7 DETERMINATION OF CAUSES OF DEATH

Careful observations of stranded marine mammals can document evidence of natural mortality, such as disease and predation, as well as human-induced *trauma*, such as entanglement in fishing gear, vessel collisions, gunshot wounds and knife marks. It is important to determine if injuries occurred before or after death (see Section 4.2).

7.1 Disease

Dugongs are susceptible to a wide range of diseases, some of them infectious or parasitic. These include *pneumonia*, pancreatitis and dermatitis. A species of *Cryptosporidium*, a small apicomplexan protozoan inhabiting the respiratory and gastrointestinal tracts of a wide range of vertebrates, was found in the small intestine of a dugong (Hill et al. 1997). Wild dugongs support a range of parasites, including at least 19 species of trematodes and one species of nematode internally, and a barnacle and a copepod externally. Dugongs may also carry a range of other diseases documented in marine mammals such as leptospirosis, lobomycosis, cryptococcosus, blastomycosis, caliciviruses, salmonellosis, morbillivirus, toxoplasmosis, tuberculosis and hepatitis (Bryden et al. 1998, Smith et al. 1978). Elliot et al. (1981) describes a fatal case of salmonellosis. Diagnosis of disease generally requires corroboration by qualified professional pathologists with supporting evidence from histopathology and microbiology. Samples should be sent to pathologists and other specialists for verification.

Instruments, surfaces, clothing etc. should be properly disinfected after the necropsy is completed and the carcass disposed. Care should be taken to avoid cross-contamination of clothing during cleaning (see Section 3.1).

The following is an example of a dugong diagnosed as dying from a bacterial peritonitis infection:

> A subadult male dugong, estimated to be about eight to nine years old and which measured 235 cm in length was reported floating offshore of Cardwell in northern Queensland, Australia. The carcass was in reasonably fresh condition, estimated to have been dead less than 24 hours. The Queensland Parks and Wildlife Service recovered the carcass, which was transported to James Cook University for a *necropsy* by a Queensland Department of Primary Industries veterinarian.
>
> **External examination**
> An examination of the external surfaces of the carcass did not reveal any unusual markings or indications of disease processes, except that bloody fluid was draining from both nares. There was a light to moderate covering of barnacles on the dorsal surface of the animal. There was no evidence of shark bites; both flippers and the tail were intact.
>
> **Internal examination (figure 17)**
> When the carcass was opened for internal examination, a substantial subcutaneous fat layer was present. The abdominal cavity was full of a copious amount of peritoneal fluid that was red/green in colour and of a foul odour. A large amount of *fibrin* was adhered to the viscera, especially to a small section of the small intestine, holding it to the dorsal body wall. Faecal material in the large intestine was hardened indicating the animal may have been dehydrated prior to death.
>
> The stomach was full of seagrass and a few nematodes were present within the cardiac gland. A large amount of blood was present in the pericardial sac and within the pleural cavity. An area of *haemorrhage* was noted at the points of attachment of the spleen to the visceral surface of the stomach.

Tissue samples and swabs of major organs and areas of excess fluid/*haemorrhage* were taken for histology, virology, and bacteriology.

Cause of Death
Severe bacterial peritonitis with haemorrhagic septicaemia, as evidenced from *post-mortem*, histological examination and bacterial isolation. The bacterial peritonitis and haemorrhagic septicaemia were judged to have been caused by a toxin producing bacterium, *Clostridium sporogenes* which is presumed to have entered the abdominal cavity via an intestinal perforation, caused by the penetration of an unidentified helminth parasite, as seen on post mortem and histological examination.

7.2 Predation

There is little information about non-human predation on dugongs. There is evidence of dugongs being preyed upon by killer whales in Shark Bay in Western Australia (Bryden et al. 1998). Specimens bearing large scars, which indicate they have experienced and survived attacks by large sharks, are occasionally sighted. There are two accounts of shark attacks on dugong calves in northern Australia and dugong remains are commonly found in the guts of tiger sharks in Shark Bay (N. Gales, pers comm. 1999). Observers in aircraft have photographed dugongs in the jaws of crocodiles off Cape York Peninsula on at least two occasions; however, it was not known whether the dugongs died before or after the attack (Bryden et al. 1998).

7.3 Dependent Calves

Calves which die at or soon after birth can be distinguished by: (1) the presence of *meconium* in the digestive tract (but no milk or vegetation), (2) an unhealed (a non-involuted) umbilicus, and clotted blood in the umbilical artery and (3) the horny plates in the mouth are unstained by seagrass. Morphological abnormalities or birth defects may contribute to an early death, particularly deformities of the heart. Signs of starvation (see below) or *anorexia* are sometimes encountered in small calves, indicating prolonged separation from mothers.

7.4 Starvation

Carcasses show *emaciation* (dorsal prosis evident), and fat undergoes *serous atrophy*, leaving a clear or jell-like appearance to remaining deposits, which are generally reduced in starving animals. This is most prominent around the ventral surfaces and interventricular groove of the heart. The presence of any clear vesicular gelatinous material adhering to the internal lining of the heart (this is also occasionally visible on the exterior surface) denotes a condition called *cachexia* ('water fat'). This is an indication of severe starvation in dugongs (an internal examination of the heart will also reveal this condition). The gastrointestinal tract may be empty or contain unusual material including algae, dead seagrass rhizomes and anoxic sediment. The gall bladder may be distended with bright yellow bile. Animals in this condition may also have infections. These may include multiple *purulent* abscesses in the dermis, musculature, umbilical vessels, and kidneys.

7.5 Vessel Strikes

Although there are few records of dugong deaths due to vessel strikes in Australian waters, the QPWS have recorded seven dugong carcasses with propeller cuts. Vessel strikes are a major cause of mortality for Florida manatees (Ackerman et al. 1995) and the rise of vessel traffic in the dugong's range is increasing the likelihood of strikes. Areas of particular risk occur where there are extensive shallow areas used by regionally important populations of dugongs that are close to recreational or commercial boating facilities (e.g. Moreton Bay, near Brisbane and Missionary Bay, near Cardwell, Queensland).

Death due to collisions with vessels is often sudden but may also be a result of a chronic long-term debilitation. Fresh, open propeller wounds or skeg marks provide obvious clues (figure 18). Dugongs can be killed by impact alone or by being crushed between the hull and the substrate leaving no propeller marks. External features that can sometimes provide clues to this type of incident include extensive scrape marks and asymmetry or twists along the main axis of the body. Superficial muscle layers, particularly on the top of the head and the back, may show signs of massive *trauma* such as bruising and/or *haemorrhage*. These usually are in well-demarcated blood-tinged patterns that can be distinguished from autolysis in all but the most badly decomposed carcasses. Broken bones, particularly recent *fracture*s of ribs or shattered scapulae, may also be observed. Broken vertebrae in dugongs caused by boat strikes have been reported in Shark Bay (N. Gales, pers comm. 1999). Massive *trauma* to internal organs may also be seen and large amounts of coagulated blood are sometimes found in the body cavities if major blood vessels are ruptured. Broken bones may perforate lungs or major blood vessels, the heart may *rupture*, and the kidneys may appear paler, softer, and larger than normal with loss of blood. Pulmonary *haemorrhage* may occur, causing the lungs to be heavy and saturated with blood, with an absence of frothy fluid in the bronchi. Correlates of a vessel collision can include *anuria*, *petechial haemorrhage* in mesenteries and blood-tinged fluid in the pericardial sac.

External propeller wounds can be minor and superficial but can be associated with massive internal *trauma* as described above. Severe wounds that penetrate the dermis and enter the flesh causing serious organ damage can occur. The possibility of a propeller cut occurring *post-mortem* can be investigated using several clues. *Post-mortem* propeller cuts show no signs of *haemorrhage* or bruising to internal organs or musculature. If the wound is cut through with a knife and examined in cross-section and shows reddening around the edges, *fibrin* and *pus* infiltration, or scar tissue, it was inflicted *ante-mortem*. The location of the propeller wound also provides a clue. Dead dugongs always float with the ventral aspect exposed, and *ante-mortem* wounds on this aspect are rare. Wounds responsible for death are usually located on the dorsal aspects. Floating dead dugongs are probably also more easily seen and avoided by boat pilots than live animals. *Post-mortem* propeller cuts have very rarely been encountered in Florida manatees (Bonde et al. 1983).

Chronic debilitation due to a boat-induced injury usually involves infection. Even a minor, externally healed propeller wound may be associated with large *purulent* internal abscesses, septicaemia, organ adhesions, or other signs of infection. Chronic *osteolytic* lesions from broken ribs can also lead to massive internal infections and subsequent death.

7.6 Incidental Catch

Accidental entanglement in mesh nets set by fishers is an identified source of dugong mortality (Heinsohn et al. 1976). Shark nets set for bather protection also entangle and kill dugongs. Being able to diagnose incidental catch in stranded dugongs is important because it may provide an indication of a problem in a certain area. Specific marks on dugongs resulting from interactions with fishing gear have not been well documented. The presence of numerous scars, scratches and parallel markings (figure 19) on the skin of the back and sides of the body are characteristic of dugongs because they rub their backs against various types of substrate. Similarly, parallel scars seen on many adults are believed to be tusk wounds resulting from interactions in mating herds. Parallel scarring may also be seen on orphaned infants that have approached adult males. Such marks are not (necessarily) indicative of entanglement. Furthermore, if a dugong carcass is left to decay in the sun, the skin will crack in a mosaic type pattern that may resemble net entanglement marks.

On cetacean carcasses, marks caused by monofilament nets, can be small thin cuts 1–2 cm into the epidermis (Hare and Mead 1987). Netting may also leave impressions instead of, or in

addition to, cuts, particularly around the neck or snout. These can sometimes be seen in relatively decomposed carcasses. Read and Murray (1998) describe various types of netting marks on small cetaceans as a result of entanglement in fishing gear, which may assist examiners in identifying similar patterns in dugongs. As evidence of entanglement of small cetaceans, Read and Murray (1998) 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. As a result, in undertaking an external examination, these areas should be closely inspected for net marks. An example of a dugong carcass with markings considered indicative of net entanglement is shown in figure 20.

Net marks may be obvious and extensive if the animal thrashes in the net or becomes more entangled during a release operation. Alternatively, net marks may be quite subtle and limited. There is some evidence that dugongs may be prone to capture stress syndrome. Elevated levels of serum potassium (a physiological manifestation of capture stress) were found in dugongs that had been chased and harpooned by indigenous hunters (Marsh and Anderson 1983). Furthermore, dugongs suffocate rather than drown by taking in water (B. Hill and R. Kelly pers comm. 1999). As a result, dugongs that become entangled may die quickly, without struggling extensively and may not exhibit any external markings indicative of entanglement. For example, in April 1998 at Port Douglas, Queensland, Australia, a dugong was entangled in a commercial gill net whilst in attendance by the fisherman. The dugong was released from the net by the fisherman and towed ashore but subsequently died as a result of the entanglement. A *necropsy* undertaken by QPWS staff identified no external markings indicative of the net entanglement.

An incidental catch diagnosis may be dependent on the collection of detailed circumstantial evidence at the stranding site and the absence of any other signs found during *necropsy* that indicate an alternative cause of death (e.g. disease, boat strike).

The following is an example of a dugong carcass that was diagnosed as having died from entanglement:

> An adult male dugong, estimated to have been dead for 2-3 days and which measured 260 cm in length, was reported floating offshore of Midge Point in northern Queensland, Australia. The Queensland Parks and Wildlife Service recovered the carcass, which was transported to a veterinary clinic for *necropsy* by a qualified veterinarian.
>
> **External examination (figure 20)**
> The carcass was severely bloated, the penis having been extruded from the prepuce from the internal pressure (bloat).
>
> Three or four bruise lines, 2 mm wide and 150 mm-200 mm long, were noted on the ventral surface of the neck. Deep bruising was observed around the base of the pectoral fins, especially on their ventral surface. Early lifting of the skin over the bruise lines on the neck was occurring. Mild emphysema (gas development) with bruised deep tissues of pectorals was noted.
>
> Mild deep bruises of the musculature at the base of the pectoral fins were noted. Possible bruising of the tail – patches of blood stained/bruised tissue near the centre of tail were collected for histology.
>
> **Internal examination**
> Severe autolysis of the liver, of the right side of heart and of the kidneys had occurred. The liver and kidney had liquefied and darkened; however, the testis had liquefied but not darkened. The stomach was full of seagrass and a few nematode worms were present. The lungs had a moderate gross emphysema (small gas filled pockets).

Samples were taken for histopathology. There were no signs of disease or infection within the animal.

Cause of Death
The bruising around the neck and pectorals is consistent with entanglement with some type of rope. The air embolisms on the tissue surface of the right lung are consistent with suffocation/drowning.

Given these findings, and the lack of any other obvious causes of death, this animal is judged to have died as a result of entanglement (i.e. suffocation). The excessive degenerative change of the liver, kidney and heart may be the result of a struggle at the time of death, raising the animal's internal body temperature while depleting the intracellular energy reserves.

7.7 Other Human-related Causes

Gunshot wounds leave small entry holes on the external surface, which must be searched for carefully during *necropsy*. Buckshot or other foreign objects resulting from non-lethal vandalism may be encountered while removing skin or flesh, for example, in the snout region. Radiography of suspect areas will help locate foreign objects. If bullets are found, they should be saved for law enforcement personnel.

Dugongs that have been killed for meat usually have large pieces of flesh missing from the carcass, often from the abdomen.

There is little information available on contaminant levels in dugong and any subsequent effects of pollutants such as potential reproductive failure and reduced immune system capability. Concentrations of polychlorinated dibenzo-*p*-dioxins in the tissues of three dugongs from the Great Barrier Reef were higher than reported for other marine mammals (Haynes et al. 1999) but the significance of this to dugong ecology and physiology is unknown.

Underwater explosions are difficult to diagnose from a cause-of-death standpoint because the *trauma* inflicted could merely be enough to cause the animal to lose consciousness. However, more severe injuries may include massive trauma and internal injury.

7.8 Undetermined

Cases can be classified as undetermined if no cause of death is apparent following *necropsy* and subsequent histopathology.