorsal fin may be cleanly severed (Figures 13-15). Fishermen and observers working aboard drift net vessels have noted that it is often extremely difficult to remove the carcasses of dolphins, pilot whales, and beaked whales from their nets. In contrast, small-bodied animals, such as porpoises, are often disentangled without mutilation. Fishermen will sometimes make a longitudinal slit along the ventral surface of the abdomen before discarding the carcass, in the belief that it will be less likely to float and reach shore (Figure 16). Occasionally the mutilation of carcasses is more severe (Figure 17).

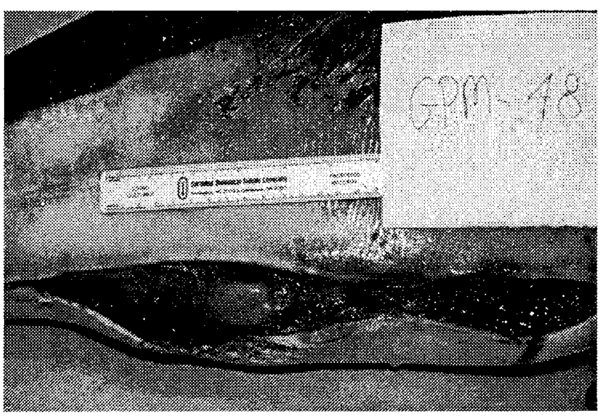

Figure 16. Longitudinal slit made in the abdomen of a harbor porpoise scarcass stranded in North Carolina. Note the clean edges of the knife cut.

2.2.4 Scavenger Damage

The degree and type of scavenger damage varies with the species and situation. For example, most harbor porpoise carcasses retrieved from sink gill nets exhibit damage from benthic scavengers. This damage ranges from superficial

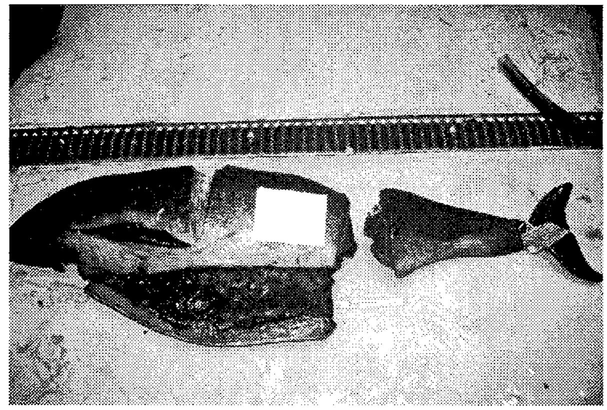

Figure 17. Dismembered carcass of a harbor porpoise stranded in New Jersey. Note the net mark encircling the body just anterior to the insertion of the flipper and the clean edges of knife cuts.

pits made in the epidermis by scavenging amphipods (Figure 18) to extensive external and internal damage caused by amphipods and hagfish (Figure 19). It is our experience that these benthic scavengers first attack the areas around

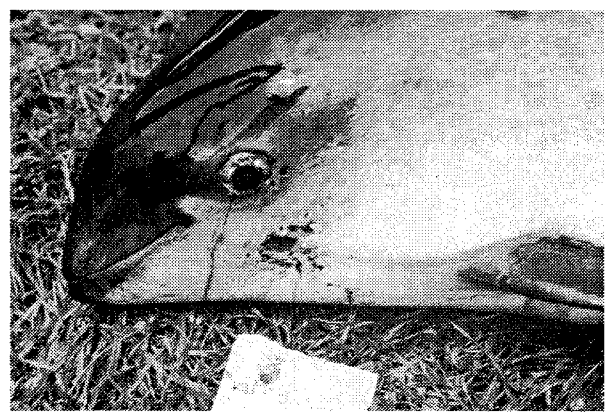

Figure 18. Mild damage caused by benthic scavengers to the head of a harbor porpoise entangled in a sink gill net in the Bay of Fundy, Canada.

the eyes, mouth, axillae and genital regions (Figure 20). In some cases the damage is so extensive that it is impossible to judge whether signs of entanglement exist in these areas. Entangled small cetaceans may also bear evidence of scavenging by sharks particularly in warmer waters. For example, a beaked whale carcass we retrieved from a pelagic drift net had been scavenged by blue sharks (*Prionace glauca*), which had left several bite marks approximately 20 cm in diameter along the ventral mid-

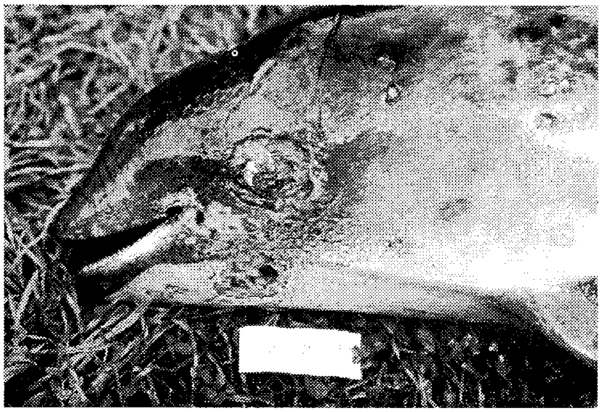

Figure 19. Extensive damage caused by benthic scavengers to the head of a harbor porpoise entangled in a sink gill net in the Bay of Fundy, Canada. Note the net marks on the rostrum.

line of the animal. Gulls (Figure 29) may also heavily scavenge stranded carcasses. This damage usually occurs while the carcass is on the beach but also may happen while it was floating in the water. Gull scavenger damage begins as a series of small 1-2 cm scrapes into the epidermal layers. These scrapes are very distinctive, usually quite shallow (<5 mm) and numerous. If the damage caused by gulls occurred while the carcass was floating in the water then it might be restricted to a specific side or region. As scav-

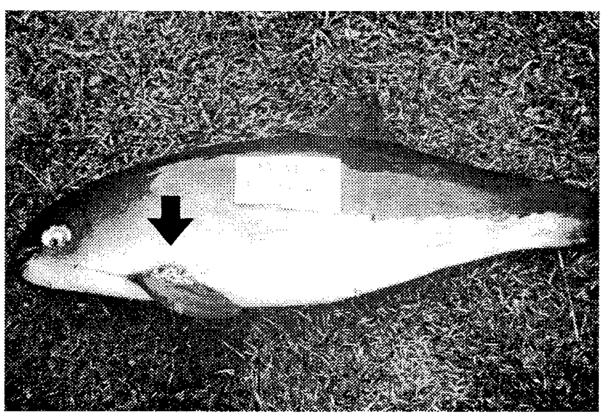

Figure 20. Damage caused by benthic scavengers around the eyes and axillae of a harbor porpoise entangled in a sink gill net in the Bay of Fundy, Canada.

enging proceeds the body cavity is usually penetrated and the birds begin to eviscerate the carcass. When the carcass reaches shore, gulls often attack the jaw area first to gain access to the lipid-rich mandibular fat pads. With the exception of the telltale epidermal scrapes, extensive gull scavenger damage may be difficult to distinguish from extensive benthic scavenger damage.

2.2.5 Hemorrhage

The carcasses of many dolphins and porpoises killed in fishing gear exhibit sub-dermal hemorrhage, particularly in the dorsal and lateral cervical regions. Hemorrhage is the escape of blood

Figure 21. Sub-dermal hemorrhage in the cervical region of a harbor porpoise entangled in a sink gill net in the Gulf of Maine.

from ruptured vessels, often caused by trauma (Bonde et al., 1983; Kuiken, 1996; Figure 21). We believe that this hemorrhage may be caused by the restraint imposed on the animal's head while it struggles in the net. It is worth noting that this form of hemorrhage is seldom evident on external examination in these specimens. Many dolphins killed in fishing gear also exhibit antemortem broken bones and associated blood clots and macerated soft tissue. Typically these bones include mandibles, flippers, ribs or the vertebral processes clots. Some bones may be broken postmortem, when the carcasses are dropped on deck or swing against the side of the vessel. Look carefully for signs of blood infiltration into the region of the broken bone and signs of hemorrhage in the surrounding tissue. Ante- and postmortem fractures can be definitively differentiated by histopathological analysis.

2.2.6 Respiratory System Contents

Often a white froth or a mix of forth and blood tinged fluid can be noted in the bronchi of dolphins and porpoises killed in fishing gear. On several occasions, fisheries observers have noted white foam venting from the blowhole as the carcass was retrieved from the net. Several researchers have discussed the appearance and contents of the lungs and airways as diagnostic of death in fishing gear (Garcia-Hartmann et al., 1996; Kuiken, 1996; Kuiken et al., 1996). As noted by Lipscomb (1996), foam in the upper and lower air passages is considered an important sign of death by human drowning victims, but is not specific to this cause of death. Researchers have also suggested that diatoms and other marine flora in the lungs are indicators of death by submersion, but these organisms may be introduced into the airways post-mortem (Larsen and Holm, 1996). In our experience, the presence of froth, blood tinged or accompanied by fluid, is a common, but not a diagnostic feature of death caused by entanglement in fishing gear. We also agree with Kuiken et al. (1996) that the presence of seawater in the respiratory tract is not a useful criterion for the diagnosis of entanglement, as we rarely noted its presence the animals we examined.

2.2.7 Other Causes of Death

It is worth noting that sometimes carcasses exhibit many of the physical signs of entanglement when death occurred from another cause. For example, harbor porpoises killed by blunt trauma inflicted by bottlenose dolphins exhibit several types of injuries. These include penetrating wounds, sub-dermal hemorrhage and broken bones (Ross and Wilson, 1996), all of which are features commonly associated with entanglement. Careful examination of these wounds may rule out entanglement as a potential cause of death. Appendages that have been cleanly severed from the body are strongly suggestive of human interactions. It is possible, however, that such mutilation can occur on the beach (Kuiken, 1996). Therefore, this type of evidence is not sufficient to confirm physical interaction with fishing gear.

2.3 Entanglement in Purse Seines

The external evidence we have documented from animals killed in purse seines is very different from that of animals entangled in gill nets. We have examined many porpoises killed in herring purse seines that bore no external marks whatsoever from the nets. One porpoise, tagged and released from a seine two weeks before it became trapped and died in another seine, showed no external marks from either episode. The only external marks present on many porpoises and dolphins killed in purse seines are small abrasions of the rostrum or of the leading edges of flukes and dorsal fin, rather than well-defined lacerations or indentations. This is consistent with the method of capture, which is by entrapment in folds of the fine-meshed net, rather than by entanglement in the webbing of the net. Thus, it is important to note that not all carcasses killed in commercial fishing gear will exhibit external marks from the nets.

Porpoises and dolphins killed in purse seines may exhibit many of the other lesions consistent with entanglement in gill nets. Some carcasses, for example, have penetrating wounds, made by the gaffs used by the fishermen. In general, it is not necessary to mutilate the animals to disentangle them from a purse seine. Approximately half of the specimens we have examined from purse seines exhibit sub-dermal hemorrhage, most frequently in the cervical region and occasionally over the head, thorax and abdomen. Therefore, animals captured in some types of fishing gear may exhibit a variety of non-specific lesions consistent with entanglement, but no distinctive marks from the gear itself.

2.4 Entanglement in Ropes and Lines

Interactions with ropes and lines may not be fatal, at least in the initial entanglement. For example, there have been observations of live bottlenose dolphins carrying lines, dragging crab pots, or becoming immobilized after entanglement in crab pot lines in coastal waters of the southeastern U.S. (W. McFee, NMFS/SEFSC & R. Wells, Chicago Zoological Society, personal communication). The majority of marine mammal interactions with pelagic longlines involve animals that are hooked and released alive (Angliss and DeMaster, 1998). Although their fate after release is not known, many of these animals are released with hooks embedded in some portion of their body. There are also an increasing number of interactions between coastal bottlenose dolphins and recreational fishing gear, in which the dolphins are hooked or entangled in monofilament fishing line (Wells et al., 1998; Figure 22).

Figure 22. Stranded bottlenose dolphin in Sarasota, FL wrapped in recreational monofilament fishing line. Photo courtesy of R.S. Wells, Chicago Zoological Society.

Evidence of entanglement in ropes or lines is usually obvious. There are often pronounced abrasions in areas where the line has wrapped around the body or appendages. These abrasions are typically found around flippers, the caudal peduncle and at the insertion of the flukes. If an animal has survived the initial entanglement and carried gear for some time before its death, the abrasions may be severe, extending into connective tissue below the blubber, muscle and even bone (Figure 23), and may be accompanied by local or systemic infections. In such cases, the entangled animals may strand with the gear still attached. Any gear found should be retained, so that the nature of the interaction can be fully documented. If entanglement in monofilament line is discovered or suspected, a thorough examination should be made of the oral cavity, esophagus and

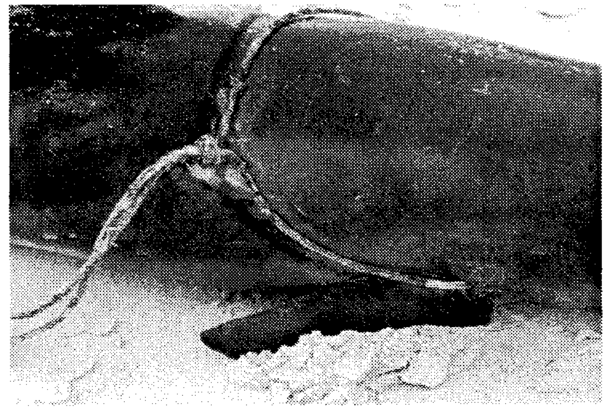

Figure 23. Stranded bottlenose dolphin in North Carolina with line extending through dermis and into the underlying connective tissue. The line had abraded completely through both humeri. Photo courtesy of Bill McLellan and Ari Friedlaender, UNC Wilmington.

forestomach during necropsy, for the presence of hooks. Line may become wrapped around the epiglottal beak if fishing lures or bait have been ingested (Gorzelany, 1998). Dolphins and porpoises killed in longline, crab or lobster pot gear may exhibit many of the same types of gross internal evidence as those entangled in other types of fisheries.

A note of caution should be stated concerning the use of tail tags and towlines by stranding personnel. The use of these items can obscure existing impressions made by the line or rope and make evaluation of a carcass difficult. Whenever possible, it is important to examine the carcass for evidence of adverse human interaction before these items are attached. In addition it is important to carefully record how and where tail tags and towropes were used to avoid spurious diagnoses if the carcass is to be evaluated by others at a later date.

3.0 PHYSICAL EVIDENCE ASSOCIATED WITH OTHER FORMS OF ANTHRO POGENIC TRAUMA

3.1 Gunshot Wounds

Gunshot wounds vary in nature depending on the type and caliber of weapon used and the proximity to the animal when the weapon was fired.

Single bullet wounds are easy to distinguish from those caused by shot pellets by their size and number. Entry wounds may be blackened or singed if the weapon was fired at close range. The size of an entry wound is not a reliable indicator of the caliber of weapon used, as the elasticity of the skin and proximity of the weapon affect the diameter of the entry wound. An abrasion collar often extends around the entry point with even, smooth edges, where the skin has

Figure 24. Entry wound from close-range shotgun blast that killed a harbor porpoise in a herring weir in the Bay of Fundy, Canada. Note the inversion of the skin into the perimeter of the wound.

inverted into the wound (Figure 24). Exit wounds may be of any size and are often characterized by jagged, irregular lacerations, eversion of the skin margins and marked removal of tissue.

It may be difficult to identify gun shot wounds in small cetaceans if time has passed since the wound was made and the superficial lesions have healed. In such cases, radiography may assist in diagnosis and facilitate location of projectiles, as their trajectory is not always linear after entry.

If you suspect a wound has been caused by a gunshot, perform a careful internal examination of the carcass. Follow the path of the wound into the animal. There may be hemorrhagic tissue and blood clots around the path of the projectile(s). Bones may be broken, particularly the skull, vertebrae and ribs, depending on the location of the wound. The presence of a bullet or pieces of shot is diagnostic of a gunshot wound. In such cases, it is imperative that a suite of histopathological samples be taken from tissues adjacent to the wound to determine whether the animal was shot ante- or post-mortem. Carefully note the exact location and size of the wounds on the data sheet, and describe all internal evidence observed. Mark the wound with a tag containing animal identification number and date. Photograph both the external and internal areas affected by the gunshot wound. Before opening the wound site, carefully probe with a blunt object to determine if the wound is penetrating and to determine the approximate path of the projectile. Extract the projectile with a gloved hand, not with metal forceps (i.e., metal forceps could leave a scratch on the bullet). Wash any bullets or shot in fresh water and store in a sealed paper envelope for future forensic analysis. Sometimes gunshot animals are missed due to the variability of entry wounds and/or the entry wound heals rapidly. Radiographs may help in locating the projectiles, as the trajectory may not be linear after entering the animal.

Unlike the wounds produced by scavengers, which are distributed over certain regions of the carcass, gunshot wounds are usually isolated on the carcass and surrounded by relatively undam-

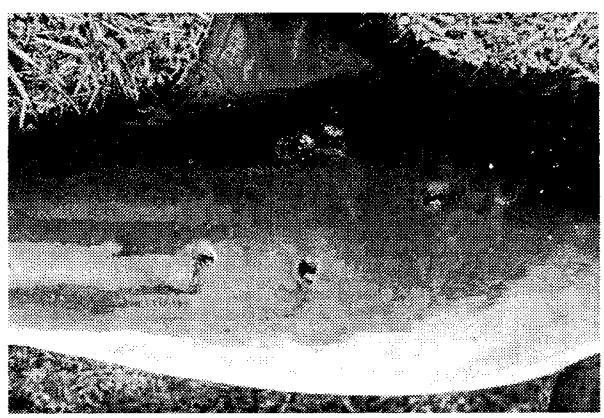

Figure 25. Multiple entry wounds from a shotgun blast that killed a harbor porpoise in a herring weir in the Bay of Fundy, Canada. Note the relatively unaffected area around the wounds.

aged skin (Figure 25). Damage from scavengers is usually shallower than gunshot wounds and more erratic in nature.

3.2 Vessel Collisions

Like manatees, dolphins and porpoises are sometimes killed or injured from collisions with small vessels. In Sarasota, Florida, for example, researchers have documented six cases of injury to bottlenose dolphins resulting from collisions with boats from 1983 to 1997 (Wells and Scott, 1997). Five of these animals survived their injuries, but bear scars from the encounters; one calf disappeared after a collision and is believed to have died (R. Wells, Chicago Zoological Society, personal communication; Figure 26).

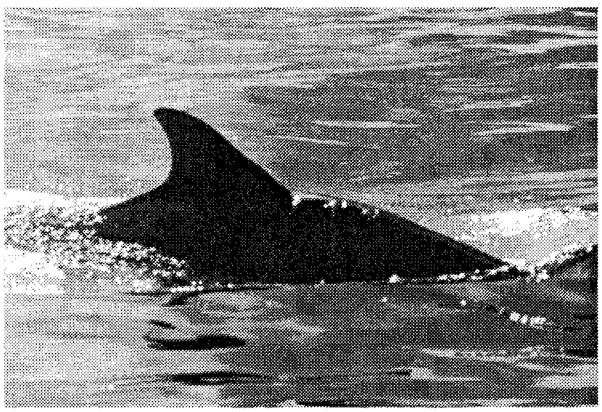

Figure 26. Healing wounds from a boat propeller on the dorsal surface of a bottlenose dolphin from Sarasota, FL. The dolphin survived the encounter. Photo courtesy of R.S. Wells, Chicago Zoological Society.

There are two distinct types of gross evidence associated with collisions with small vessels: blunt trauma from the impact itself and lacerations from the propeller. Either or both may be present, depending on the nature of the collision. Evidence of blunt trauma and lacerations from propellers are typically found on the dorsal surface of the animal and often involve the dorsal fin. Evidence of blunt trauma may consist of hemorrhage, occasionally massive or diffuse, around the point of impact. In severe cases, broken bones, ruptured organs, and torn underlying tissue may accompany the hemorrhage. The hemorrhage may not be visible externally, so be sure to conduct a full internal examination to look for evidence of blunt trauma. Wounds from propellers are usually obvious and distinctive. Lacerations from propellers consist of parallel, evenly spaced cuts on the body surface or appendages (Figure 27). It is usually possible to visualize the course

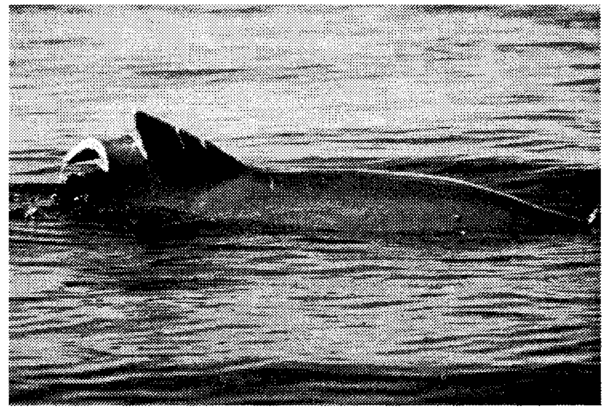

Figure 27. Healing wounds from a boat propeller on the dorsal fin of a bottlenose dolphin from Sarasota, FL. Note the parallel and evenly spaced cuts on the fin. The photograph was taken in 1983 shortly after the encounter; the dolphin was still alive, although disfigured, in 1998. Photo courtesy of R.S. Wells, Chicago Zoological Society.

of the propeller blades over the body of a dolphin or porpoise. The lacerations may be deep, sometimes penetrating completely through the dorsal fin (Wells and Scott, 1997).

If the animal survives the initial collision, lacerations may be in the process of healing and may be infected. It is important to distinguish these cases from those in which the animal was killed outright from the collision; so take detailed notes, obtain photographs and, most importantly, retain samples for histopathological analysis (see Geraci and Lounsbury, 1993). Histopathology samples will allow determination of whether the impact occurred ante- or post-mortem, as boats occasionally strike the floating carcass of a dolphin or porpoise. In post-mortem collisions, the propeller marks may be on the ventral or lateral surfaces. As noted above, many dolphins survive collisions with boats and exhibit healed scars from these adverse encounters. Obviously, it is important to distinguish such cases from those with recent wounds that may have contributed to the death of an animal.

3.3 Blast-Induced Trauma

Only scattered observations exist regarding the effects of blast-induced trauma on marine mammals. The most detailed observations of blast injuries have been made with large whales (Ketten, 1995). Direct observations are lacking, but it is likely that explosions can cause both acoustic and percussive trauma in small cetaceans, as they do in other marine mammals. This trauma is caused by rapid and massive pressure changes brought about by the shock wave from the explosion. The degree of tissue damage will vary with the size and distance from the blast, in addition to other factors (Ketten, 1995). Lethal injury from such explosions may be very difficult to detect, particularly for non-specialists, as much of the trauma may occur within the ear. Fractures of the periotic bone have been reported from humpback whales exposed to explosive blasts, but much of the other trauma exhibited by these whales would not be readily apparent in a routine necropsy. Therefore, we recommend that, if blast injury is suspected as a probable cause of death of a dolphin or porpoise, the entire head should be retained and examined by a specialist with experience in assessment of blast injury.

4.0 EXAMINING A SMALL CETACEAN FOR EVIDENCE OF HUMAN INTERACTION

As noted in the field guide to strandings by Geraci and Lounsbury (1993), information has scientific value only when carefully documented. For this reason, it is recommended that a standard data form, which prompts observers to check for each category of physical evidence, be used to record information. We present here the data form we use to score gross evidence of human interaction in our field examinations. Other standard data (sex, length, body mass, morphometrics etc.) should be recorded on appropriate data sheets. This protocol was first developed by Haley and Read (1993) and refined herein. Other useful advice on conducting post-mortem examinations of small cetaceans may be found in Geraci and Lounsbury (1993) and Jefferson et al. (1994). Helpful information may also be found in similar manuals designed for use with other species of marine mammals (Bonde et al., 1983; Dierauf, 1994; Hare and Mead, 1987).

Whenever possible, examinations should be performed on carcasses that have not been frozen. Freezing and thawing carcasses may introduce artificial marks, cracks, or damage to appendages and lead to improper identification of an interaction such as entanglement. In addition, freezer breakdowns may completely destroy important evidence. Therefore, it is preferable to conduct this examination on a fresh carcass as soon as possible after discovery, even if a full necropsy is not to be conducted immediately.

4.1 General Information

Follow the general procedures for recording data described by Geraci and Lounsbury (1993). Record the field number, species, sex, length, cause of death (if known), date of death (if known), date and location of the examination, stranding location and name of the examiner. It is critical to take video footage and/or photographs of the whole animal and of any unusual marks or lesions (Figure 28) and note this on the data sheet. Extreme care should be taken with photo-documentation; avoid poor lighting, exposure, and composition. Ensure that the field number is visible in each photograph and at some point in the video footage. It is often useful to have someone provide an audio narrative on the videotape describing particular lesions, marks or other features of interest. Any other relevant information should also be recorded at this time. The condition of the carcass should be evaluated using the Smithsonian Institution criteria: Code 1 = live; Code 2 = good condition (fresh/edible); Code 3 = fair condition (decomposed, but organs intact); Code 4 = poor condition (advanced decomposition); Code 5 = mummified or skeletal remains (Geraci and Lounsbury, 1993). Useful information can be obtained from Codes 1 B 3, and occasionally even from Code 4 specimens. Any additional comments can also be included at this time.

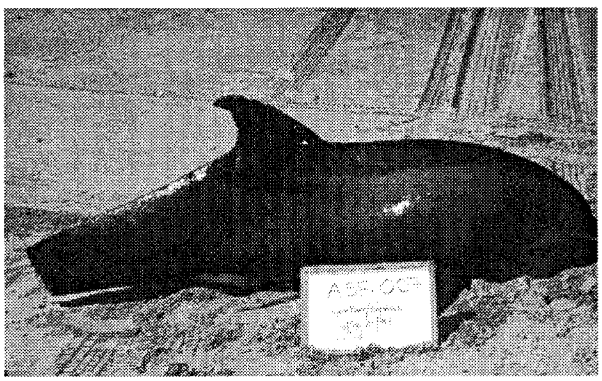

Figure 28. An example of a good field photograph. The lighting, exposure and composition are appropriate and the field number, location and date are clearly visible. The caudal peduncle of this bottlenose dolphin, stranded in North Carolina, has been clearly severed. Photo courtesy of Andrew Westgate, Duke University Marine Lab.

4.2 External Examination

4.2.1 Body Condition

On the data sheet, denote the animal as "emaciated" or "not emaciated." An emaciated animal is in poor nutritional condition with a thin blubber layer, sunken cervical region posterior to the skull, and atrophied epaxial musculature (Kuiken, 1996). Animals in good nutritional condition have a relatively thick blubber layer and well-developed musculature. The relative thickness of the blubber in robust specimens will obviously vary from species to species and even from season to season within a species. The apparent condition of a carcass may also change with decomposition; very degraded carcasses can sometimes appear emaciated after the blubber has rendered. The body condition of animals in advanced states of decomposition (Codes 3+) or those in which the body condition of the animal cannot be assessed should be recorded as "CBD" (cannot be determined). We find this general assessment of body condition to be useful in distinguishing between animals that died of chronic health problems and those that died of acute causes.

4.2.2 Net or Line Marks

Thoroughly examine the entire body for unusual marks, such as those from lines or nets. Be sure to examine both sides of the carcass and the dorsal and ventral sides of all appendages. As described in detail above, lesions from monofilament gill nets appear as thin, distinct indentations on the skin of the animal that occasionally penetrate through the dermis. Multifilament net and lines often leave an impression of the braided material in the skin. Describe each mark in detail and be sure to obtain good photographs of each lesion. After discovery, carcasses are often secured by line or rope, which may leave impressions in the skin. If this is the case, be sure to note on the data sheet that these impressions occurred after discovery. The same also holds for numbered tail tags attached by NMFS observers.

4.2.3 Fishing Gear Present and Retained

If fishing gear or other objects are attached to the carcass photograph then remove and retain a representative sample and note this clearly on the data sheet. It is often possible to identify the fishery responsible for an entangled marine mammal from only a fragment of net or line. Note where and under whose supervision such materials are retained.

4.2.4 Penetrating Wounds

Carefully examine the body for any penetrating wounds, caused by gunshots, gaffs, or other equipment (e.g., temperature probes). Describe the size, depth, and location of all wounds. Follow the path of the wound into the superficial tissue and obtain samples for histopathology to determine whether the wound occurred ante- or post-mortem (Geraci and Lounsbury, 1993). The remains of a bullet or shot can often be found internally within the vicinity of the gunshot wound.

4.2.5 Mutilation

Note any missing appendages or any other signs of mutilation, such as cuts or slits into the body cavity. Human removal of appendages can be distinguished from advanced decomposition, predation or scavenging by the clean, smooth surfaces left by knife cuts. Appendages or the body surface may also be severed or damaged from collisions with boat propellers. If a series of parallel cuts have been made into the skin, measure the distance between the cuts and take a photograph of the region. Ante-mortem wounds are associated with hemorrhage; post-mortem wounds are usually blanched and not associated with hemorrhage. Ante- and post-mortem wounds can be readily differentiated by histopathological analysis.

4.2.6 Hemorrhaging/Bruising

A hemorrhage is the escape of blood from ruptured vessels, which is often caused by trauma (Bonde et al., 1983; Kuiken, 1996). Note any subcutaneous hemorrhage on the exterior of the body B these areas will appear purplish, red and/or swollen. Measure the size of the hemorrhage in three dimensions. Carefully examine the tissue and muscles beneath any external hemorrhage during the interior examination, and remember to check for the presence of broken bones. In some cases, even massive blunt trauma may not be evident externally, so be sure to conduct a thorough internal examination.

4.2.7 Scavenger Damage

Record all areas on the external surface of the carcass where scavenger damage is apparent. This will help to describe the overall condition and appearance of the carcass. Carcasses of small cetaceans taken in bottom-set gill nets may sustain damage from benthic scavengers such as amphipods and hagfish while they are entangled in the net. Carefully examine circular holes in the animal, particularly if they appear to extend deep into the internal cavity of the carcass, to ensure that they are not gunshot wounds. Gulls cause the most common type of scavenger damage found on stranded small cetaceans. Gull pecks typically occur on areas of the carcass exposed on the beach or while afloat and appear as multiple, shallow scrapes into the skin or appendages. Gulls will often preferentially scavenge around the lower jaws to obtain access to the lipid-rich mandibular fat pads (Figure 29).

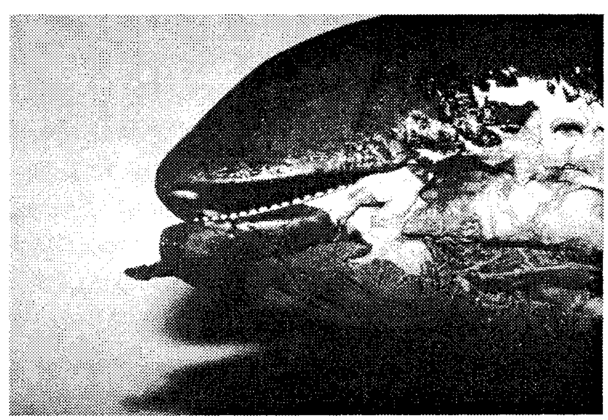

Figure 29. Damage caused by gulls scavenging around the left lower jaw of a harbor porpoise stranded in Virginia. Note the exposed mandible.

4.3 Internal Examination

Follow the general recommendations for internal examinations laid out in Geraci and Lounsbury (1993) and Jefferson et al. (1994). Our protocol is compatible with most internal examinations conducted on small cetacean carcasses, but care should be taken to record all pertinent information on the data sheet as the necropsy progresses.

4.3.1 Sub-Dermal Hemorrhaging

Carefully strip the blubber from the entire carcass and examine the underlying muscles and tissue for any inflammation and reddening. Pay particular attention to the cervical region as this area is often characterized by hemorrhage in entangled specimens. The size and location of all hemorrhages should be recorded and photographed. Focal hemorrhages are indicative of blunt trauma. Attempt to match any sub-dermal hemorrhage with evidence of external trauma in the overlying tissue. It is important to distinguish ante- and post-mortem trauma, as the former may be associated with the cause of death but the latter is not. Ante-mortem hemorrhage is characterized by infiltration of blood and fluid from ruptured vessels into surrounding tissue and is often accompanied by swelling. In post-mortem trauma, there is no infiltration or swelling, but pockets of coagulated blood may be present.

4.3.2 Broken Bones

Describe any fractures and disarticulated joints. Pay particular attention to the ribs and skull, where fractures often occur, particularly in the smallest cetaceans. Make a careful evaluation and description of any broken bones, as bones can be broken during post-mortem handling. Look for any signs of healing in a fracture, such as fibrous connections between bone fragments, that might indicate that the trauma was not of a recent origin. Recent ante-mortem fractures are always associated with hemorrhage.

4.3.3 Lung Contents

Open the trachea and main bronchi in each lung and describe the contents (froth, fluid, or air). Froth may be white, yellow, or blood-tinged. Fluid and froth are often found together. Death by hypoxia is often associated with edematous lungs that appear wet and heavy.

4.3.4 Stomach Contents

A full stomach, containing partially digested prey, may be indicative of an animal that was in good health and died a traumatic death. It is useful, therefore, to excise the stomach and make a careful examination of the contents after the necropsy is completed. The general cetacean stomach complex consists of three compartments: the forestomach, main stomach, and pyloric stomach. The forestomach is an enlargement of the esophagus, with no definitive demarcation between the two structures. In contrast, narrow passages separate the fore from the main stomach, the main from the pyloric stomach, and the pyloric from the duodenal ampulla. Beaked whales differ from other cetaceans in that they lack a forestomach and have up to 11 "connecting chambers" between the main and pyloric stomachs (Mead, 1993). Tie off tightly both the esophageal and duodenal ends with a string or cable before removing the stomach complex. As much of the esophagus should be taken as possible, since animals that die traumatically sometimes vomit and food items may still be lodged therein. The duodenum should be pinched and tied 10-cm posterior to the pyloric sphincter (Jefferson et al., 1994). After the necropsy has been completed, weigh the entire stomach complex in the laboratory and open each compartment individually, starting with the esophagus/forestomach and working toward the pyloric stomach. Usually, most of the intact prey remains are found in the forestomach. Intact remains should be removed immediately and frozen. Look carefully for any foreign objects that may be lodged in the stomach or esophagus. After the intact prey have been removed, the stomach compartment should be everted and gently rinsed in water to dislodge all remaining prey parts. A sieve or strainer should be used during the rinsing to collect small prey remains and foreign objects. Otoliths and other bones should be stored dry, cephalopod beaks can be placed in 70% ethanol, and parasites should be fixed in an appropriate solution (Dierauf, 1994). Weigh the entire stomach complex again after all contents have been removed.

4.3.5 Histopathology Samples

Examination of histological samples by an experienced pathologist is an essential component of post-mortem examinations of stranded marine mammals. When possible, samples should be taken from a fresh carcass, but samples from a frozen carcass may still be useful. Abnormal and adjacent normal tissues should both be sampled, because the diagnosis of condition often occurs at this interface. The optimal size tissue sample to yield the best fixation is 1 cm^3, though larger samples can be taken if adequate fixation is supplied. The ratio of formalin (10% solution) to tissues in the container, preferably a plastic jar with a screw-top closure, should be at least 10:1 (i.e., 10 parts formalin to 1 part tissue (Dierauf, 1994). Multiple samples can be placed in the same jar. All major organs including brain, lung, heart, spleen, liver, kidney, adrenal gland, lymph nodes and urinary bladder should be sampled. Also sample all areas of hemorrhage, fracture, blunt trauma, infection, and any regions of unusual pathology. Label the histopathology jar with the animal=s field number, species, date, and fixative contents, using a permanent ink marker.

4.3.6 Gross Pathology

All major organs should be examined for the presence of parasites or other lesions. Examine ducts and lumens of each organ, as parasites are most often found in these areas. Note the type, quantity, and location of the parasites present. If necessary, cut around the area with the parasite and preserve in an appropriate fixative (Jefferson et al., 1994; see Dierauf, 1994, for more specific collection, preparation, and preservation of tissues with parasites). Also note any organs which are enlarged or reduced, and unusual lesions in the interior or exterior of the animal.

4.4 Diagnosis

Diagnosis of the cause of death of any stranded small cetacean requires the completion of a pathology report and consultation with a veterinary pathologist. Nevertheless, we consider several types of gross evidence to be diagnostic of various anthropogenic causes of death in these animals, as outlined above. Other lines of evidence are consistent with, but not diagnostic of, traumatic death from human activities. Mutilation, for example, can occasionally occur on the beach and thus is not diagnostic of traumatic death at sea (Figure 30). Personnel conducting the post-mortem examination should be conservative in their evaluation and diagnosis. It is our experience that, in the vast majority of post-mortem examinations, it is not possible to assign a cause of death, even when the specimen is fresh. Nevertheless, with care, it is often possible to identify cases in which animals have died as a result of adverse interactions with humans.

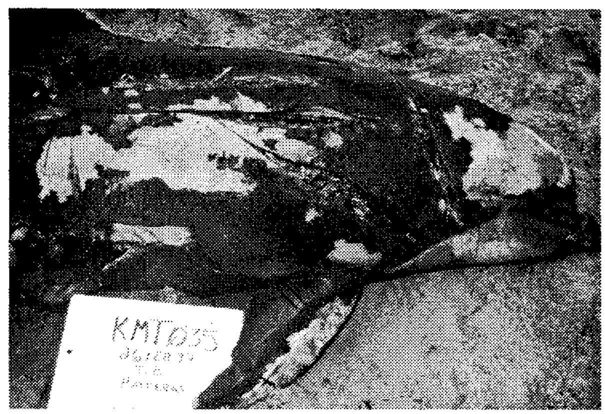

Figure 30. Post-mortem mutilation on a bottlenose dolphin stranded in North Carolina. Strips of skin and blubber had been removed by a bystander to feed gulls, prior to the response of stranding network personnel.

5.0 EVALUATION OF HUMAN INTERACTIONS WITH SMALL CETACEANS

1. GENERAL INFORMATION

Field No.____________________

Species ________________

Sex ______ Length ______________

Examiners________________

Cause of Death (If known) ______________

Date of Death (If known) __________

Location of Exam ________________

Date of Exam ________________

Video (Tape Number)_____________

Photos (Roll and Frame Nos.) ________

Condition: SI Code: 1 2 3 4 5

Fresh or Frozen ________________

Comments:

2. EXTERNAL EXAMINATION

A. BODY CONDITION: Emaciated specimens often exhibit sunken epaxial musculature and a neck

EMACIATED _____ NOT EMACIATED_____ CBD _____ N/E _____

B. NET OR LINE MARKS: Indicate Y/N/CBD/NE for each area and carefully describe net or line marks:

HEAD _____ D. FIN _____ FLUKES _____ L. FLIPPER _____ R. FLIPPER _____ PEDUNCLE _____

OTHER _____

C. FISHING GEAR PRESENT ON ANIMAL

YES_____NO_____

D. GEAR RETAINED

YES_____NO_____

E. PENETRATING WOUNDS: YES _____ NO _____ CBD _____ N/E _____
Describe bullet wounds, gaff marks, punctures, etc:

F. MUTILATION: Body Slit or Mutilated? YES _____ NO _____ CBD _____ N/E _____

Appendages Removed? YES _____ NO _____ CBD _____ N/E _____

Describe cuts, slashes, slits in body wall, missing appendages, etc:

G. HEMORRHAGING/BRUISING: YES _____ NO _____ CBD _____ N/E _____
Describe extent and area:

H. SCAVENGER DAMAGE: YES _____ NO _____ CBD _____ N/E _____
Describe extent and area:

 Field No. ___________________

3. INTERNAL EXAMINATION

A. SUB-DERMAL HEMORRHAGING: YES _____ NO _____ CBD _____ N/E _____
Describe extent and area:

B. BROKEN BONES: YES _____ NO _____ CBD _____ N/E _____
Describe:

C. LUNGS & BRONCHI CONTENTS: AIR _____ FLUID _____ FROTH _____ CBD _____ N/E ____
Describe appearance of lungs (heavy, consolidated, etc.) and contents of respiratory tract:

D. STOMACH CONTENTS: PRESENT ______ ABSENT ______
RETAINED: YES _____ NO _____

E. HISTOPATHOLOGY SAMPLES RETAINED: YES _____ NO _____

F. GROSS PATHOLOGY: YES _____ NO _____ CBD _____ N/E _____
Describe:

4. DIAGNOSIS:

Indicate initial diagnosis; a final diagnosis should be made after all test results are completed.

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