

The following supplement accompanies the article

Lethal entanglement in baleen whales

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Supplement. Detailed case histories for all 21 stranded baleen whale carcasses examined in the present study

Case 1: CCSN 99-127/MH 99-638-Ba (*Balaenoptera acutorostrata*). Fig. S1.

This juvenile minke whale showed evidence of a recent rope entanglement when it stranded dead in Orleans, Massachusetts, USA on June 16, 1999. Rope, originating in the left mouth, traveled dorsally along the body, passing around the right base of the dorsal fin, and then finally wrapped several times around the caudal peduncle.

Damage from the rope included a large, focal region of necrotic soft tissue inside the left mouth, a 2 x 2 cm cut on the dorsal fluke base, and marked hemorrhage and bruising along the line marks. The exact cause of death could not be determined due to the advanced state of decomposition. However, based on the extent of the rope wounds, entanglement most likely played a major role.



Fig. S1 – Case 1: minke whale entanglement. a. Left side. Linear laceration from left angle of mouth around dorsal fin and then running cranially to the right of the dorsal fin. b. View of head, tongue and body. c. Line marks at exit from left gape of mouth. d. Right aspect of dorsal fin with line mark at base. e. Detail of laceration at base of right aspect of dorsal fin. f. Laceration on base of dorsal flukes.

Case 2: CCSN 03-147-Ba (*Balaenoptera acutorostrata*). Fig. S2.

This juvenile minke whale stranded on August 10, 2003 in Chatham, Massachusetts, USA. Based on impressions in the epithelia, the majority of its head and mouth had been wrapped in a large amount of 4 mm strand-width multifilament netting. Additional netting may also have been attached to the fluke base.

The surface of the mandible, ventral oral cavity, and distal rostrum were diffusely abraded from the gear. Abrasions were accompanied by extensive subdermal hemorrhage, typical of pre-mortem entanglement injury. Deeper and wider abrasions were found on the leading edges of both flukes. Damage was most severe in a portion of the upper jaw, where the bone had separated completely from surrounding flesh. It was unclear whether this damage to the jaw was an entanglement-related injury. However, it seems likely since there was no evidence of blunt trauma.

Histopathology was impeded by advanced organ autolysis. However a large cyst was found in the left renal pelvis that was either a product of autolysis or marked hydronephrosis (presumptively parasite-associated). Factors involved in the death of this case, may have included impaired locomotion and foraging secondary to entanglement.

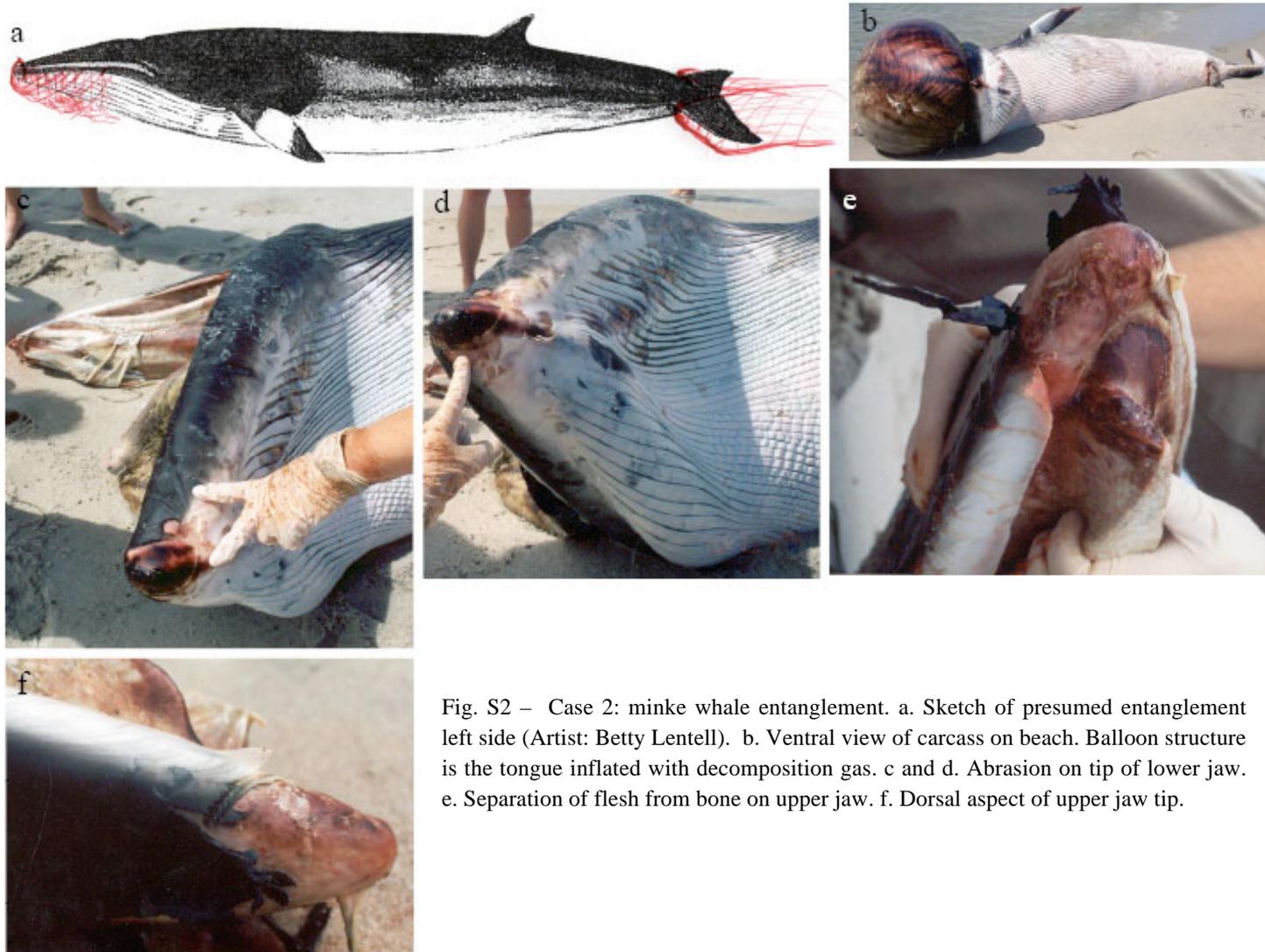


Fig. S2 – Case 2: minke whale entanglement. a. Sketch of presumed entanglement left side (Artist: Betty Lentell). b. Ventral view of carcass on beach. Balloon structure is the tongue inflated with decomposition gas. c and d. Abrasion on tip of lower jaw. e. Separation of flesh from bone on upper jaw. f. Dorsal aspect of upper jaw tip.

Case 3: CCSN 04-175-Ba (*Balaenoptera acutorostrata*). Fig. S3.

Stranding of this adult female minke whale occurred on July 19, 2004 in Eastham, Massachusetts, USA. Based on line marks on the carcass, rope had encircled the trunk 2-3 times just caudal to the flippers. Although the exact nature of the entanglement was unknown, line had been attached to the mouth, dorsal fin, caudal peduncle, and flukes.

This whale had extensive gross evidence of entanglement in rope. The most prominent wound was a deep notch, penetrating 1.9 cm into the blubber layer of the ventral peduncle at the base of the flukes. There were associated abrasions on the leading edges of both flukes that continued along the dorsal and ventral aspects. A subtle rope mark was found at the gape of the mouth, and an obvious rope mark was observed at the anterior insertion of the dorsal fin, trailing caudally. There was evidence of shark damage on the dorsal peduncle and blood tinged fluid from the blowhole. Although an internal examination was not conducted, the evidence suggests that entanglement played a major role in the animal's demise.

Case 4: CCSN 07-194-Ba (*Balaenoptera acutorostrata*). Fig. S4.

When this juvenile female minke whale was found floating near Cornhill Beach, Massachusetts, USA on August 5, 2007, it had one line wrapped around the circumference of its trunk at the level of the cranial flipper insertions. The gear had created a gaping laceration around 2/3 the girth of this animal's trunk, exposing the underlying blubber, which was necrotic and heavily blood-stained (Fig. 3). The laceration extended from ventral midline to right of dorsal midline, passing just in front of the left flipper. It became wider and deeper moving dorsally, reaching a maximum width of 7.3 cm and a maximum depth of 4 cm. In addition, the animal had extensive line lacerations on the flippers and left fluke. Several abnormalities of the internal organs were detected: severe congestion of the lung parenchyma; 2 large caseous nodules within the right lung; and regional necrosis of the ventral liver.

On microscopic examination, there was marked bacterial overgrowth within the gear lacerations with associated necrosis of underlying skeletal muscle. Additional findings included necrosuppurative bronchopneumonia, bacterial emboli in the brain, and atrophy of the liver and blubber. Death, in this case, was due to septicemia, stemming either from the pneumonia or from severe bacterial infection of entanglement wounds.

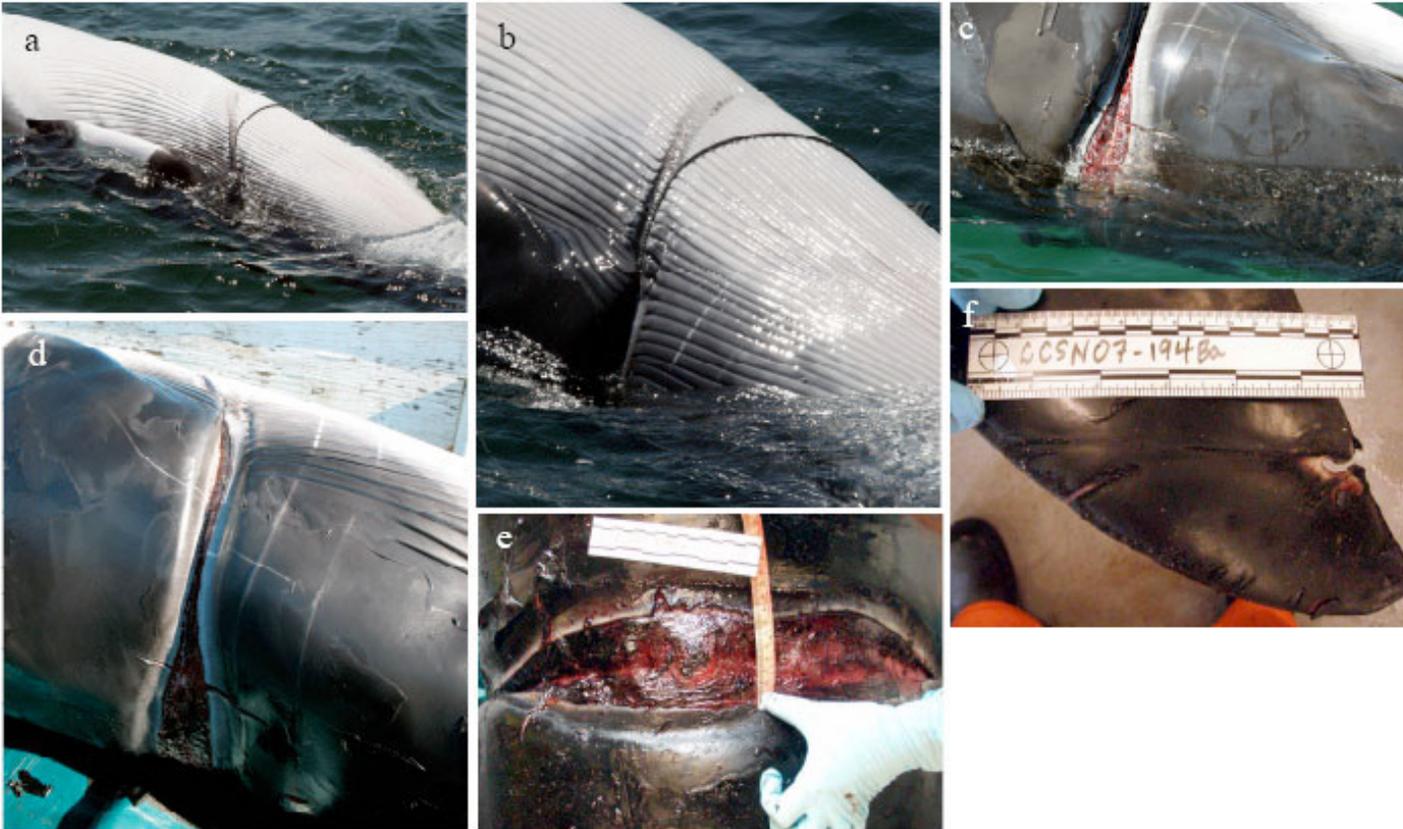


Fig. S4 – Case 4: minke whale entanglement. a. Ventral view of carcass with encircling lines over ventral pleats. b. Closer view of line laceration at cranial insertion of left flipper. c and d. Granulation tissue at the base of a wedge shaped laceration in the dorsal aspect. e. Detail of dorsal aspect of laceration. f. Lacerations on tip of left fluke.

Case 5: CCSN 08-125-Ba (*Balaenoptera acutorostrata*). Fig. S5.

This juvenile female minke whale stranded on June 14, 2008 in Orleans, Massachusetts, USA with numerous impressions and abrasions indicating that it had been entangled in fishing line. Heavy, post-mortem scavenger damage obscured some of the line marks, particularly on the dorsal trunk. The best interpretation was that a 1 cm line was anchored to the left upper lip. One end wrapped around the rostrum, crossing the blowhole, while the other end entered the oral cavity through the left baleen plates and traveled across the roof of the mouth. The 2 ends of the line then passed ventrally together from the right corner of the mouth and encircled the trunk twice, once at the level of the flippers and once at the level of the umbilicus. Finally, the line wrapped around the ventral caudal peduncle.

Rope lacerations, many of which showed bruising and hemorrhage, were most concentrated on the rostrum and flippers. They were particularly deep along the left upper lip, blowhole, and ventral caudal peduncle. Both lungs were dark maroon, wet, and congested, and the thoracic cavity was filled with 2 L of blood. Given the robust body condition, death was acute and likely the result of entanglement-associated drowning based on the thoracopulmonary findings.



Fig. S5 – Case 5: minke whale entanglement. a. Dorsal view of heavily scavenged carcass. Note line marks around peduncle (arrow). b. Line mark encircling the abdomen at the level of the umbilicus (arrow). c and d. Laceration on left upper lip, with line mark crossing blowholes (arrow). e and f. Ventral aspect of peduncle showing line laceration in ventral keel (arrow). g. Right gape of mouth, with baleen on right and tongue at center, showing lacerations in gape of mouth (arrow). h. Incision into lung. showing dark, congested, wet lung.

Case 6: WAM 587 (*Balaenoptera brydei*). Fig. S6.

This adult male Bryde's whale was potentially alive when it stranded on March 13, 2003 in Carolina Beach, North Carolina, USA, with a major entanglement of the mouth. Black, 1.2 cm polypropylene line under great tension, ran from right to left corners of the mouth, where it had embedded in soft tissue. The line then crossed the oral cavity again, this time embedding in the roof of the mouth, penetrating the midline bones of the rostrum (Fig. 2). The remainder of the line, which had become tangled into a bulky knot, trailed from the left side of the mouth, along the animal's back.

The major gross findings were severe rope lacerations that extended several centimeters into blubber at the left angle of the mouth and into bone in the medial roof of the mouth. It was evident that these wounds were markedly chronic, as bone had completely remodeled around the rope, and scar tissue had formed superficially. Skin along a 20-30 cm long region of the cranial back had been abraded by the trailing line. The outline of the ribs and scapulae were clearly visible due to the animal's severely emaciated state.

In addition, there was histological evidence that the animal's health had deteriorated. Findings included arteriolar medial hypertrophy (hypertension), myocardial fibrosis, mild membranous glomerulopathy, and gastric ulceration. It was concluded that this animal died from debilitation and impaired foraging leading to starvation due to chronic entanglement.



Fig. S6 – Case 6: Bryde’s whale entanglement. a. Dorsal view of severely emaciated carcass. Note tow strap added around peduncle. b. Line mark scar in upper right jaw (arrow) and knot of line hanging over right lip. c and d. Embedded line in upper jaw. e . View of roof of mouth looking cranially, with line embedded in the middle of the rostrum.

Case 7: Eg 2366/MCZ 62052 (*Eubalaena glacialis*) (Moore et al. 2004). Fig. S7.

This 2.5 yr-old male North Atlantic right whale was entangled in floating groundline from lobster gear for at least 10 mo (first sighting: August 28, 1994) before it stranded on July 17, 1995 in Middletown, Rhode Island, USA. Six to eight lines encircled the proximal right flipper, embedding in the radius. One line was entangled in the mouth, passing from the base of the tongue to the right corner. This whale also had a scar from previous entanglement that travelled from the right corner of the mouth along the ventrum.

Grossly, there was marked deformity of the right radius, where the rope had cut deeply into the flipper. A large bone defect on the leading edge was 4.4 cm wide and 7.6 cm deep and had large areas of bone proliferation on its exterior margins from chronic mechanical irritation. Although food was absent from stomach and small intestine, the large intestine had large quantities of feces, indicating that the whale had recently stopped feeding. Given the severe nature of the flipper wound and the involvement of the mouth in this entanglement, it is likely that swimming and feeding were impaired, leading to the animal's demise.



Fig. S7 – Case 7: North Atlantic right whale entanglement. a and b. Multiple wraps of rope around the right flipper. c. Right flipper after rope removed. d. Notch in right radius after soft tissue cleaned away. Massive periosteal new bone fell away during the cleaning process, leaving only a small amount adherent to the underlying regular bone.

Case 8: Eg 2030/CCSN 99-143 (*Eubalaena glacialis*) (Moore et al. 2004). Fig. S8.

This 10 yr-old female North Atlantic right whale became entangled in gillnet gear, comprised of anchor and buoy lines, bridle, and 15.2 m of net. Lines under marked tension, were wrapped around each flipper insertion (1 time around the right; 4-5 times around the left) and extended across the dorsum and ventrum from flipper to flipper. All of the lines snapped audibly when cut from the carcass. During a 4 month period between sightings of the entangled whale (May 10-September 13, 1999), the dorsal line gradually incised down to the skeletal muscle on the back and then moved caudally, flensing a large section of blubber. Despite numerous disentanglement attempts throughout this period, only 2 of the left flipper wraps were removed.

On gross examination, it was found that the dorsal trunk laceration, where the blubber had been stripped by the gear, reached a maximum width of 1.4 m mid-dorsally and then tapered to its narrowest width at each flipper insertion (Fig. 4). Both scapulae were exposed by the wound, and there was diffuse periosteal proliferation on the right, medial scapula. Both flippers had sustained deep cuts at their leading edges, down to the bone (left cut, 12.7 cm deep; right cut, 17.8 cm deep). Radiographs of one of the flippers showed that the carpal bones were irregularly marginated, particularly the largest carpal bone, which had moderately smooth bone spurs emanating from its surface. These boney changes are indicative of chronic alteration in biomechanical forces, chronic degeneration, or low grade osteomyelitis due to entanglement. In addition, the animal appeared slightly emaciated, had an empty stomach, and was covered with cyamids over its entire body surface. Death in this case was attributed to massive traumatic injury and starvation due to chronic entanglement.



Fig. S8 – Case 8: North Atlantic right whale entanglement. a. Left lateral view. Blubber has been stripped off by taught ropes that ran from each axilla over the back. b and c. Multiple wraps of rope around the right axilla. d. X radiograph of carpal bone showing irregular margination and bony spurs. e. Periosteal proliferation on the surface of the right humerus.

Case 9: Eg 1238 (*Eubalaena glacialis*). Fig. S9.

This male North Atlantic right whale was at least 19 yr old when it stranded near the Magdalen Islands, Quebec, Canada on October 29, 2001, entangled in over 200 m of 3-strand, 2.2 cm, lead filament rope. Nearly all of its body parts were affected by the entanglement. One line, anchored to the right corner of the mouth, crossed the tongue and exited the mouth through the left baleen plates. It then passed ventrally from the right to left flipper, which it wrapped 3 times. The rope finally crossed the body again dorsally and wrapped around the left flipper again. A second line, which was also anchored in the right mouth, exited the oral cavity without any further attachments. Finally, a third line encircled the caudal peduncle at least 3 times and trailed along the ventral flukes. The most likely scenario is that the whale became entangled in line while feeding.

Major gear-induced wounds included a long laceration, continuous from the right corner of the mouth to the left flipper, a number of cuts and abrasions around the right flipper insertion, and a deep encircling wound around the fluke base. Wound depth indicated that these lacerations had occurred pre-mortem as a result of the rope sliding across the skin as the animal flexed and extended its body. Although cause of death could not be conclusively determined, asphyxiation due to drowning was suspected in this case because of the involvement of all appendages as well as the mouth.



Fig. S9 – Case 9: North Atlantic right whale entanglement. a. Sketch of entanglement (Scott Landry). B. Ventral aspect with rope draped over chest. c and e. Line hanging from mouth. Rope ends broken not cut. d. Rope at front of mouth and around both axillae. f. Rope and rope impressions around left axilla.

Case 10: Eg 3107/MH 02-726 (*Eubalaena glacialis*)(Moore et al. 2004). Fig. S10.

This 1 yr-old female North Atlantic right whale was first sighted entangled on July 6, 2002 near Brier Island, Nova Scotia, Canada. It had a single line, identified as lobster gear, wrapped around the distal peduncle. The line was deeply embedded in the ventral and lateral aspects of the peduncle and then trailed along the dorsal surface of the flukes. A disentanglement crew was able to remove the gear from the animal in the Bay of Fundy on September 1, 2002, 8 wk after the initial sighting. During a final sighting on October 1, 2002, 11 d prior to stranding, the animal was found to be pale and cachectic.

The major gross finding in this case, was a severe laceration around the peduncle at the site of entanglement. The laceration depth was 15-19 cm laterally and 5 cm ventrally. The whale was also heavily infested with cyamids. In the ventral part of the laceration, the gear had severed a pair of large, superficial arteries (interior diameter = 8 mm). The gear was blocked from further tissue penetration ventrally by thick tendons. Scar tissue had formed in the severed arteries caudal to the wound, completely occluding the vessels.

Sections of the lacerated arteries examined histologically, revealed an absence of inflammatory cells, fibroblasts, or blood vessel infiltration. The lack of recent wound healing, suggests that vessel occlusion was markedly chronic. It was concluded that death was initiated by the deep laceration in the peduncle. Given the large diameter of the transected arteries and their importance for heat exchange, it is likely that the laceration led to impaired thermoregulation and severe hemorrhage.

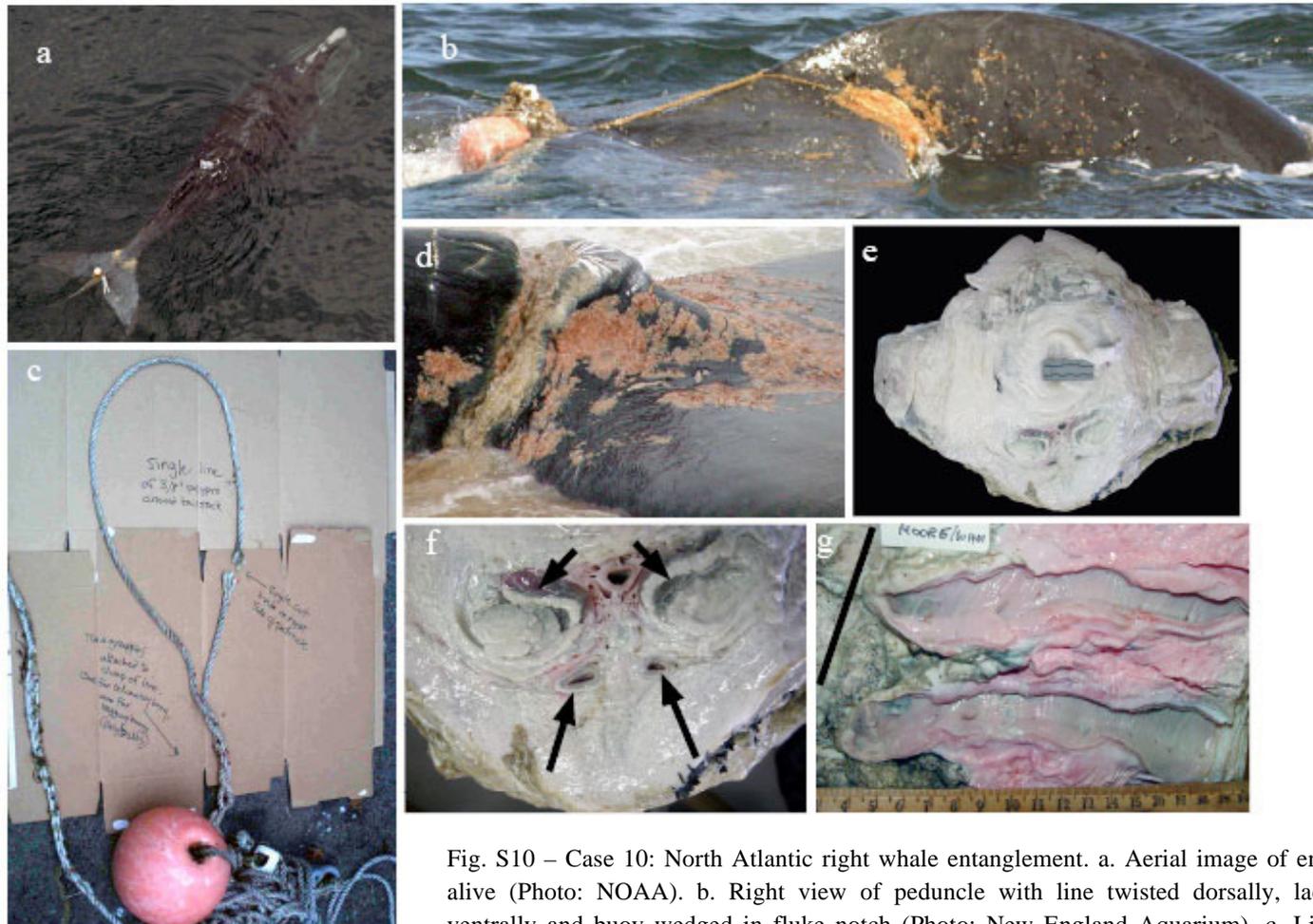


Fig. S10 – Case 10: North Atlantic right whale entanglement. a. Aerial image of entanglement while alive (Photo: NOAA). b. Right view of peduncle with line twisted dorsally, lacerating peduncle ventrally and buoy wedged in fluke notch (Photo: New England Aquarium). c. Line removed from whale at sea (Photo: New England Aquarium). d. Ventral view of peduncle laceration on beach. e. Section of peduncle that contains laceration. f. Close up of (e). Short arrows show ventral tendons, long arrows show thick walled veins draining flukes. g. Coronal section at the level of the veins highlighted in (e). Vein walls are cut to show occlusion at the point where the rope lacerated the veins that were then occluded by scar formation (see black line).

Case 11: Eg 2301/VAQS 2005-1008-Eg (*Eubalaena glacialis*). Fig. S11.

This 12 yr-old female North Atlantic right whale stranded on Wreck Island, Virginia, USA on March 3, 2005. Two tracks of line impressions originating at a point of attachment within the left baleen, exited the oral cavity at the right midline, passed dorsally across the blowhole, and wrapped around the circumference of the left flipper. A knot of frayed rope located at the proximal end of the line, was wedged between the upper lip and baleen plates on the right side, displacing the baleen cranially. Attached gear wrapped around the left baleen plates in a complex tangle, consisting of about 11 m of 1.1 cm sink line and 17 m of 1 cm float line.

This animal suffered grave gear-related injuries to the left flipper and blowhole due to the extreme compressive forces of the line. On the left flipper, in response to multiple constricting lines, large, irregular masses of partially ossified repair tissue formed on the humerus and adjacent long bones. The rope also radically disfigured the blowhole, leaving a 6 cm deep and 42 cm long furrow across the left nares (Fig. 5). In addition, constriction greatly reduced blood flow to the left flipper, as evidenced by the extreme pallor of the distal limb, observed during a sighting 6 mo prior to death.

The major histological findings in this animal were: marked fibrosis and periosteal proliferation at the entanglement site on the left flipper; sequestrum formation in the left humerus; and trabecular osteopenia and muscle atrophy distal to the site of entanglement on the left flipper. The sequestrum, which likely formed due to constriction and pressure necrosis, may have been a site of osteomyelitis. However, the evidence was inconclusive. Together, these findings suggested severe debilitation of the left flipper, resulting in chronic disuse.

According to reported sightings, this animal's health deteriorated very slowly during the entanglement. On September 6, 2004, the whale appeared thin, had poor skin condition, was covered diffusely by cyanids, and had lost much of the color in its left flipper. However, it did not finally succumb to its injuries until 6 mo later. When the emaciated animal stranded, it was without gear but had fresh edges on its entanglement wounds. Therefore, it was concluded that the animal lost its gear shortly before stranding and died acutely due to a rapid release of pressure on the left flipper and subsequent hemorrhage.

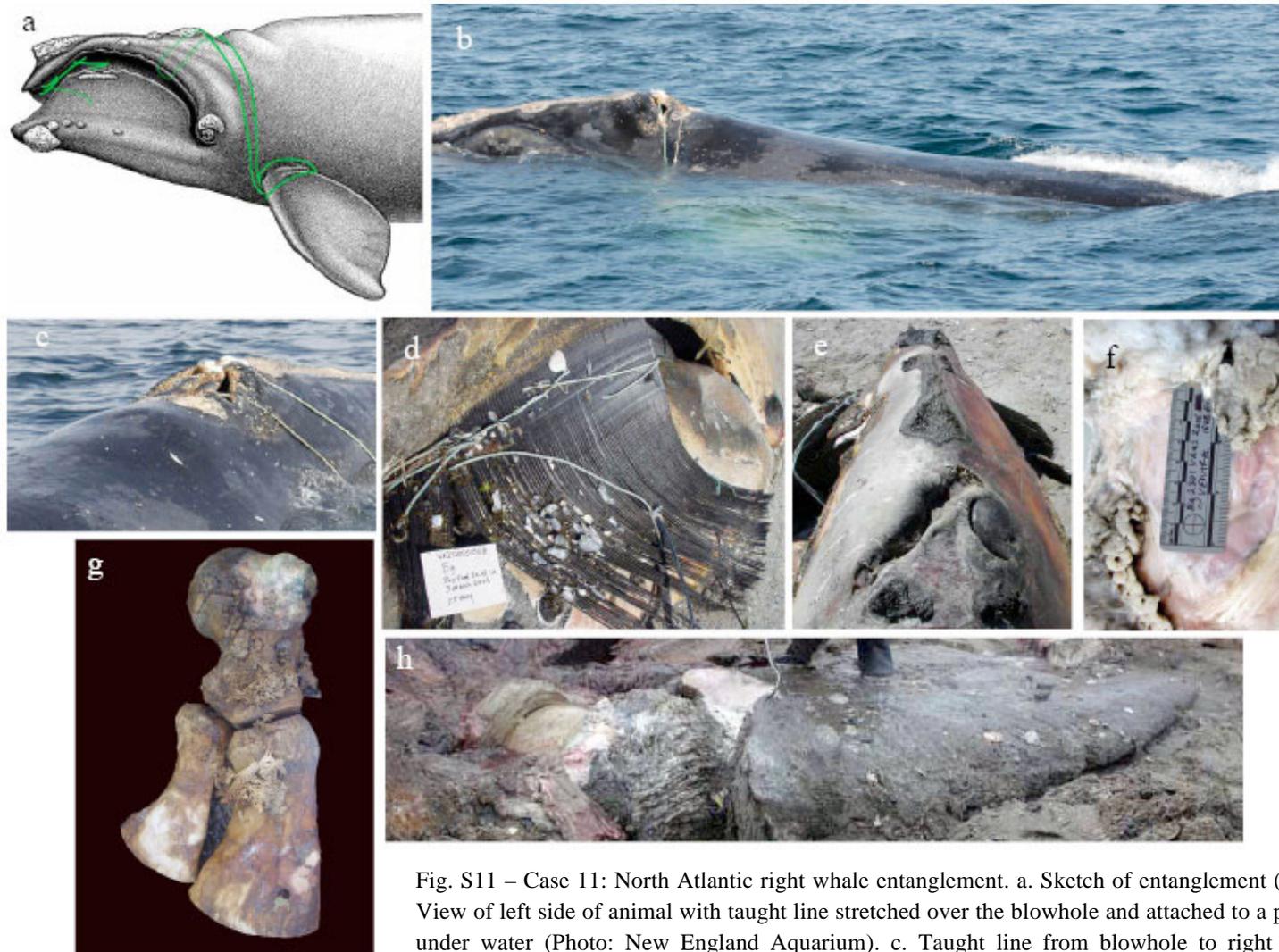


Fig. S11 – Case 11: North Atlantic right whale entanglement. a. Sketch of entanglement (Scott Landry). b. View of left side of animal with taught line stretched over the blowhole and attached to a pallid flipper seen under water (Photo: New England Aquarium). c. Taught line from blowhole to right lip (Photo: New England Aquarium). d. Ventral left baleen rack on beach with multiple wraps of rope. e. Dorsal view of head. Left nares shows major depression furrow from chronic line pressure. f. New periosteal bone proliferating around a sequestrum in the left humerus. g. Cleaned left humerus, radius and ulnar showing what remains of the massive periosteal new bone that attempted to wall off the encircling lines shown in situ in (h). h. Dissected left flipper on beach showing perisoteal proliferation around the forearm bones.

Case 12: Eg NEFL-0603 (*Eubalaena glacialis*). Fig. S12.

This North Atlantic right whale calf, observed dead offshore near Jacksonville, Florida, USA on January 22, 2006, had skin lesions indicating that its caudal peduncle had been wrapped in gill net (stretched mesh size = 15.2 cm). It had 2 major gross abnormalities: net lacerations and shark bites on the peduncle; and a large, gaping dorsal defect, from which there was extrusion of the intestines. The gear lesions, which were first observed about 15 d prior to death, consisted of a series of regularly spaced, diamond and “v”-shaped 9-10 x 12-13 cm cuts (maximum depth = 1.2 cm) along the entire length of the peduncle (located cranial to a post-mortem towing laceration around the fluke base). Two shark bite wounds (jaw gape = 22 cm), which penetrated through the dermis, were located on the right dorso-lateral peduncle. According to sighting records, the shark predation occurred pre-mortem, about 1-3 wk prior to the entanglement. The dorsal defect, which was 1.2 by 2.4 m in size, was attributed to post-mortem buildup and release of gas in the abdomen. At the time of death, the animal was in good body condition, but had no gastrointestinal contents, indicating that suckling had ceased at least 1 day prior to death. The animal’s peduncle was also heavily infested by cyamids.

Histology supported the conclusion that the regularly spaced peduncle lacerations were gear-induced, rather than the product of shark predation, based on the fact that the lacerations were superficial to the dermal-epidermal junction. Although internal organs were autolyzed, there was no indication of systemic disease. Given the seriousness of the animal’s skin wounds, it was determined that death was most likely initiated by shark predation and subsequent entanglement.



Fig. S12 – Case 12: North Atlantic right whale entanglement. a. Aerial image of carcass showing dorsal defect with extruded intestines (Image: Florida Wildlife Commission). b. Left peduncle with diamond pattern and linear scratches (Photo: Florida Wildlife Commission). c. Excised caudal peduncle showing 12x10cm diamond pattern. d. Dorsal view of carcass on beach showing dorsal defect. Line around peduncle was used for towing ashore. e. Dorsal aspect of flukes and peduncle showing cyamid coverage. f. Shark bite wounds on left aspect of dorsal portion of the peduncle.

Case 13: Dead Eg 052106 (*Eubalaena glacialis*). Fig. S13.

The carcass of this 3 yr-old female North Atlantic right whale was found at sea near Block Island, Rhode Island, USA on May 18, 2006, in a very advanced state of decomposition, making gross examination difficult. It was deduced from visible markings that line had been attached to a portion of the oral cavity and left mandible. In addition, there had been multiple tight line wraps around the right flipper and multiple loose line wraps around the caudal peduncle.

Gross pathology, which was evaluated using aerial photos and video, as well as underwater pole video, revealed that the animal had been cut extensively by the line. Numerous superficial lacerations were present on the left mandible, dorsal and ventral fluke insertions, and, most notably, on the right axilla. Although there was insufficient information to determine cause of death, entanglement was a probable factor, especially since there were no external injuries from a ship strike or predation, although blunt trauma with no external signs could not be ruled out.

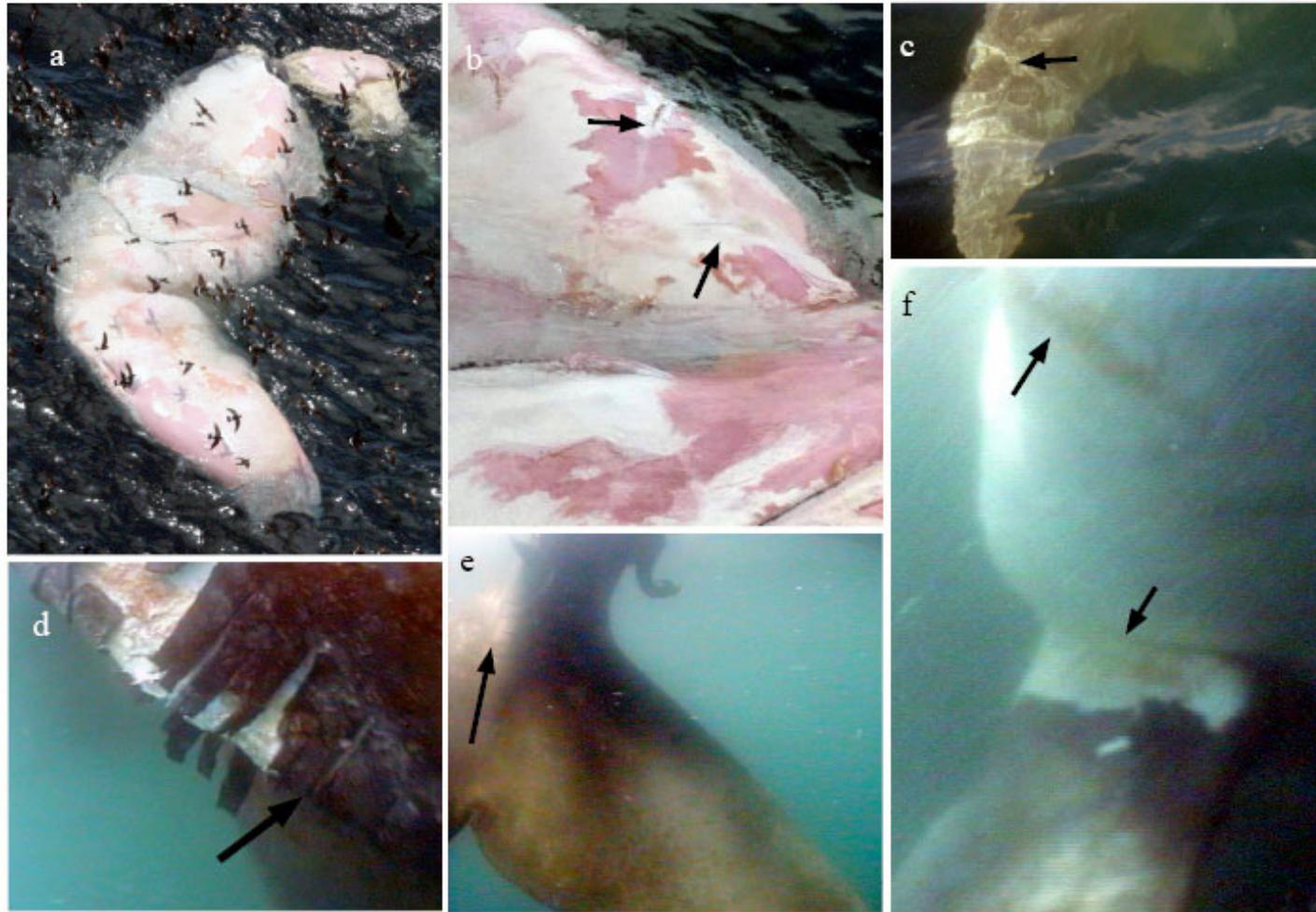


Fig. S13 – Case 13: North Atlantic right whale entanglement. a. Image of carcass at sea showing advanced decomposition. b. Left ventral lower jaw region with linear marks overlying mandible (arrows). c. Left fluke blade underwater showing linear abrasion (arrow). d. Ventral fluke midline. Note parallel linear abrasions and non penetrating defect (arrow). e. Dorsal aspect of flukes 4 transverse abrasions that are in line with those shown ventrally (d). f. Linear marks around right axilla (arrows).

a to c: above water. d to f: underwater video frames.

Case 14: CCSN 99-001/MH 99-403-Mn (*Megaptera novaeangliae*). Fig. S14.

This male juvenile humpback whale stranded on January 12, 1999 in Martha's Vineyard, Massachusetts, USA with marks indicating that its mouth and peduncle had been seriously entangled on fishing line. It appeared that line had passed through the oral cavity, tightly encircling the mandible 3 times. The line then exited the right angle of the mouth, ran ventrally along the body, and finally wrapped multiple times around the caudal peduncle.

On necropsy, it was found that the rope had incised the soft tissue down through the muscle at the right corner of the mouth (depth = 20 cm). The rope had also left a series of deep gashes (1-5 cm wide) accompanied by superficial hemorrhage around the caudal peduncle. The deepest cuts, located dorsally, penetrated down to the blubber. The entanglement wounds appeared to be very recent, as there was no apparent granulation or scar tissue formation. A detailed internal exam was not conducted. However given that the animal appeared to be in good health and body condition when it stranded, and that the entanglement wounds occurred shortly before death, it was concluded that animal died from drowning.

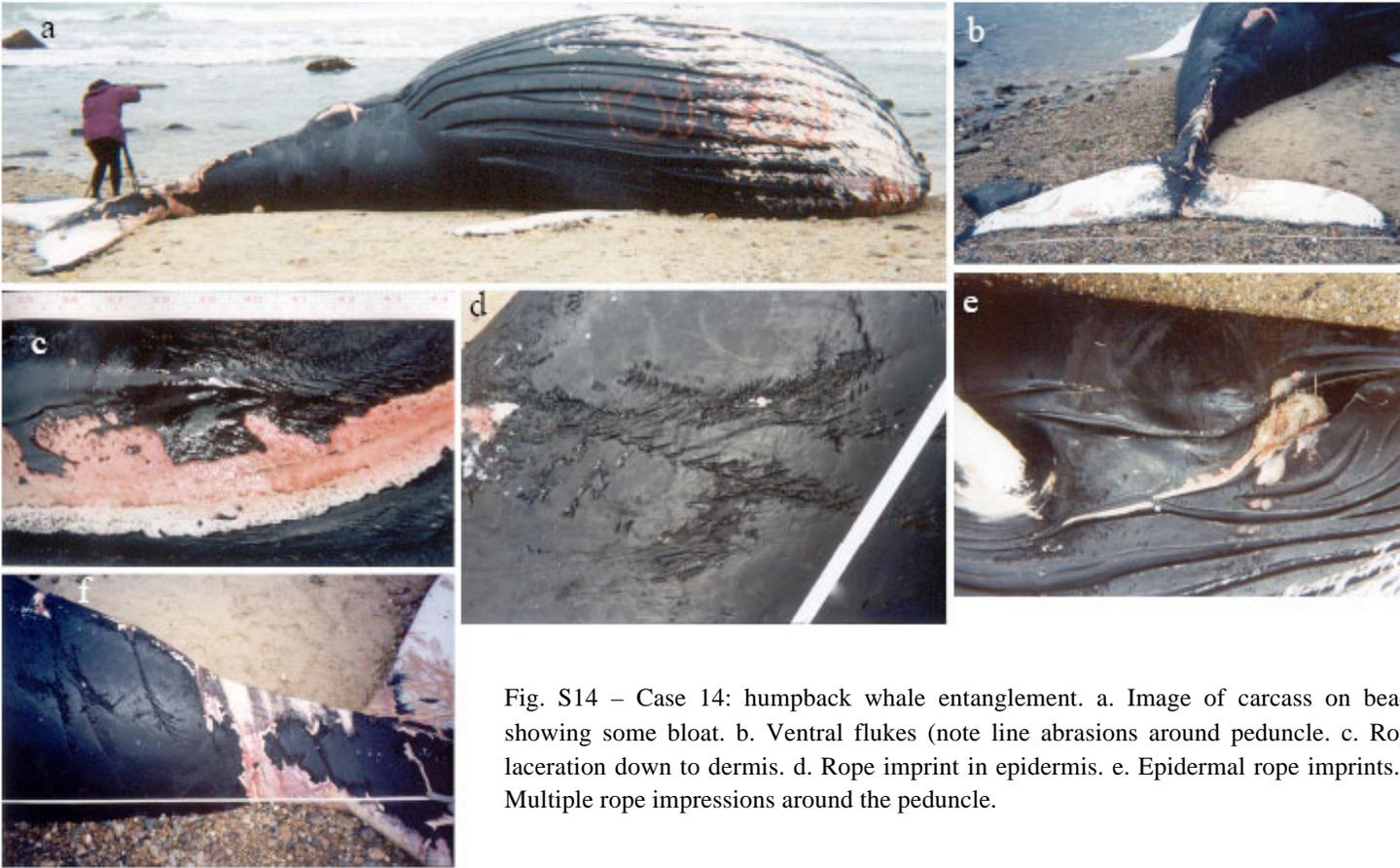


Fig. S14 – Case 14: humpback whale entanglement. a. Image of carcass on beach showing some bloat. b. Ventral flukes (note line abrasions around peduncle. c. Rope laceration down to dermis. d. Rope imprint in epidermis. e. Epidermal rope imprints. f. Multiple rope impressions around the peduncle.

Case 15: CCSN 00-079/MH 00-554-Mn (*Megaptera novaeangliae*). No images.

This juvenile male humpback whale stranded at First Encounter Beach, Massachusetts, USA on May 12, 2000 after its trunk had been entangled in fishing gear. Line lacerated the trunk on the left side at the level of the flipper, leaving a 30.5 cm long wound that was mostly healed. Two of the whale's dorsal chevrons were fractured, possibly as a result of the entanglement. They were surrounded by considerable subdermal hemorrhage and edema. The whale was also emaciated. Although cause of death could not be determined, entanglement was likely an important factor.

Case 16: CCSN 00-126/MH 00-766-Mn (*Megaptera novaeangliae*). Fig. S15.

This humpback whale calf stranded on October 7, 2000 at Sandy Neck Beach, Massachusetts, USA after an encounter with fishing net involving at least the blowhole. The only major finding was a 13 x 22 cm bundle of net material that had become lodged within the dorsal nasal passage. The full extent of the entanglement was unknown, as none of the skin remained on the carcass due to advanced decomposition. This animal did not have any evidence of skeletal injury. Obstruction of the nares by the netting was presumed to be responsible for the animal's death, as it likely interfered with respiration. In addition, it may have prevented complete closure of the nares during diving and, thus, led to aspiration of seawater.

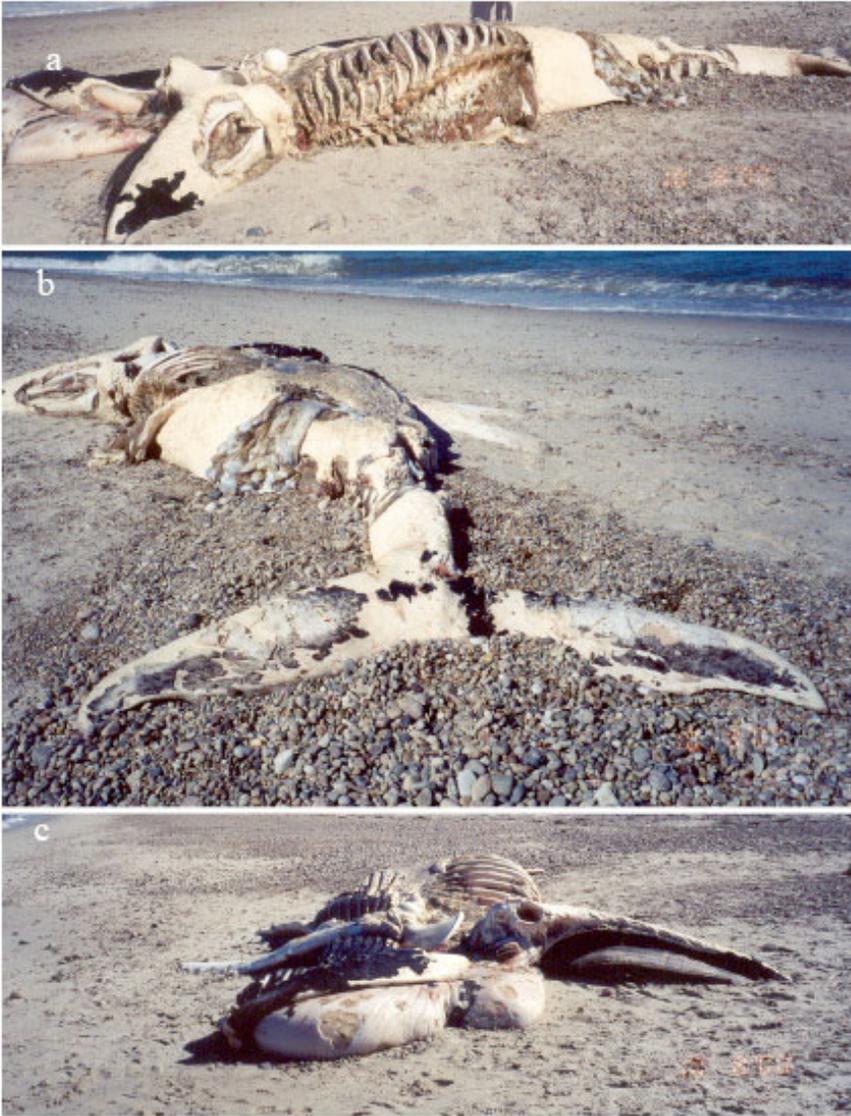


Fig. S15 – Case 16: humpback whale entanglement. a, b and c. Images of carcass on beach showing major decomposition. Netting was found within the nares.

Case 17: SC 01-18-Mn (*Megaptera novaeangliae*). Fig. S16.

This male humpback whale calf, which stranded potentially alive on April 8, 2001 in Myrtle Beach, South Carolina, USA, showed evidence of chronic entanglement, involving encircling line wraps around the caudal peduncle. It also had been involved in a ship strike, which injured its left peduncle and severed the left flipper. The entanglement caused paired lacerations on both lateral aspects of the peduncle that were deep and necrotic. The animal also had 7 propeller wounds on the left peduncle and 3 propeller wounds on the left flipper. Three of the propeller lacerations were deep and necrotic, while the rest were healed. Cyamids filled all of the wounds and also were scattered diffusely on the back. The animal was so severely emaciated that its vertebral processes clearly protruded along its back. Its stomach was empty, except for 20 cm of fishing line. Death, in this case, was attributed to starvation due to debilitating propeller and entanglement wounds.



Fig. S16 – Case 17: humpback whale entanglement. a. Head and flippers. Note severe loss of muscle mass between the scapulae. b. Flukes. c. Head. d. Left lateral body. Note propeller wounds on left peduncle and flipper, and severe loss of muscle mass overlying rib cage. e. Entanglement and propeller wounds on right peduncle.

Case 18: CCSN 02-255 (*Megaptera novaeangliae*). Fig. S17.

This female humpback whale calf was observed offshore near Plymouth, Massachusetts, USA on October 1, 2001. It was extensively entangled in 3-strand lobster line and was floating just below the surface, anchored by the gear. A day later, the animal floated ashore in Provincetown, Massachusetts. Although gear was no longer present, obvious line impressions indicated that two ropes, originating in the left mouth, wrapped around the calf's body at least 12 times between the blowhole and fluke base, forming a criss-cross pattern along the caudal back. Another line ran from the right mouth and encircled the right flipper insertion (Fig. 1). As a result of the entanglement, both flippers were pinioned tightly to the body.

Cutaneous rope impressions, without any noticeable bleeding, were present on almost all parts that had been in contact with rope. In addition, there were several large areas of superficial skeletal muscle with marked bruising, such as on the left lower jaw, right mid-lateral trunk, and right ventral peduncle. Some of these bruised areas were greater than 40 cm wide. Autolysis of organs and muscles was much more pronounced in the thoracic cavity, as compared to the abdomen, implying there had been a higher degree of metabolic heat generation in the chest.

Evidence from the gross observations suggests that the animal encountered lobster gear, possibly while feeding, and became further entangled as it tried to free itself. The calf strained intensely against the line, as indicated by the large areas of bruising in the muscle. As a result, the line may have prevented the animal from surfacing to breathe at high tide.

While drowning is the most plausible explanation for the calf's death, there is also evidence that hyperthermia played a role. The more rapid rate of autolysis in the chest, as compared to the abdomen, suggests that temperatures in the thoracic cavity were much higher than normal at the time of death. Excessive heat may have been generated by increased cardiac effort due to prolonged struggling against the gear, or an increased respiratory effort due to restricted chest expansion.



Fig. S17 – Case 18: humpback whale entanglement. a. Sketch of entanglement (Scott Landry). b. Lateral view of left head. c. Rope impression caudal to left eye (arrow). d. Multiple rope imprints around peduncle. e. Chafing and rope marks on insertion of left fluke blade into peduncle. f. Multiple criss-cross rope impressions around the ventral aspect of the peduncle. g. Muscular bruising on the left lumbar region. The overlying blubber has been reflected. h. Subdermal decomposition and bruising overlying the right chest wall.

Case 19: CCSN 03-145-Mn (*Megaptera novaeangliae*). Fig. S18.

This juvenile female humpback whale, examined at sea near Georges Bank on July 28, 2003, was part of an unusual mortality event involving 21 dead whales of which 16 were humpbacks. Rope impressions suggested that line had been wrapped around this whale's flippers, mouth, and rostrum. The rope had caused 3 abrasions on the right flipper, a small notch on the leading edge of the left flipper, and partially healed lacerations passing over the rostrum between the right and left corners of the mouth. Although an exact cause of death could not be determined due to limited information, entanglement likely played a role. The nature of the lacerations suggested mobile gear with steel wire might have been involved.

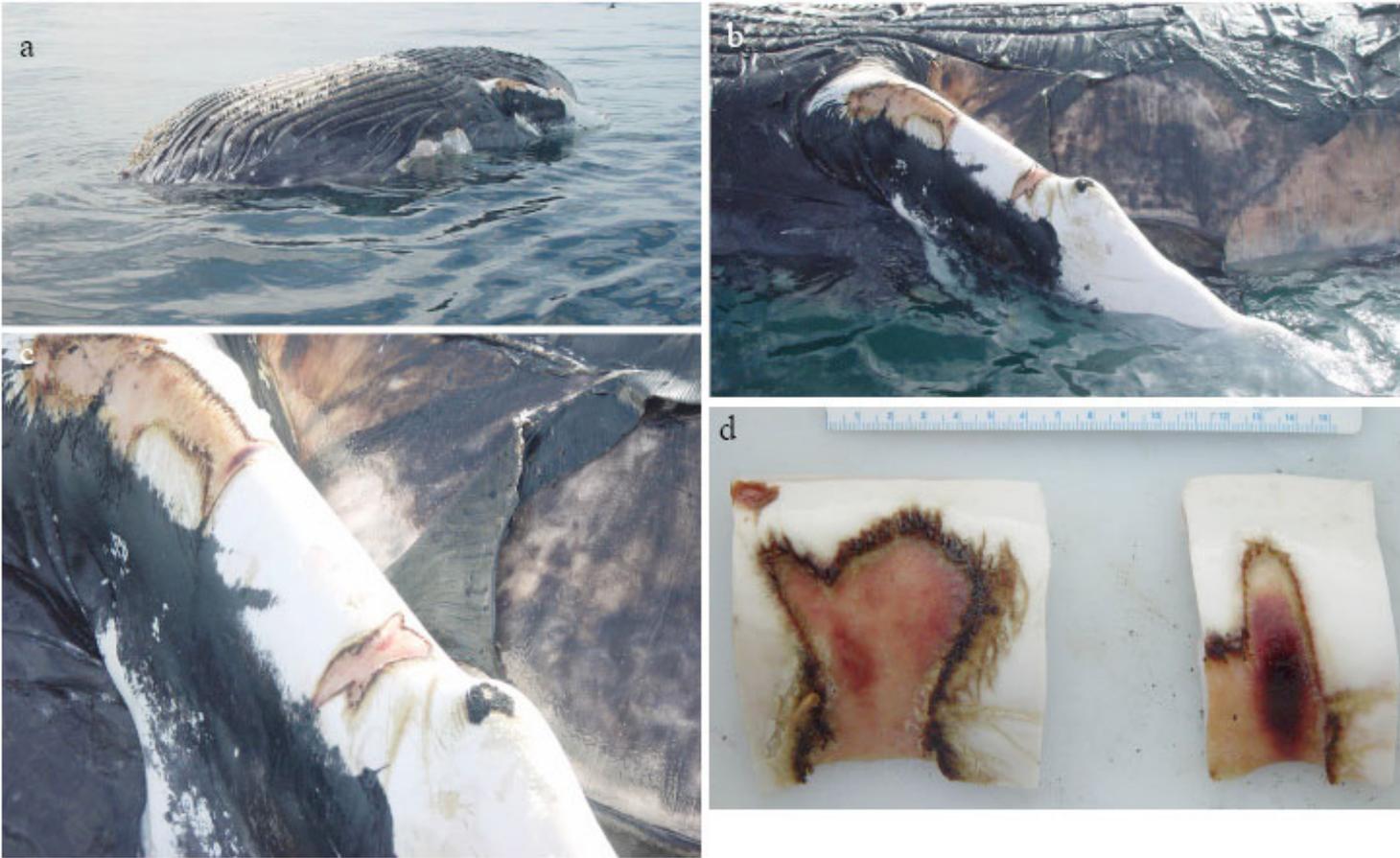


Fig. S18 – Case 19: humpback whale entanglement. a. View of right side floating at sea. b. Lateral view of right flipper. c. Close up of lacerations on leading edge of right flipper. d. Sections of the lacerations in (c) showing wound margins and focal hemorrhage at the pressure line of the abrading gear.

Case 20: MLC002 (*Megaptera novaeangliae*). Fig. S19.

This juvenile male humpback whale was found floating at sea near Ocean Sands, North Carolina, USA on December 21, 2007 with gill net wrapped around its body. The left fluke, where bridle or lead line attached, was the most severely entangled. However, net covered most of the body, including mouth, flippers, dorsal fin, and peduncle.

On gross examination, substantial net-associated abrasions were observed on the dorsal and ventral flukes, and leading edge of the dorsal fin. On the left fluke, the abrasions were very deep (4-5 mm into dermis), suggesting that the animal had been chronically entangled or that the gear had been weighted or anchored. In addition, the whale had deep net marks on the left mandible and left flipper insertion, and a bloody ulcerated region at the tip of the penis. Although the whale had some fish in its stomach, its epaxial muscles were dramatically sunken, indicating emaciation.

The chronicity of this animal's entanglement was confirmed histologically, by the presence of dermal fibrosis, epithelial hyperplasia, lymphocytes, and macrophages within abraded regions. Large numbers of bacterial cocci and algae were observed in gear-related wounds and adjacent skin. These were accompanied by infiltrates of neutrophils. The overgrowth of bacteria and algae suggests a decreased rate of epithelial turnover, possibly due to reduced swimming speed, nutritional compromise, or immunosuppression. This animal possibly starved to death due to chronic entanglement and infection of gear-induced abrasions.



Fig. S19 – Case 20: humpback whale entanglement. a. Gillnet and floats wrapped around the carcass. b. Leading edge of right flipper with line associated laceration c. Bilateral thickening of tailstock d. Abrasion in leading edge of left fluke close to fluke insertion into peduncle. e. Abraded leading edge of dorsal fin f. Circumferential lesion around left flipper consistent with net wrap. g. Dermal erosion, ulceration, chronic-active dermatitis, and dermal fibrosis with superficial and intra-epithelial bacterial cocci and algae.

Case 21: KLC033 (*Megaptera novaeangliae*). Fig. S20.

This juvenile male humpback whale beached in Nags Head, North Carolina, USA on February 16, 2009. Fresh wounds indicated that line had been anchored at the right and left corners of the mouth, extending caudally along the ventrum and flippers. This whale also had scars on the peduncle and flukes from a separate encounter with gear.

The major gross findings in this case were severe bilateral cuts originating internally at the corners of the mouth and terminating on the ventrum just beyond the flippers. Lacerated tissue on the right side was edematous and possibly necrotic. Based on the considerable depth of the cuts proximally (up to 3.5 cm), it is likely that the line around the mouth was weighted or had a large surface area, creating a lot of drag.

Expectedly, these wounds showed microscopic evidence of chronic inflammation and fibrosis. However, many were also sites of active inflammation, suggesting recent, ongoing mechanical irritation by the gear. Although the amount of internal information in this case was limited due to decomposition, it seems likely that the inflamed entanglement wounds led to debilitation and death.



Fig. S20 – Case 21: humpback whale entanglement. a. Right lateral view of body. b. Laceration from left gape of mouth under left flipper (arrows) c. Muscle at left mandibular joint d. Muscle at left flipper joint. e. Abraded dorsal aspect of peduncle f. Abraded leading edge of right fluke blade. g. Abraded ventral aspect of peduncle.