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Handbook for Determination of Adverse Human-Marine Mammal Interactions from Necropsies

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NOTICE

HANDBOOK FOR DETERMINATION OF ADVERSE HUMAN-MARINE MAMMAL INTERACTIONS FROM NECROPSIES

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INTRODUCTION

Knowledge of human/marine mammal interactions is at present limited by a lack of definitive data. Entanglement in fishing gear, ingestion of marine debris, harassment, vessel collisions, and pollution induced stress are but a few of the most visible human/marine mammal interactions detrimental to the latter. We cannot assume these impacts to be negligible or leave them unmonitored while human use of coastal ocean resources is growing. Even for those direct interactions for which we have a great deal of documentation, questions remain about what species are involved, how many individuals are affected, and its temporal and geographic extent.

This handbook is a reference manual for personnel encountering stranded animals. It is primarily intended for use at the stranding site by previously trained personnel of a regional stranding network. By using this reference, those personnel can: (1) perform adequate necropsies; (2) adequately document the results of these examinations; (3) correctly identify the evidence left by adverse human interactions with marine mammals. The importance of proper documentation of strandings unrelated to human activities is stressed because of its comparative value to cases of human related mortality. It outlines procedures to be followed when performing a necropsy and gives suggestions as to other possible sources of information relating to the animal. A section is included on the known types of adverse human-marine mammal interactions. If you are not a member of a stranding network and desire to become one, contact the local office of the National Marine Fisheries Service who will put you in touch with the closest network member.

By using this handbook, network participants should be able to collect more detailed and accurate data. These data will contribute to improved monitoring of human/marine mammal interactions.

Accurate monitoring depends on systematic beach coverage and qualified respondents. Monitoring is currently dependent upon public or institutional interest. This is variable and difficult to measure. Through training, we can have more consistent data collected. Respondents must be able to recognize signs of human interaction and know how to document evidence supporting their interpretations. A well intentioned respondent can mistake bird peck marks for bullet holes or tooth rake marks for net marks unless there are criteria by which to judge trauma and methods to confirm the interpretation made. An effort must be made to determine if trauma occurred before death, and hence was a mortality factor, or after death, presumably in an unrelated incident.

For the purposes of this handbook a stranding is broadly defined as an animal beached or impaired due to disease, trauma or aberrant behavior. This definition includes natural and human related mortality at sea which results in dead animals who are cast ashore, injured animals who come ashore, and animals who are injured or preyed upon while hauled-out.

The information in this handbook is based on our own experiences and from responses collected through dissemination of a questionaire which was sent to persons having expertise in marine mammal necropsy and strandings.

STRANDING RESPONSE PROCEDURES

A consistent effort to examine all reported beached animals is imperative if there is to be a confident record of species frequencies and an unbiased monitor of human impacts. Immediate initial response to a reported stranding is important. A consistent effort shown by agencies responsible for strandings provides positive reinforcement to people in a position to discover and report events.

INITIAL REPORT

Question the original reporting source to get the stranding located with sufficient precision that directions to the site can be given to someone who is unfamiliar with the area. An attempt should be made to secure the animal if it is in danger of drifting away with tidal changes. The means of access to the animal should be ascertained. It is important to know if the animal is only accessible after a 3 mile walk or a 45 minute boat ride, or if one can drive (with a two wheel drive vehicle) right to the animal. The number of animals involved, an estimate of their size and their condition (live or dead) should be obtained. Find out what other parties have been notified that might also respond.

EXTERNAL EXAMINATION

The most questionable data typically collected by the general public from stranded animals is species identification and sex. Identification guides are not commonly used in the field by laypersons and they are often unprepared to describe diagnostic characters after the fact. Sex is usually difficult to determine in marine mammals. Variation in the presence or absence of mammary slits on males makes visual gender determination in most cetaceans unreliable. The only positive method of sexing cetaceans, short of extracting the gonads, is to probe the genital passage; if it proceeds toward the head, it is a female, if it towards the tail, it is a male.

Live strandings

Photographs are an important means of preserving visual data from a live stranding. It is important to photograph the animals before moving or releasing them. Views that show evidence of previous human interaction would be helpful. If the animal is to be released at sea, photos should be taken to enable the individual to be identified if it strands again. Views of the color pattern, scars, dorsal fin, flipper and fluke shape are necessary. Include a ruler or object of known dimensions for scale in all photographs. If possible the animal should also be tagged or marked before release.

Dead strandings

Upon arrival at a stranding, question persons on the scene to get further information relative to any activities involving the animal. An external examination and photo documentation are best done before exposure or movement cause further deterioration. Include a ruler or object of known dimensions for scale in all photographs. Response to a beached animal is seldom immediate. The longer an animal is beached before response by trained personnel, the greater the chance that postmortem trauma will occur to the carcass. Beachcombers, weather, gulls and predators can all take their toll before examination. Distinguishing between ante- and postmortem trauma in strandings reduces many of the factors complicating interpretations. For example, to ascertain if propeller slashes on a dead beached animal occurred when the animal was alive, look for signs of bruising or incipient healing. If the animal was already dead when the propellor struck it, there should be no signs of bruised tissue and the edges of the wound should be clean and sharp. Before peeling away blubber or opening the abdominal cavity, thoroughly examine external wounds suspected of being of human origin. Look for evidence of reddening around the edges, pus infiltration, and scar tissue throughout the length of the wounds (Bonde et al. 1983). These are visible biological reactions to trauma which cannot be induced postmortem.

External human induced wounds include bruises from blunt trauma, gun shot and other penetrating wounds, and debris entanglements. Size, depth, and location of each external mark is important. Closely examine all body orifices for parasites and document with close-up photographs or drawings any unusual marks, scars, or wounds.

The absence of marks or wounds indicating human interaction is as important to document as its presence. Full length photographs and close-ups of the appendages and head of these specimens should be taken. It is important to comment on negative findings such as absence of entanglement scars and genuineness of bird peck marks on the report to indicate that these items were examined.

Note the overall condition of the animal with reference to the description given by the original reporting source. The following categories serve to describe stages of decomposition in marine mammals.

Condition 1. Live.

Condition 2. Freshly dead (usually one to two days postmortem, meat is considered by most to be edible, skin may be abraded but usually is not sloughing off, minimal bloating).

Condition 3. Moderately decomposed (usually from several days to a several weeks postmortem. Organs are still physically intact, skin often has started to slough, carcass frequently has become bloated to the point that viscera are extruded, carcass usually still intact).

Condition 4. Advanced decomposition (usually from several weeks to several months, organs frequently not intact, parts of carcass may separate).

Condition 5. Indeterminate (mummies or skeletons).

If the animal is freshly dead and personnel are available to necropsy it immediately, steps should be taken to keep the carcass from deteriorating. Heat contributes to deterioration more than any other factor. Covering the carcass with wet blankets or packing it in crushed ice will help to slow the rate of deterioration.

To prevent confusion arising from marks that were inflicted upon the carcass in the process of moving it, be sure to note how the animal was moved and what mechanisms were employed to move it.

If there is foreign matter attached to the carcass (investigate the origin of such material to be sure it was not from a recovery effort), take close-up photos at the point of attachment and overall views showing extent of attachment (Figure 1,5). Remove the foreign matter with care not to inflict additional damage and photograph the detail of abrasions and wounds left by the object. Record the type of object removed, its size, and retain a sample with a label cross referencing it to this animal.

One source of confusion is the interpretation of marks left on the carcass by nets. Look for net marks on parts of the animal by which it may have been held in a net. In cetaceans this means the dorsal fin, flippers, flukes and, in relatively long-snouted forms, the snout (Figure 2,3). Pinnipeds are often caught by the neck and shoulders. Net

marks are more likely to be produced in the relatively tender skin of a cetacean than in the skin of a seal or sea otter which is protected by fur. Remember also that there are a host of other factors which act on a stranded animal and are capable of producing marks that can easily be mistaken for net marks. The only clear net marks are marks which encircle the neck or shoulders, or three or more marks with a consistent spacing on cetacean appendages. Any suspected net marks should be photographed at close range.

Even when entanglement marks are not visible externally in seals, scar tissue can sometimes be seen between the dermis and blubber. Scars or bruising from entanglement appear as linear marks circling the animal in the neck region. They may appear as "blue lines" from an early stage of pressure necrosis or as raised or indented scar tissue easily discerned by palpation. The skin is weakened and tears more readily along the scar tissue (Scordino et al. 1984). A simple excision of blubber and skin should be made on any carcasses that are suspected of having been involved in entanglement. The neck region is by far the most frequent attachment site of net debris on pinnipeds, although Hawaiian monk seals have been reported with debris around the snout and girdling the body at the shoulders and abdomen (Henderson 1984). Other areas may be affected in other species.

This sampling technique will be most feasible and profitable if used consistently by removing a six inch wide rectangle of tissue from between the ears to between the shoulders. An entanglement scar, if present, will be noticeable as a line spanning the sample. Photograph the strip of tissue showing the scar. It is important to make certain that a scale is included and the orientation of the strip is shown. Collect a cross section of the scar including hair, skin, and blubber wide enough to make the damaged tissue clearly visible. Collect a small sample in 10% formaldehyde for histology. Note the absence of any visible scar.

A sample of the debris should be collected from all entangled animals. This is important even if the origin of the debris and its relation to the cause of death is uncertain. Measure mesh size by stretching the mesh and measuring from knot to knot. The circumference of the entangling loop on the animal at the point of attachment should be measured. Note the length of the wound (express as a linear measurement and as degrees in a circle, the perimeter of which is the animals skin), portions of the wound where skin is broken, and how tightly the debris girdled the animal (Scordino and Fisher 1983).

Penetrating wounds can be the result of gunshot or puncture with a sharp object. Whenever possible, x-ray specimens suspected of being shot before necropsy. Veterinary hospitals may be able to provide these services for small fresh carcasses. Slugs, shot, even lead trails (in flippers:

Bonde, pers. comm.) can sometimes be discerned. Confirm such visual observations by finding the projectile in necropsy. Sample adjacent dermal tissues and superficial musculature with a cross-sectional slice no greater than 2 cm wide and including healthy adjacent tissue. Samples should be taken where the wound is most clearly delineated and freshest and fixed in 10% formaldehyde.

INTERNAL EXAMINATION

It is always best to have the necropsy undertaken by someone with experience in dealing with marine mammal carcasses and in interpreting the data that is likely to be found. However, if no qualified biologist is available and the specimen will be lost, then even the grossest examination by an inexperienced person, using common sense and the quidelines provided below, can yield valuable data.

Special attention should be paid to internal signs of acute trauma such as broken bones, ruptured organs, or hemorrhage, as well as conditions indicative of violent, stressful death. Large amounts of coagulated blood may be found where blood vessels have been ruptured. Reddened tissue and hemorrhaging are signs of bruising which cannot be produced after death. These indications of trauma are less visible in the dark muscled cetaceans and pinnipeds, but sometimes evident around connective tissue or along the blubber. Sample the margin between healthy and damaged tissue and preserve the sample in 10% formaldehyde for histopathological analysis.

Proper documentation of a gunshot wound should include the entry hole, path of the projectile, and either the projectile or its exit hole, as shown for a dolphin in figure 4. Radiography is the easiest method, although often impractical, to confirm the presence of shot in a carcass. Wounds not visible externally may become evident if blubber and skin is peeled off in large sheets. The projectile track should be followed taking note of its path and associated damage (e.g. bones broken, ruptured organs). The track is likely to stray from a straight line, even if travelling through soft tissue. Collect a tissue sample across the track at several points for histological evidence of antemortem tissue response. Save any bullets or buckshot for law enforcement personnel.

In cases where you suspect that a freshly dead animal died by drowning, cut out a section of lung (a cubic centimeter will do) and see if it floats or sinks in water. If it is waterlogged, it will sink indicating that there is a possibility that drowning was the cause of death. This procedure is mainly of use for pinnipeds which may inhale water when they drown. Cetaceans do not have a breathing reflex so they do not inhale water when they pass out.

Drowning in cetaceans is usually a matter of simple suffocation. However, stillborn cetaceans have lung tissue that is still unaerated and will sink in water. Also note the presence or absence of froth in the bronchi, which can indicate a stressful death.

Cause of death determination, in cases where vessel collision is suspected, must include proof that the event was antemortem because the damage inflicted by vessels can occur with floating dead carcasses. Record the total length of a propellor wound (distance from the two end slashes), the width and depth of each individual incision, and the width between incisions. Diagram or photograph the position of the wound on the animal.

In instances where there is reason to suspect underwater explosion as being the cause of death, particular attention should be given to the examination of air containing structures (lungs and middle ears) in the carcass to see if there are signs of trauma in them.

Where possible, examine the digestive tract from the upper esophagus to the duodenum and note the amount, location, and degree of digestion of contents. This is an important indicator of feeding habits before death which may circumstantially support or refute suspicions of incidental catch. Fully document the presence of foreign matter even if it does not appear to have caused death. Complete monitoring of the impact of foreign matter ingestion requires consistent examination of the esophagus and stomach of stranded animals, recording position and amount of debris when present. Stomachs should be thoroughly examined, each compartment cut open and all contents preserved in 70 percent alcohol or frozen. Never use formaldehyde (formalin) as this will dissolve otoliths. The walls of the digestive tract are thick and strong, often maintaining their integrity and allowing examination in very decomposed carcasses.

Normal necropsy procedure for fresh animals should include collection and preservation of samples in 10% formaldehyde from all organ systems for histopathology.

Collect tissues for heavy metal and organochlorine analyses. A minimum of 10 grams of tissue (approximately one-half the size of a 35mm film cassette) should be collected and frozen from the following prioritized list:

1) Brain (label as cerebrum, cerebellum, medulla, etc.)
2) Liver
3) Kidney
4) Blubber
5) Whole blood or clotted blood from major vessel or heart.
6) Muscle
7) Bone

Rinse a scalpel or dissecting knife with acetone prior to collection of each tissue for residue analysis. Tissues should be placed only on non-lubricated aluminum foil or directly in glass jars which have been rinsed with acetone and labeled on the outside of the jar. Labels should be clearly marked using pencil or indelible ink with contents, specific location of sample origin (i.e. region of organ), collector's number, sex and condition of animal. Line the jar lids with non-lubricated aluminum foil before closure. Avoid exposure of samples to plastics, soaps or oils. Stainless steel dissection tools should be wiped clean and rinsed with acetone before working on each sample. Chill or freeze samples as soon as possible and maintain frozen.

Glass jars are sometimes economically and logistically impractical for field conditions and indefinite freezer storage of samples. We offer an alternate procedure using whirl-packs, or analogous polyethylene enclosures. Samples should be wrapped in non-lubricated aluminum foil and placed with a label into a whirl-pack for organochlorine residue surveys . Put this and a duplicate label into a second whirl-pack (to assure that at least one readable label will persist). Samples collected for heavy metal analysis can be placed into the first whirl-pack bare and this, enclosed with a label, into a second whirl-pack. Labeling directly on plastic containers with a marking pen is not recommended.

DISPOSAL OF CARCASS

Floating carcasses can be hazards to marine navigation and will often instigate involvement by the U.S. Coast Guard. In many areas a carcass must be towed in excess of 10 miles seaward if it is to be kept from beaching on an adjacent shore. Relocating a carcass to an unpopulated beach for necropsy and burial is usually the best solution for all concerned. Permission much be obtained from the owners of the beach that has been chosen for burial before this is attempted. If at all possible, select a burial site not subject to the action of high tides. Small carcasses are best handled by a sanitary landfill. Disposing of carcasses by means of explosives or fire is not recommended.

OTHER SOURCES OF DATA

If there is evidence that a vessel collision was involved in the case of large whales, try to determine the individual vessel and interview the crew members. Usually the engineer keeps records of the engine rpm's and the ships speed and can pinpoint where the collision took place. Ask if the bridge and/or deck watch noticed any unusual activity such as whales, dolphins or birds.

If there is reason to believe that entrapment in a man-made structure (such as dry dock or canal locks) was responsible for the cause of death, circumstantial evidence such as proximity of the carcass to locks and schedules of gate operation are important corroborative pieces of information.

REPORTING OF DATA

If circumstances prevent response to or collection of a stranding, photographic documentation should be requested from the reporting party. Generally a full lateral view will suffice for identification.

Necessary information should be sent to the proper authorities. The National Marine Fisheries Service and the Marine Mammal Events Program at the Smithsonian Institution (MMEP) maintain a national data base on cetacean stranding events. Basic information is requested concerning who, what, when, and where an event occurred. Data are also requested on the nature of occurrence (what type of human involvement is suspected, if any), the evidence supporting this designation, and the disposition of specimens material collected from the carcass. Appendix 1 is a standard data form outlining the minimum data requested. Information compiled by MMEP is available on request from the Smithsonian Institution. However records of human induced mortality cannot be interpreted unless the evidence leading to a cause of death determination is reported.

As of January, 1987, there is no agency responsible for the gathering and interpreting of comparable data on pinnipeds for the whole country. This has been handled in a variety of ways by the four regional stranding networks. We hope a nationwide pinniped center will emerge and until that time we recommend that workers contact the National Marine Fisheries Service in their area to determine who handles pinniped data.

EXAMPLES OF HUMAN IMPACTS

FISHING GEAR

Net Entanglement

Net entanglement of marine mammals is geographically and taxonomically widespread. It is virtually impossible to distinguish between events occurring at sea which involve set nets or marine debris, from examination of beached animals found with netting. Debris related strandings will be covered in another section. Furthermore many species of cetaceans and

pinnipeds, as well as California sea otters, are known to sink while fresh, making any interpretation of stranding evidence uncertain (Bodkin in litt. 28 Oct). Apparently not every carcass sinks, at least with harbor porpoise (Deiter pers. comm.), possibly because of the affects of body fat on buoyancy or from retention of air in the lungs.

Seagars et al (1986) point out the stranding data cannot be used for estimating total mortality or monitoring the effect of net entanglement mortality on a population because the proportion of the population that winds up as strandings is unknown. However, such information can be used as an index which can alert management agencies to a need for the initiation of more extensive monitoring programs.

Cetaceans: Along United States coasts the stranding record and reports of floating and live entangled whales shows the greatest impact from nets among harbor porpoise and large whales, especially grey whales and humpbacks (Smithsonian files; Seagars et al 1986; Woodhouse, C. D.[1]).

Several biases suggest that this may be an artifact of the sampling method. Large whales can more easily escape from an encounter with gill netting, albeit sometimes trailing evidence of the encounter. This allows greater opportunity for observation and recording of the event. Occasional evidence of net entanglement has been recorded from all four NMFS regions (Smithsonian files). The frequency of this conflict appears to be greater than indicated by the stranding record when intensive efforts are made to investigate specific fishery interactions (Prescott and Fiorelli 1980; Reynolds 1985; Wynne in litt. 13 Nov.).

When large cetaceans are caught in a net they may break through, carry the net away (providing evidence of the encounter after death), or may be cut out of the net by fishermen. Net marks are less likely to be apparent on large whales than dolphins, but their location will be similar, with emphasis on the peduncle and flipper joints. The eye or tender tissue surrounding it may be cut on great whales by tightly wrapped monofilament net. If a whale frees itself from a fixed net, the debris will sometimes gather at the peduncle, though the motion of swimming, and cause damage such as that expected from a rope (see section on entrapment in non-fishing situations).

[1]Woodhouse, C. D. 1984 Patterns of marine mammal mortality in three coastal counties of California. Technical report submitted to Arthur D. Little, Inc., Acorn Park, Cambridge, Massachusetts.

Porpoises presumably must struggle in a gill net to cause monofilament or other material to slice the skin. The marks caused by monofilament nets are small thin cuts 1-2 cm into the epidermis on appendages, dorsoventrally on the caudal peduncle, or on the snout (Deiter, Kelly, Wynne, questionnaires) (Figure 6). Netting may leave impressions instead of or in addition to cuts, particularly around the neck or snout (Deiter [2]; Wynne in litt. 13 Nov.) (Figure 7). These can sometimes be seen in relatively decomposed carcasses.

Other marks sometimes associated with gill net incidental take are gaff marks, excised appendages, and slit abdominal cavities (presumably to make carcasses sink)(Dieter [2]; Kelly in litt. 28 Oct.; Wynne in litt. 13 Nov.). Wynne (in litt. 13 Nov.) reports a 20 percent incidence of gaffing and 5-10 percent removal of flukes on harbor porpoise by gill net fishermen from a small sample of observations along the Maine coast. The possibility that any one of these marks could be made on the beach by pedestrians or scavengers prevents their singular use as evidence of net entanglement. The only dismemberment positively documented from a fishery has been of flukes (Wynne in litt. 13 Nov., Seagars and Henderson 1985:778), although absence of dorsal fin and flippers has been reported associated with presumed entanglement victims. Clean dismemberment is uncharacteristic of shark predation. The work of fishermen is likely to leave a clean (not jagged) cut (Wynne in litt. 13 Nov.; Kelly in litt. 28 Oct.) (Figure 8). Gaff marks are deep slashes or punctures, usually located in the anterior dorsolateral section of the animal (Wynne in litt. 13 Nov.).

Most of these guidelines are based on entangled harbor porpoise with very few corroborative observations on fishing operations. Marks left by entanglement will vary between each fisherman and fishing method, different net mesh sizes, and different species of cetacean caught. Fishing methods change and fishermen may alter their behavior to hide evidence of entanglement. Better documentation of beach evidence and further efforts at direct observation of fishing operations is a necessity.

Pinnipeds: Coastal gill net entanglement has been positively documented for the harbor seal, California sea lion, and northern elephant seal (Bodkin in litt. 28 Oct.; Wynne in litt. 13 Nov.). Net entangled Northern fur seals have beached on the U.S. West Coast, but without positive

[2]Deiter, R. L. Necropsy protocol for marine mammal mortality along the Point Reyes National Seashore January 1 - October 17, 1985. Preliminary report to the Marine Mammal Commission for contract no. MM2911030-8]

evidence that entrapment occurred in deployed nets (Snow questionnaire). Circumstantial evidence is insufficient to designate entanglement as cause of death in a pinniped, yet pinniped fur usually effectively prevents any superficial wounds from net entanglement except for lacerations on thin skinned extremities such as the snout and flippers (Kelly in litt. 28 Oct.; Wynne in litt. 13 Nov.) (Figure 9). Observations have been made of belly slashing by fishermen on harbor seals, presumably to prevent refloating of the carcass from gas build up. Finding this mutilation on a beached carcass provides only circumstantial evidence of a fishery conflict because it cannot be differentiated from postmortem trauma inflicted on the beach.

Sea otters: Entanglement of sea otters in gill nets has been documented along California (Bodkin in litt. 28 Oct.) but no marks are known to result because of their thick fur.

Manatees: Entanglement of the West Indian manatee has been reported in fisherman's hoop nets and shrimp trawls (Bonde et al. 1983). Externally visible trauma is minimal from these incidents (Beck in litt. 23 Dec.).

Other Fishing Gear

Cetaceans: Incidental catch of harbor porpoise in herring weirs has been reported for the Bay of Fundy (Smith et al. 1983) as well as occasional entrapment of minke and humpback whales (Stone et al. 1982). Empty stomachs are found in many of the entrapped porpoises, but mortality results from only a few of these events. Incidental takes of harbor porpoise, minke and humpback whales have also occurred in cod and squid traps, salmon, mackerel and groundfish nets, (Smith et al. 1983; Lien in Goodman 1984) and possibly on tuna long lines (Testaverde 1979). Drowning of a bottlenose dolphin due to entanglement in the lines attached to a trawl net was reported by a fisherman in our questionnaire survey (R. Herring questionnaire). Large whales have become entangled in mooring and lobster pot buoy lines (Stone et al. 1982; Smithsonian files).

Ropes and lines supply a concentrated surface force (compared with netting) so that a wound is much more likely to result. Cuts, abrasions, and scars from rope damage can occur anywhere on the body but are typically found around the caudal peduncle and on the head near the mouth. A minke whale is shown in figure 10 with an open wound on the corner of the upper jaw and discoloration along the rope track around the lower jaw. The caudal peduncle often seems to catch and hold rope which creates abrasions dorsoventrally on the peduncle and/or medially on the tail flukes near the junction of these two structures (Figure 11). This junction is also where carcasses are towed, so the type of line involved and how it is attached is important to note.

Pinnipeds: One respondent recorded a rope burn across the back of a California sea lion, but this seems to be a less frequent observation than with cetaceans. Net debris bunches up around the neck of pinnipeds producing a wound similar to rope abrasions and this will be discussed under "debris".

Sea otters: No data.

Manatees: Crab trap float lines have caused injuries and subsequent death in manatees as they become inextricably tangled around the flippers and cause necrosis and septicemia (Bonde et al. 1983).

Ingestion

Few records exist of ingested fishing gear in cetaceans and pinnipeds, none are known from otters. Pinnipeds are found with fish hooks caught in the mouth and intestine (Hodder and Howorth questionnaires). Manatees have been found with balls of monofilament line and fish hooks in the digestive system, presumably debris consumed while foraging.

DEBRIS

Entanglement

It is virtually impossible to distinguish between material which entangled an animal while set from that which was picked up as flotsam. Entanglements in set gear can cause death before release by fishermen or create light damage of an acute nature. Even if gear is left attached to the carcass, this should not abrade and work its way into the skin as debris would on a live animal. Signs of antemortem biological reactions should be visible histologically. The rate that debris can debilitate an animal or its affect on life expectancy is uncertain (Scordino 1985). Debris can become further entangled or tighter by the action of swimming, eventually cutting the skin causing necrosis and potentially death due to infection. Scars found on unentangled Northern fur seals suggest that removal of debris is sometimes possible (Scordino and Fisher 1983; Scordino et al. 1984).

Cetaceans: We are not aware of any cetacean entanglements where the entangling material was known to be debris. Trauma produced by material entangling cetaceans is covered under fishing gear entanglements.

Pinnipeds: Concern for debris entanglement of pinnipeds is growing as studies document their vulnerability (Fowler

1982; Scordino and Fisher 1983; Scordino et al. 1984; Scordino 1985; Henderson 1984). Species observed entangled in debris include Northern and California sea lions, Hawaiian monk seal, Northern elephant seal, and the Northern fur seal (Scordino and Fisher 1983). Net fragments, ropes and lines, and plastic packing bands are all contributing to this problem (Scordino and Fisher 1983; Fowler 1982). Hawaiian monk seals have been reported to investigate floating debris and approach debris on haul out sites (Henderson 1984). Fur seals may approach floating flotsam to feed on congregating prey species, to haul out, or for play (Fowler 1982).

Unencumbered fur seals from the Pribilof Islands frequently show signs of previous entanglement (presumably from debris) externally and on the underside of the dermis after machine "blubbering" of the hide (Scordino et al. 1984). Even when entanglement marks are not visible externally in seals, scar tissue can sometimes be seen between the dermis and blubber. Scars or bruising from entanglement appear as linear marks circling the animal in the neck region. They may appear as "blue lines" from an early stage of pressure necrosis or as raised or indented scar tissue easily discerned by palpation. The skin is weakened and tears more readily along the scar tissue (Scordino et al. 1984).

This observation has only been reported in northern fur seals for which an annual harvest and processing provide an opportunity to examine the results of entanglement (Scordino and Fisher 1983; Scordino et al. 1984; Scordino 1985). There is no reason to expect that the same trace would not be left on other affected species. A simple excision of blubber and skin can be made from beached carcasses to check for scar tissue visually and tactilely. The neck region is by far the most frequent attachment site of net debris, although Hawaiian monk seals have been reported with debris around the snout and girdling the body at the shoulders and abdomen (Henderson 1984). Other areas may be aflicted in other species. This sampling technique will be most feasible and profitable if used consistently by removing a six inch wide rectangle of tissue from between the ears to between the shoulders. An entanglement scar, if present, will be noticeable as a line spanning the six inch width below the blubber. Collect a cross section of the scar including hair, skin, and blubber wide enough to make the damaged tissue clearly visible, or photograph the scar and collect a small sample for histology. Note the absence of any visible scar.

All debris entangled animals should be described and measured as outlined under "fishing gear entanglement" and a sample of the debris collected. Measure the stretched mesh size or circumference of the entangling loop and the same on the animal at the point of attachment. Note the length of the

wound (express as a linear measurement and as degrees in a circle, the perimeter of which is the animals skin), portions of the wound where skin is broken, and how tightly the debris girdled the animal (Scordino and Fisher 1983).

Sea Otters: No data.

Manatees: Manatees found with fishing line cinched around a flipper or the tail may be picking this up as suspended or sunken debris. However, the exact nature of such "entanglement" cannot be ascertained.

Ingestion

Ingestion of debris is a poorly documented form of human effect on marine mammals. Reports of ingested debris on questionnaires included plastic bags and a silver mylar balloon. Fishing related debris are covered under another section. Monitoring of this impact requires consistent examination of the esophagus and stomach of stranded animals, recording position and amount of debris when present. Ingestion of debris does not appear to be critical, but no measure is available on the proportion of stranding reports lacking this information because stomachs were not examined.

Cetaceans: Cetacean genera reported to have ingested debris are Mesoplodon, Ziphius, Kogia, Physeter, Grampus, Stenella, Tursiops, Phocoenoides (Smithsonian files) and Balaenoptera (Lambertsen pers comm). Most of these are single recorded events involving plastic bags in the stomach, though they have also been found in the esophagus.

Pinnipeds: No data.

Sea Otters: No data.

Manatees: Bonde et al. (1983) report bits of plastic ingested by West Indian manatees. This is most likely consumed incidental to vegetation and has not been observed to impair the animal.

WOUNDS

Gunshot Wounds

Gunshot wounds are commonly reported but infrequently documented or confirmed by retrieval of the projectile. Not long after beaching or death scavengers will start working on a carcass and in the case of gulls, will create marks or holes that have the appearance of gunshot wounds. With cetaceans the work of scavengers is often concentrated around the gape, eyes and lower jaw, but can be anywhere on an old carcass.

Even if gull peck marks could be distinguished from gunshot wounds, confusion and misinterpretation often arise after gulls attack an existing wound, as they commonly do. These difficulties underscore the need for proper documentation and confirmation of suspected bullet wounds.

Cetaceans: Gunshot wounds are not common in cetaceans, and appear to be non-fatal in large cetaceans where damage is restricted to muscle tissue.

Pinnipeds: Gunshot wounds were found to be the most common cause of death in Oregon pinnipeds during the 1970's (Stroud and Roffe 1979) and a high frequency of reports, mainly from California, Oregon, and Washington have accompanied the survey responses. Gunshot wounds are not always externally visible on pinnipeds. Hair or fur usually obscure the entry holes (Deiter pers. comm.), but they may be noticeable as in figure 12.

Sea Otters: Gunshot wounds have been documented in California sea otters with radiographs (Bodkin in litt. 28 Oct.) and are a suspected cause of mortality in South Central Alaska (Early, pers. comm.).

Manatees: Bullets and buckshot have been found in manatees, associated at times with large portions of missing flesh believed to be the work of poachers.

Other Wounds

This category includes knife, gaff, and other bludgeon or mutilating wounds. Some of these wounds have been discussed in other sections as they are often associated with fishery conflicts. Difficulty arises in assigning the cause of death because a wide variety of wounds are just as likely to be inflicted postmortem on a floating or beached carcass. Floating carcasses are subject to vessel collisions and target practice, whereas beached carcasses may elicit the meanest behavior in beachcombing public.

EXPLOSIONS

A few marine mammal deaths may result from underwater explosions, primarily from detonation of military ordinance or underwater blasting. This is a difficult situation to diagnose from a cause-of-death standpoint because the trauma inflicted could just be enough to cause the animal to lose consciousness. There has been one mass stranding of goosebeaked whales (Ziphius cavirostris) in which detonations of military ordinance were implicated (van Bree and Kristensen 1974). There are museum specimens of cetaceans whose middle ear bullae have been shattered in life and healed with no

damage to surrounding tissue. The only conceivable cause for such an injury is the extreme acoustic energy connected with an underwater explosion.

VESSEL COLLISION

Bonde et al. (1983) and Beck et al. (1982) have provided the only information available on marine mammal boat collisions from their work with manatees. Vessel collisions are frequently recorded for manatees, dolphins less so than large whales, and pinnipeds. Vessel collisions can leave characteristic propeller slashes or blunt trauma from bow impact. Skeg marks, scrapes made from the propeller guard on outboard engines, have also been reported in manatees (Bonde et al. 1983).

Propeller slashes will vary in appearance depending upon the speed of the boat, size of propeller, posture and speed of the animal when hit (Figures 13-15). These wounds will characteristically have several to many parallel slashes of varying length in which the length of each slash is related to its depth. In addition, width between slashes will generally be constant and related to the size and pitch of a propeller, though this relationship is also influenced by details of each collision. Sometimes each individual propeller slash in a series will have a slight bend at either end forming a shallow "s" curve.

Location and appearance of a wound will help indicate if the collision occurred postmortem. Most marine mammals float belly-up but do not normally expose their underside to the surface where it is vulnerable to boats. Hence, as has been found in manatees (Bonde et al. 1983), ante-mortem propeller cuts will rarely be on the underside of an animal. In addition, they may show the gross signs and certainly the histological evidence of hemorrhage and "healing".

Propeller wounds were determined to be the primary factor in the death of manatees from boat collisions during the late 1970's (Beck et al. 1982). Scars from previous non-fatal propeller wounds are common on manatees. Beck et al. (1982) shows that these scars result from impacts with propellers smaller than those causing the larger fatal wounds found in carcasses.

ACCIDENTAL ENTRAPMENT IN NON FISHING SITUATIONS

Although large cetaceans have been trapped in dry dock compartments (Smithsonian files), the best documentation in this category pertains to manatees caught in flood gates or canal locks (Bonde et al. 1983). External abrasions, impressions left by gate edges, and internal damage such as cleanly broken (not shattered) and/or disarticulated ribs.

Circumstantial evidence such as proximity of the carcass to locks and schedules of gate operation are important corroborative pieces of information.

ATTACK BY CARNIVORES

Attacks from domestic dogs was reported by only two respondents (Cunningham and Howorth questionnaires) involving a hauled-out California sea lion. This impact is presumably limited to pinnipeds and of limited frequency, if only because pinnipeds are generally wary enough to escape. Coyotes and foxes are responsible for scavenging of pinnipeds carcasses, primarily harbor seals, along the restricted coastline of Vandenburg Air Force Base, California and on offshore islands (Pergler in litt. 28 Oct.; Seagars pers. comm.). In these cases tracks remain around the remains of harbor seals which are often completely devoured and sea lions on which ragged wound lines are concentrated around the head and genital region. Bears and foxes are also reported to scavenge marine mammal carcasses in areas sparsely inhabited by humans (Glenn and Miller 1980; Bengston and DeLong pers comm).

SUMMARY

Scientific documentation of adverse human/marine mammal interactions is necessary if we hope to ascertain the precise nature of the problem. Ocassionally evidence of such interactions will be needed in court. It is imperative that events unassociated with human activities be documented as extensively as those where human impact was involved. Photographic documentation, coupled with good notes, are the best ways of preserving appropriate data. Even though human interaction may appear to be involved in an event, it is incumbent upon the investigator to gather as much data as possible for review by others. Only by collecting data on the former events will we have a relative measure of human interactions. The most important concern with a human interaction case is to preserve specimens and data that support a determination that the observed trauma was produced while the animal was alive or after death. Be prepared to justify intermediate categories such as 1) STRANDING (natural mortality), 2) POSSIBLE STRANDING (appears to be natural mortality but there is some reason to question it), 3) POSSIBLE HUMAN INTERACTION (appears to have been some human interaction but the evidence is not definitive) and 4) HUMAN INTERACTION (definitive evidence).

ACKNOWLEDGEMENTS

The many people who offered information from their experience with marine mammals have helped us to broaden the scope of this handbook. In particular we would like to thank all respondents to the questionnaire, the generous people who sent us photographs and data, Dana Seagars and Tracey McKenzie who provided constructive criticism of drafts of this manuscript, and the pathologists who kindly did their best to answer our difficult questions.

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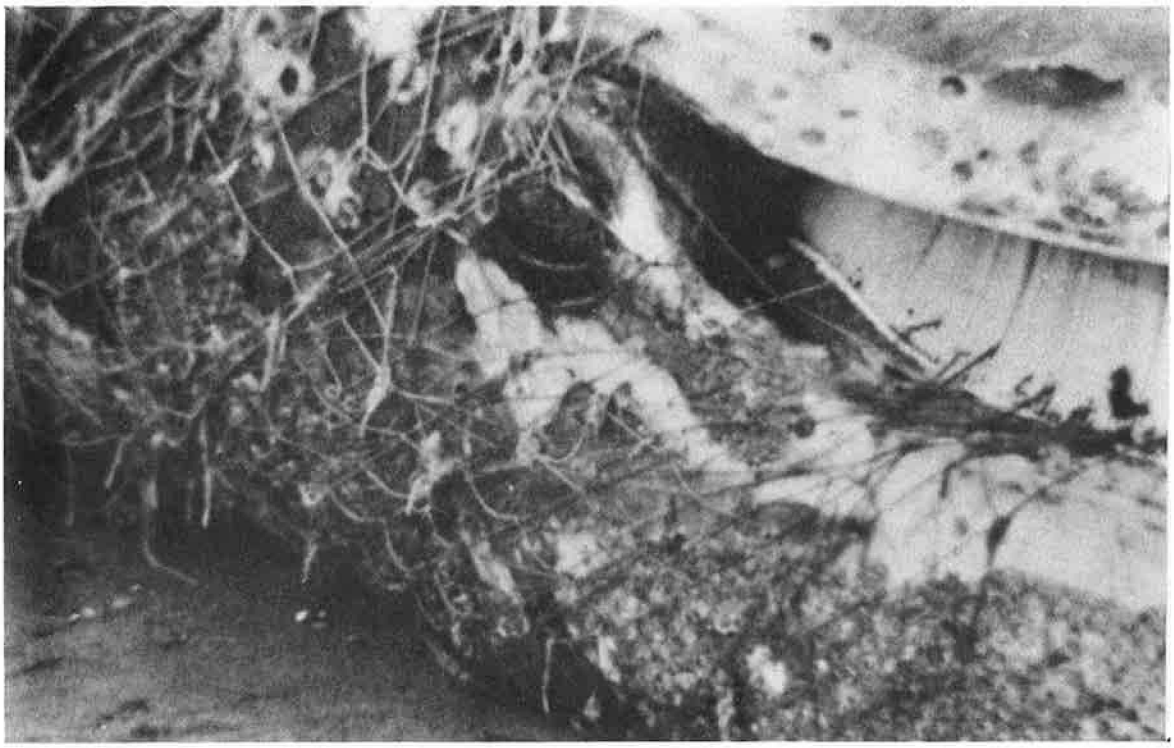

Figure 1. Lateral view of a gray whale head entangled in netting. Animal is lying on its back with the eye in the center of the picture. (photo by R. E. Jones, specimen number REJ 1226).

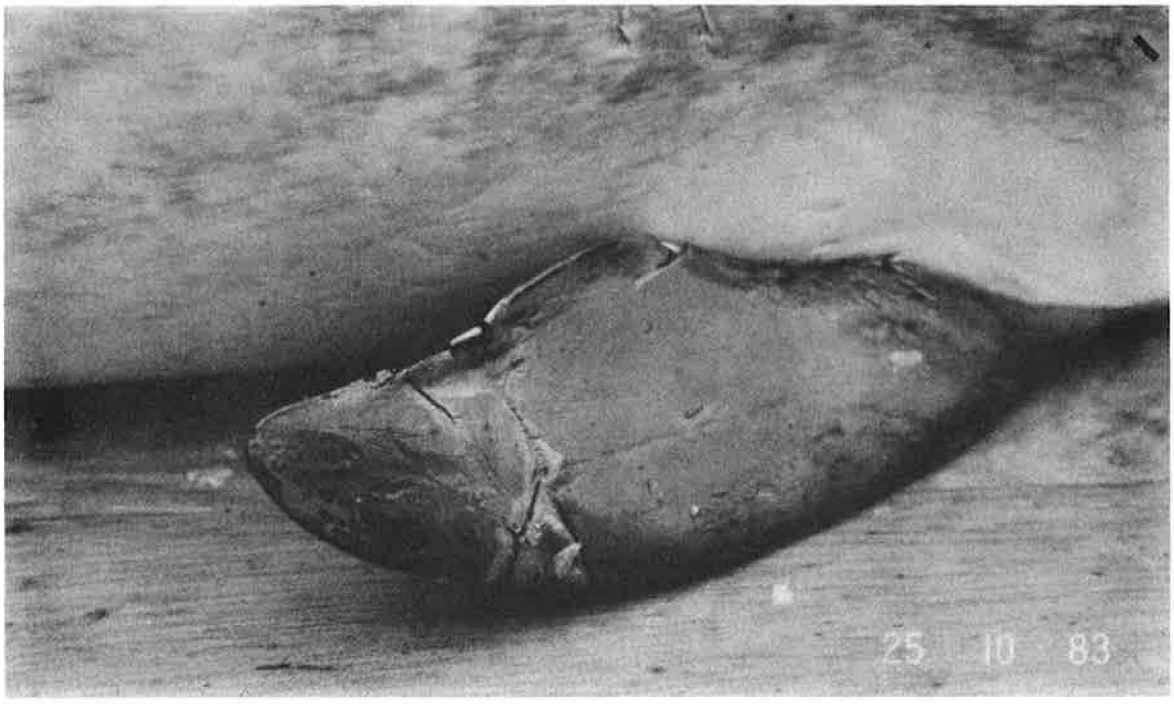

Figure 2. Net marks along the edges and the lateral surface of a harbor porpoise flipper. The impression of the net twine can be seen on the lateral surface of the flipper. (photo by Kate Wynne, University of Maine, Orono, Marine Mammal Project).

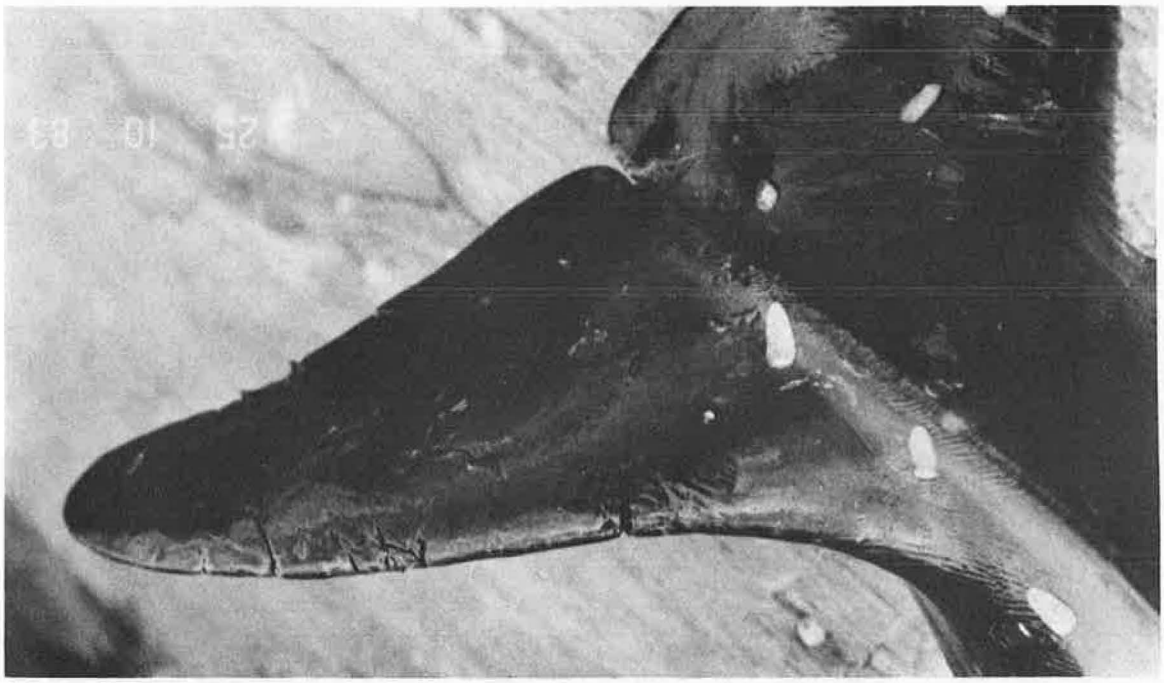

Figure 3. Net marks along the edges of the flukes of a harbor porpoise. (photo by Kate Wynne, University of Maine, Orono, Marine Mammal Project).

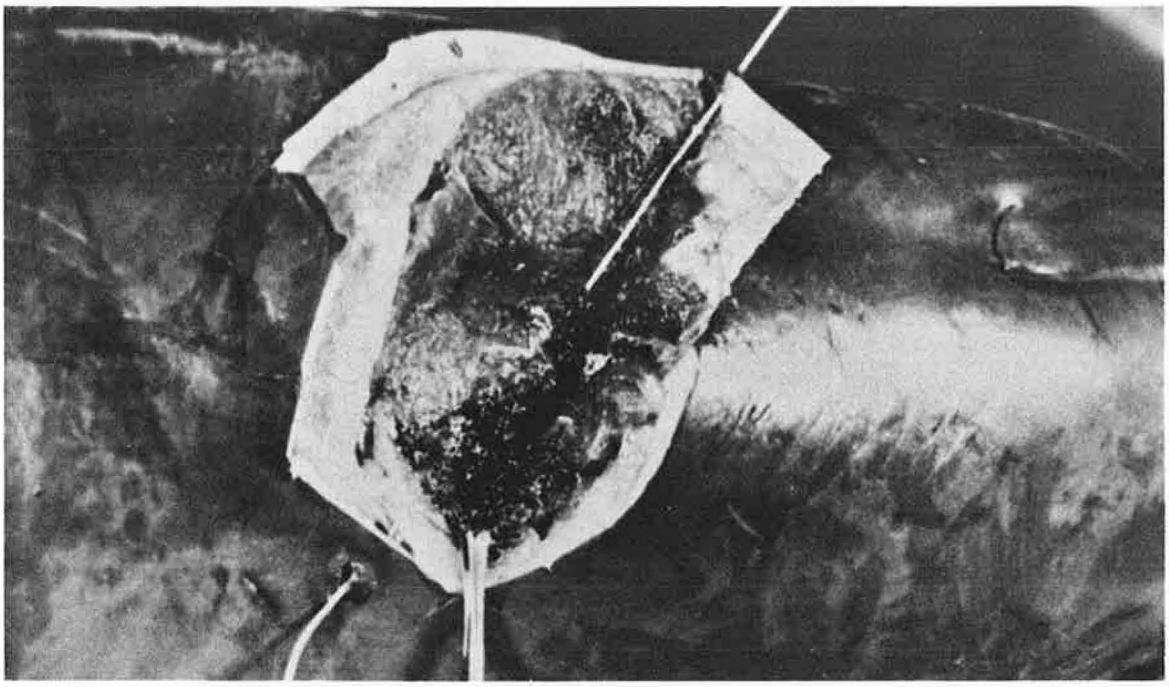

Figure 4. Dorsolateral view of the neck of a bottlenose dolphin (the blowhole is to the left) showing a dissection of the track of a projectile (the white probe follows the track). (photo by Raymond Tarpley, specimen number C11).

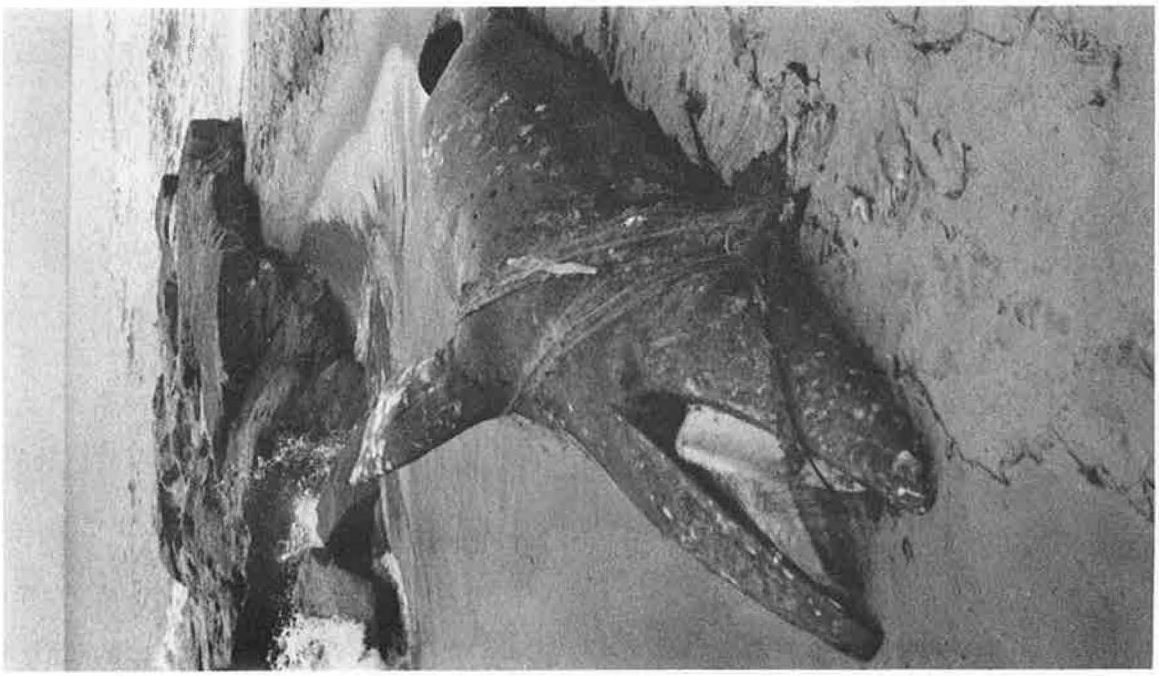

Figure 5. A gray whale carcass entangled in netting. (photo by Pierce Harris, specimen number HJB 012).

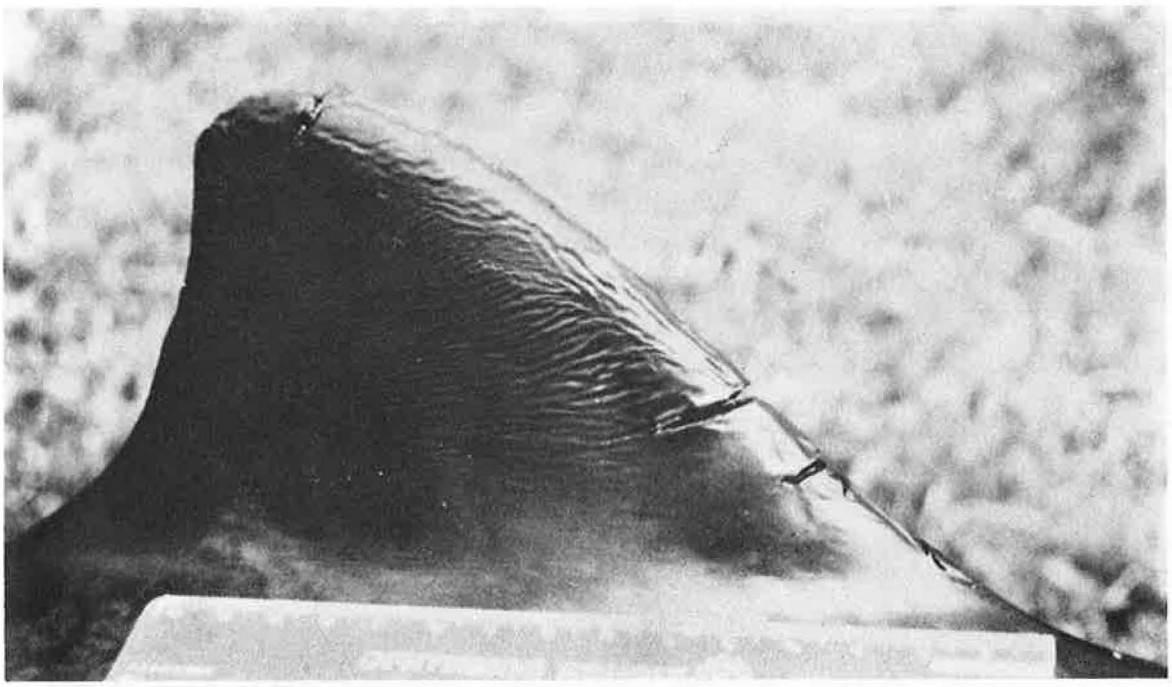

Figure 6. Cuts made by monofilament net in the anterior edge of the dorsal fin of a harbor porpoise. (Smithsonian photo, specimen number USNM 550448).

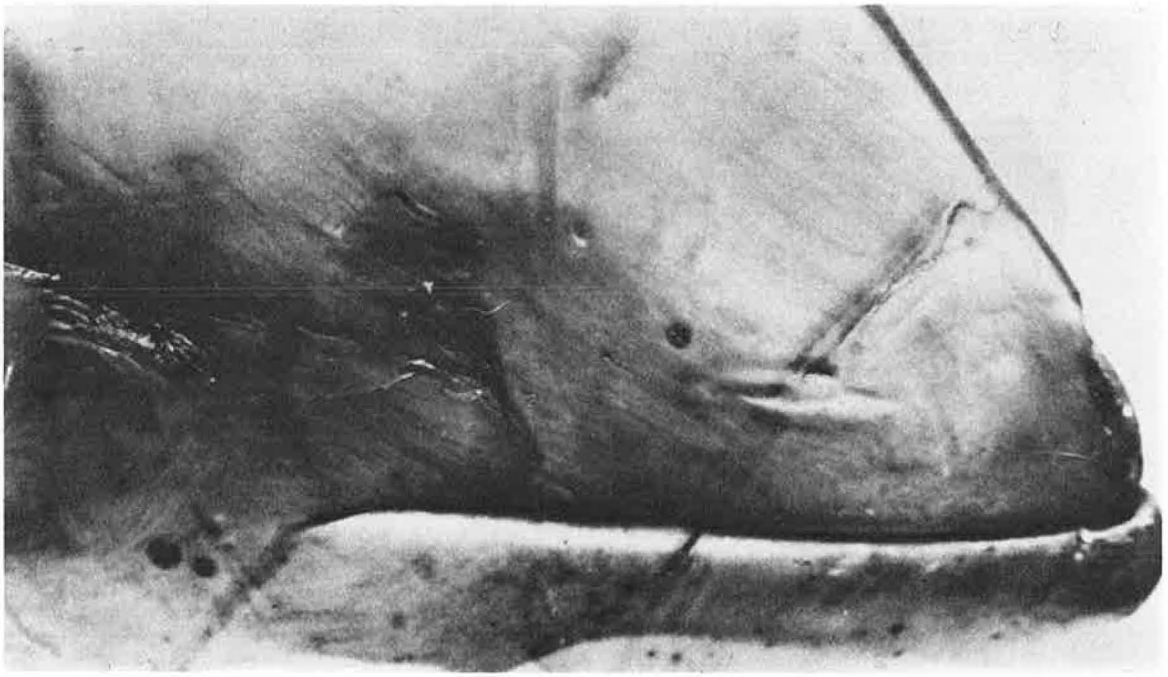

Figure 7. Dark net marks encirling the snout of a harbor porpoise. (Smithsonian photo, specimen number USNM 550448).

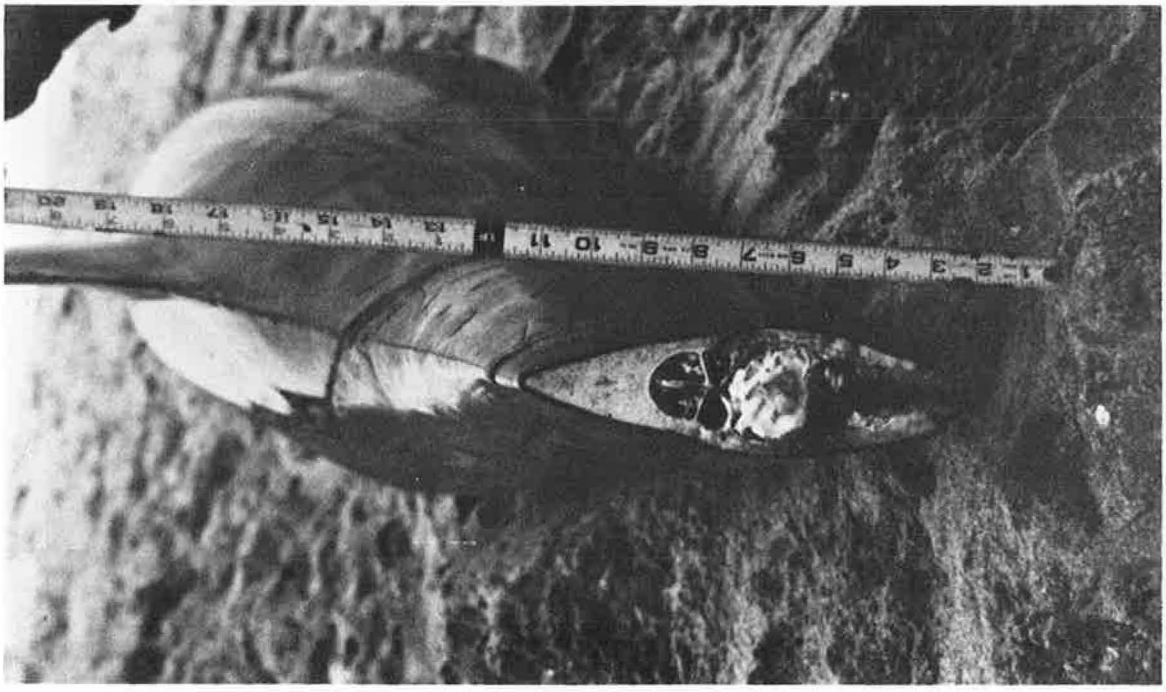

Figure 8. Dolphin carcass with the flukes cleanly cut off. (photo by Dennis Kelly, specimen number DK-85-08).

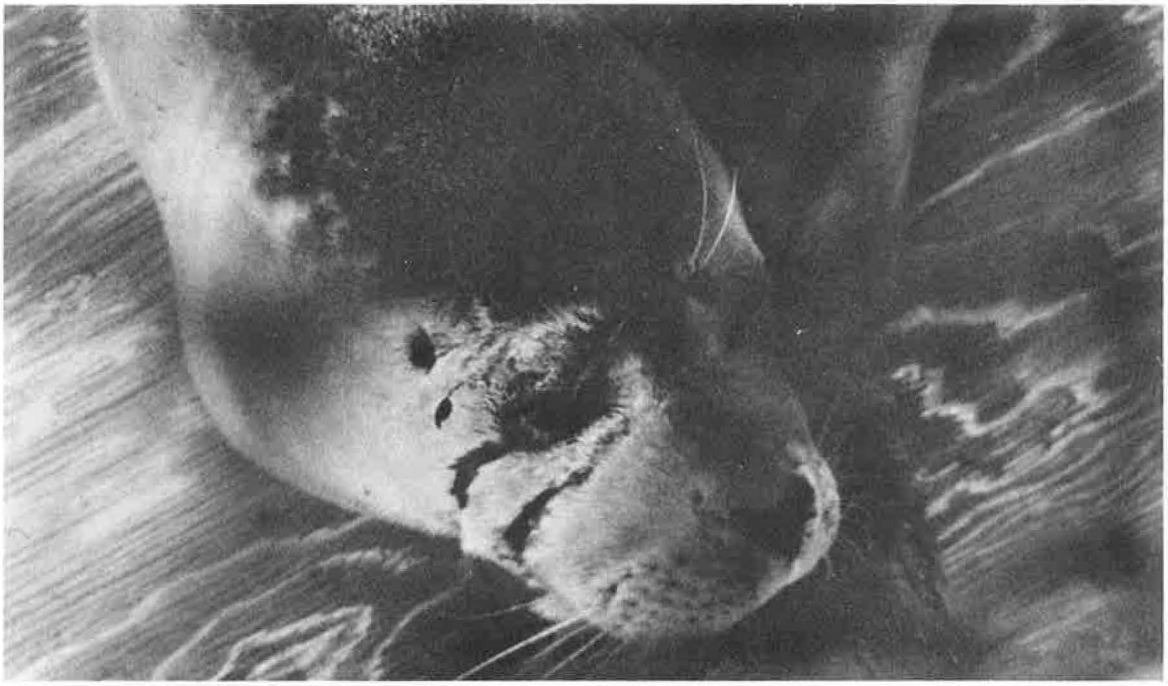

Figure 9. Net marks on the snout of a harbor seal. (photo by New England Aquarium).

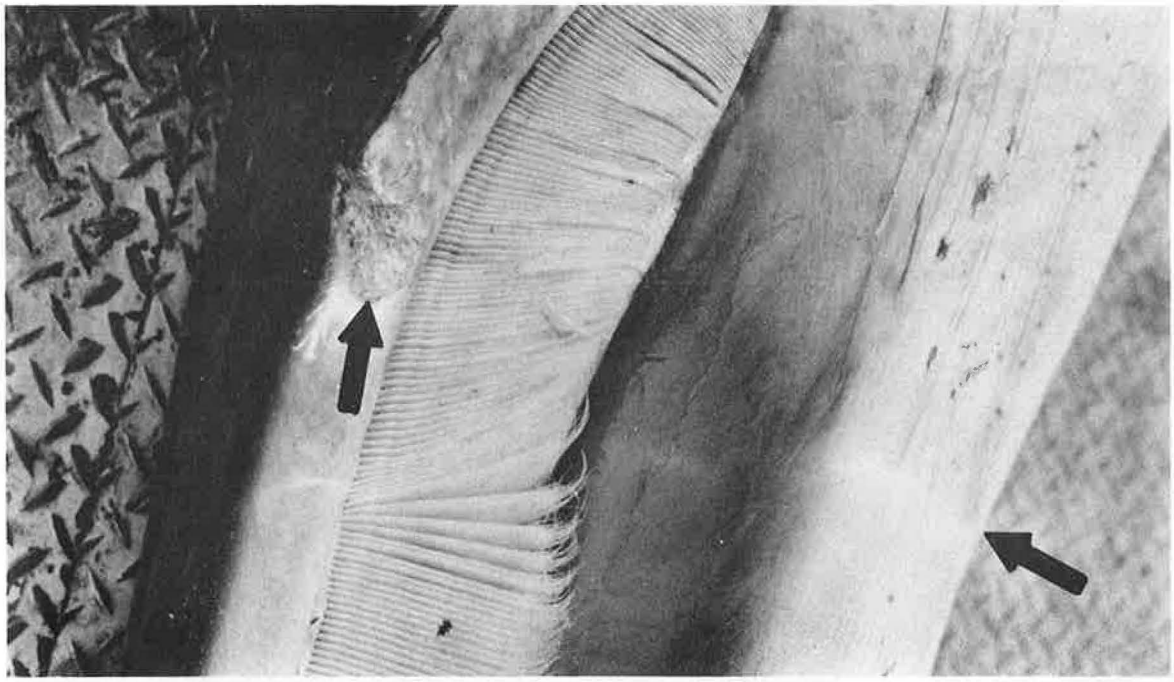

Figure 10. Injury to a minke whale's mouth made by a rope. The upper jaw is to the right showing a small open wound which was produced by the rope. The lower jaw is to the left showing a light mark produced by passage of the rope around the head. (Smithsonian photo, specimen number USNM 504674).

Figure 11. Caudal peduncle of a humpback showing marks left by netting or a rope at the juncture of the peduncle with the flukes. (Smithsonian photo, specimen number USNM 484991).

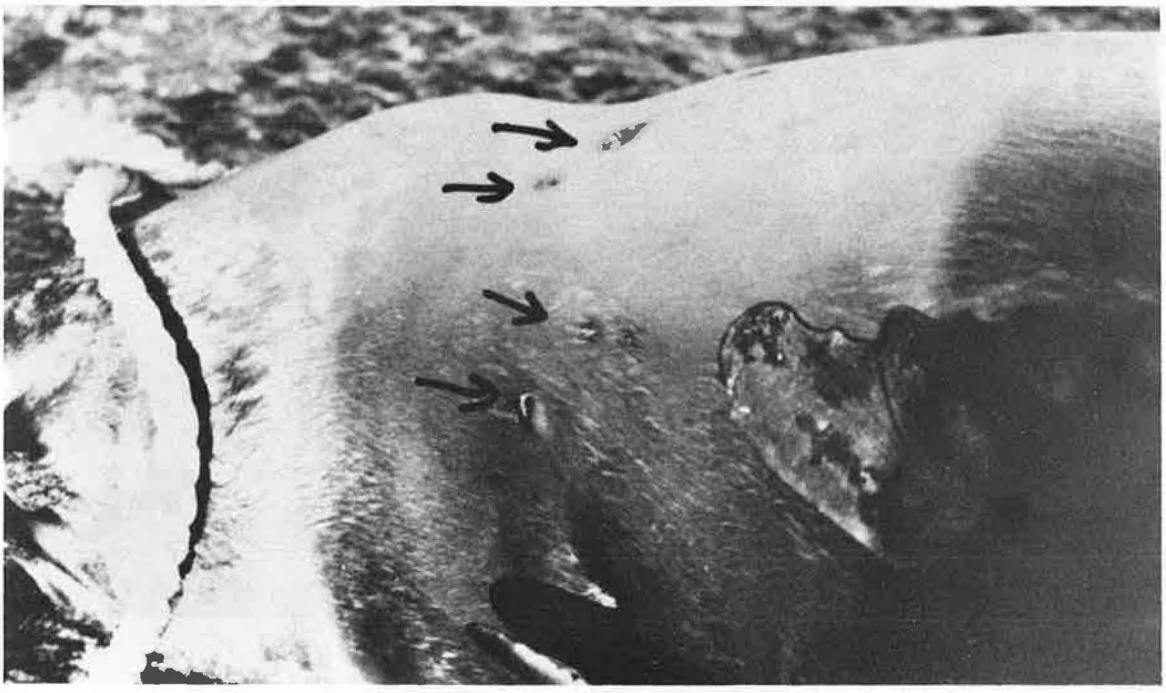

Figure 12. Lateral view of the back of a California sea lion. The arrows point to entry wounds of shot. (photos by Susan Shane, specimen number ZC 008).

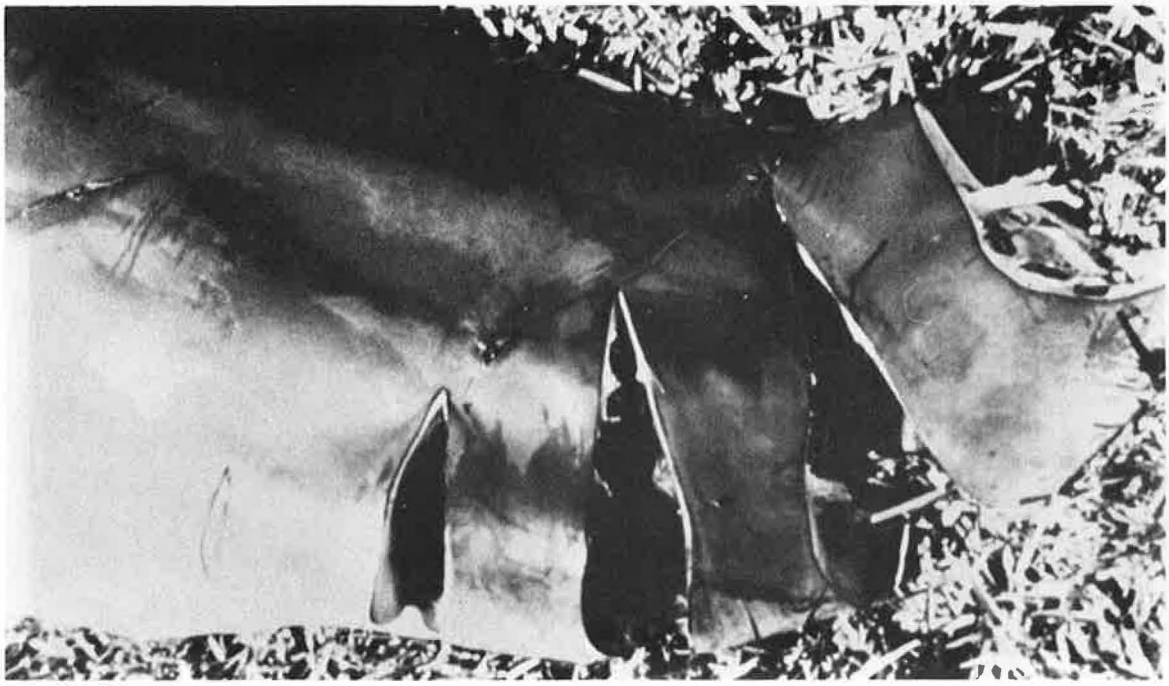

Figure 13. Lateral view of the tail of a bottlenose porpoise showing 5 propellor cuts. The peduncle was severed by one of the cuts and the flukes were lost. (photo by Dennis Kellenberger).

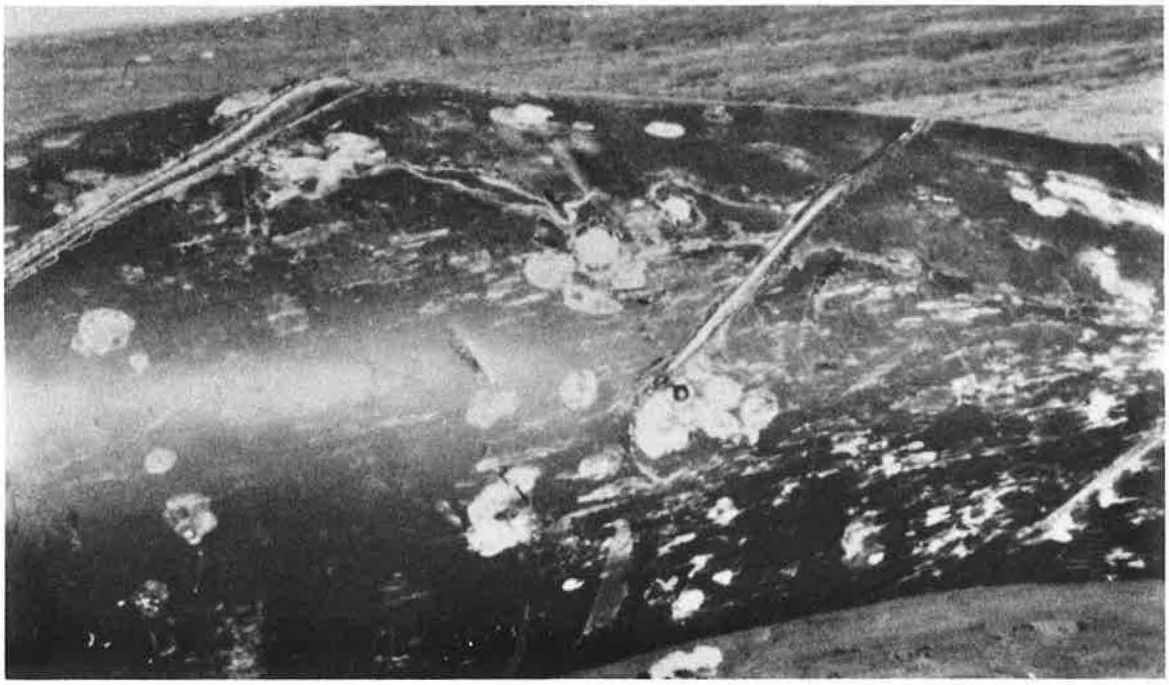

Figure 14. Carcass of the gray whale showing 3 propellor wounds made by a large vessel. (photo by Jacqueline Schonewald, specimen number JS 676).

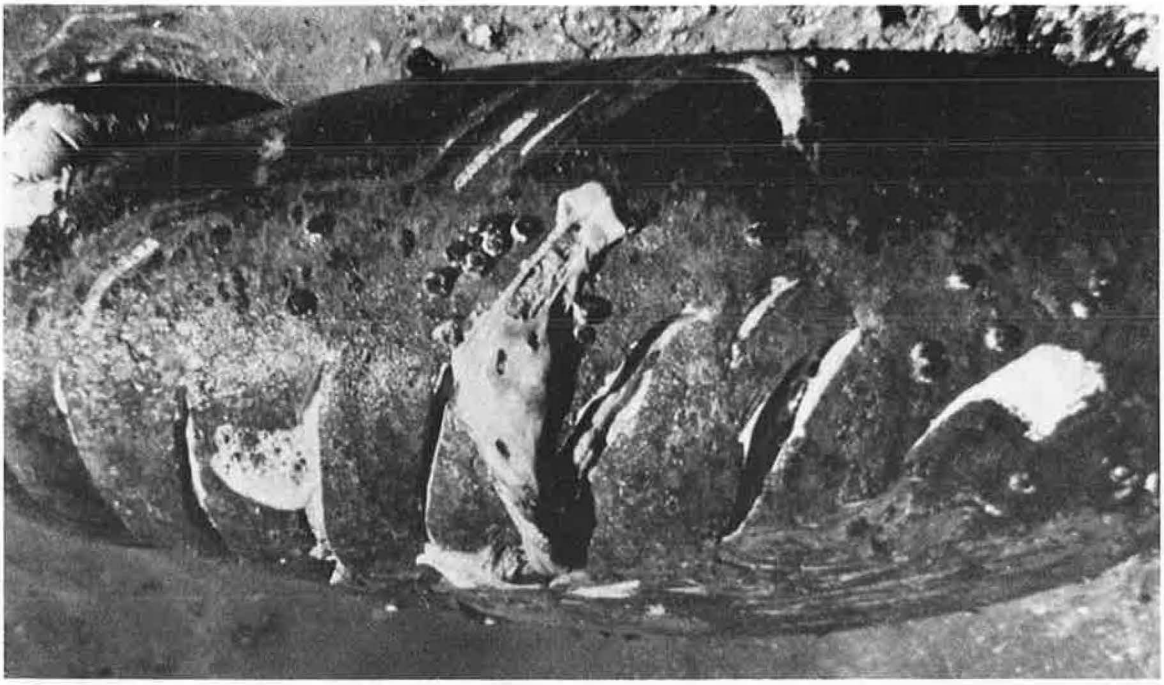

Figure 15. Dorsal view of a manatee (head is to the left) showing eight propellor wounds along the back. Note the slight "S" curve at the ends of the individual wounds. (photo by U. S. Fish and Wildlife Service, Sirenian Project, specimen number CB 114-8).

APPENDIX 1

MARINE MAMMAL EVENTS PROGRAM
DATA SHEET

DATE OF OCCURRENCE_____

DATE OF EXAMINATION_____

COLLECTOR_____ COLLECTOR'S NUMBER_____

GENUS_____ SPECIES_____

TYPE OF OCCURRENCE (Stranding? Sighting? etc.)_____

STATE_____ COUNTY_____ CLOSEST TOWNSHIP_____

SPECIFIC LOCATION_____

_____

LATITUDE/LONGITUDE(IF KNOWN)_____

SEX_____ LENGTH_____ NUMBER OF ANIMALS_____

CONDITION: Alive, Freshly dead, Mod. decomp., Very decomp., Indeterminate

UNUSUAL MARKS, SCARS, LESIONS_____

_____

DISPOSITION (Circle one): Left at site Moved to secure area Buried
Returned to sea Freezer storage Other:_____

MATERIALS COLLECTED_____

_____

PHOTOS TAKEN? YES_____ NO_____

DISPOSITION OF MATERIALS COLLECTED_____

_____

COMMENTS_____

_____

_____

_____

MMEP DATA STANDARDS

Explanations of some of the data categories

DATE OF OCCURRENCE.....Date of death or when first found.

DATE OF EXAMINATION.....When the data is collected.

COLLECTOR.....Name of the person responsible for the data and species I.D., followed by affiliation (e.g.NMFS).

COLLECTOR'S NUMBER.....Assigned by the collector and remains unique to this record.

TYPE OF OCCURRENCE.....This includes single or mass strandings, capture, incidental catch, etc.

SPECIFIC LOCATION.....The most specific description possible using local geographic features or place names.

CONDITION.....Mod. decomposed = organs still intact, only days old.

Very decomposed = organs beyond recognition, carcass still intact, weeks old.

Indeterminate = skeletal remains or mummy, age indeterminant.

COMMENTS.....Any miscellaneous information concerning the event.

APPENDIX 2
SOLUTIONS TO BE USED IN PRESERVING SPECIMENS

FORMALDEHYDE. A ten percent solution of concentrated (38%) formaldehyde is the best fixative to use for marine mammal tissues. It is best to carry the concentrated solution and dilute it to a ten percent solution on the scene. This can be done by mixing one part concentrated formaldehyde solution with nine parts of water. Sea water forms the best dilutant as it has buffering properties which serve to keep the formaldehyde solution from going acid. This is not to imply that fresh water should not be used but rather that fresh water is not the only thing that can be used to dilute formaldehyde. The solution should be kept from freezing because that renders the formaldehyde permanently ineffective as a fixative. Formaldehyde can usually be purchased in small quantities at drug stores. Treat formaldehyde with care as it is a strong poison. Take care not to inhale the toxic fumes emitted by formaldehyde. The term "formalin" is frequently used as a synonym for formaldehyde.

ALCOHOL. Alcohol is not a fixative for mammalian tissue. Any fresh tissue that is put into alcohol will eventually decay. Alcohol is commonly used as a short term preservative for stomach contents, particularly those that are suspected to contain fish otoliths. The gradual acidification of formaldehyde dissolves the otoliths. Otoliths should be separated and stored as air dried specimens.

A
Absence of marks or wounds, 3
Access, 2
ALCOHOL, 33
Audience, **1**

B
Bears, 18
Belly slashing, 12
Bird peck marks, 3
Blue lines, 5, 14
Bow impact, 17
Broken bones, 6
Bruising, **3**, 6
Bullae
  shattered, **16**
Burial, 8

C
Canal locks, 17
COLLECTOR, 32
COLLECTOR'S NUMBER, 32
Condition, 2, 4, 32

D
DATE OF EXAMINATION, 32
DATE OF OCCURRENCE, 32
Debris, 5
Deterioration, 4
Dismemberment, 11
Drowning, 6
Dry dock, 17

E
Entanglement marks, 5
Entrapment, 9
Explosion, 7

F
Fish hooks, 13
Flood gates, 17
Foreign matter, 4
FORMALDEHYDE, 33
Formalin, **33**
Foxes, 18

G
Gaff marks, 11

H
Heat, 4
Heavy metal analysis, **7**
Hemorrhage, 6

I
Ingestion, 15

L
Lead trails, 6
Location, **2**
  specific, **32**

M
Mesh size, 5
MMEP, 9
Military ordinance, 16
Moving the animal, **4**

N
Net marks, 4, 10
Number of animals, 2

O
Occurrence
  type of, **32**
Organization, **1**
Organocholine analysis, **7**
Otoliths, 33

P
Parasites, 3
Photographs, 3, **4**, **5**, **9**
Plastic bags, 15
Plastic packing bands, 14
Projectile track, 6
Propeller slashes, 17

R
Relocating a carcass, 8
Reporting source, 2
Response, 3
  initial, **2**
Rope burn, 13
Rope marks, **12**
Ruptured organs, 6

S
Sex, 2
Sinking of carcasses, **10**
Skeg marks, 17
Specimens
  histopathology, **7**
  residue analysis, **7**
Stomach contents, **7**
Stranding
  definition, **2**

T
Tagging
  released stranded animals, **3**
Total mortality, 10
Trauma
  ante- vs postmortem, **3**

U
Underwater blasting, 16

V
Vessel collision, 7, 8

W
Wounds, 3
  gunshot, **5**, **6**, **15**
  penetrating, **5**
  propellor, **7**, **17**

X
X-ray, 5