Pathological Findings in a Rare Mass Stranding of Melon-Headed Whales (*Peponocephala electra*) in Florida

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Abstract

Pathological findings associated with the mass stranding of five melon-headed whales (*Peponocephala electra*) along the Atlantic coast of Florida are reported. Four of the five whales were freshly dead, and the fifth was moderately decomposed. Body weights ranged from 160 to 180 kg, and all whales had mild to moderate weight loss evidenced by postnuchal depression and pronounced scapulae and peduncular vertebrae. All whales had from 10 to 21 ovoid dermal scars consistent with healed cookie-cutter shark (*Isistius brasiliensis*) wounds. Gastric compartments of all whales contained from 6 to 20 squid beaks with no other solid food items present. The peritoneum of all whales contained many parasitic cestode cysts consistent with *Monorygma* spp. In all cases, the alimentary tract had gross and microscopic lesions. Colons had an unusual microscopic lesion diagnosed as particularly florid examples of the collagenous stage of microscopic colitis known as collagenous colitis as reported in humans. The lesion was characterized by a diffuse, irregular, moderate thickening of the colonic wall due to deposition of subepithelial collagen between the muscularis mucosae and basement membrane of the surface epithelium in the lamina propria. The surface epithelium and collagen layer had mild multifocal infiltrates of neutrophils and eosinophils and mildly increased numbers of lymphocytes and plasma cells. Additionally, mild to moderate myocardial degeneration was a consistent finding in all cases. Less consistent lesions included erosive esophagitis, ulcerative gastritis, granulomatous gastritis, ulcerative dermatitis, and *Nasitrema*-associated suppurative sinusitis. The cause of the mass stranding was not determined; however, all whales exhibited pathological changes consistent with pre-existing chronic disease with inanition that developed prior to the stranding event.

Key Words: melon-headed whale, *Peponocephala electra*, pathology, mass stranding, Florida

Introduction

The melon-headed whale (*Peponocephala electra*) is distributed worldwide in tropical to subtropical waters (Jefferson et al., 1994). A paucity of sightings of this species exists in the tropical western north Atlantic, however, probably due to a naturally low number of groups compared to other cetacean species (Waring et al., 2006). Numerous vessel and aircraft surveys for marine mammals have been conducted in the nearshore and oceanic waters along the Atlantic coast of the United States since the early 1980s, and only two sightings of this species in 1999 and 2002 have been documented. Both sightings occurred in waters about 2,000 m deep offshore of Cape Hatteras, North Carolina.

Melon-headed whales are observed more frequently in the northern Gulf of Mexico (Mullin et al., 1994), and currently there is no evidence to suggest those in the western North Atlantic are a different stock, although they are considered as such for management purposes (Waring et al., 2006). The first sightings in the Gulf of Mexico occurred in oceanic waters (Mullin et al., 1994) during 1992, and most sightings in the Gulf have occurred along the 1,000-m isobath. The population within the northern Gulf was estimated at about 3,500 animals (Mullin & Fulling, 2004), but there are no population estimates for the western North Atlantic.

Strandings of melon-headed whales in U.S. continental waters are rare, and in Hawaii, a stranding occurs only about once in five years (Geraci & Lounsbury, 2005; Southall et al., 2006). According to Southeastern U.S. Marine Mammal Stranding Network records, no reports of stranded melon-headed whales were described in the southeastern U.S (all states between North Carolina and Texas, including Puerto Rico and the U.S. Virgin Islands) prior to 1990. From 1990 to 2006, three melon-headed whales stranded as single individuals in Florida, and only one of these whales was on the Atlantic coast (Daniel K. Odell, Hubbs-SeaWorld Research Institute, pers. comm.). In this report, we document the first pathological findings associated with a mass stranding of this species that occurred along the central Atlantic coast of Florida, USA, in March 2006. This was the first reported mass stranding of melon-headed whales in the southeastern United States and only the second stranding of this species on the Atlantic coast of Florida.

Materials and Methods

Five adult male melon-headed whales stranded within a 24-h period on 30-31 March 2006 along the central Atlantic coast between Vero Beach, Florida, USA ($n = 1$), and Stuart, Florida, USA ($n = 4$). Three whales stranded alive and subsequently were euthanized on the beach. One whale was found freshly dead, and the fifth whale was moderately decomposed. Stranding data, including the latitude and longitude of the strandings, case field numbers, whale weights and morphometrics, and specimen repository information were recorded and archived at Harbor Branch Oceanographic Institution, Fort Pierce, Florida, USA. Age was estimated from total body length, and a necropsy was performed on all five whales according to recommended protocols (Geraci & Lounsbury, 2005). Tissue sections from the lung, liver, spleen, multiple lymph nodes, thymus (if present), esophagus, forestomach, fundic stomach, pyloric stomach, small intestine, large intestine, pancreas, kidney, adrenal gland, skeletal muscle, skin, cerebrum, cerebellum, midbrain, brain stem, cervical spinal cord, pterygoid sinuses, and vestibulocochlear nerve were collected for histological examination. Heart tissue was collected as previously detailed (Hensley et al., 2005). Briefly, cross sections of the whole heart were made and designated as Levels 1 through 5, from apex to base, respectively. Further evaluation involved the collection of 12 heart sections that included the septal summit (2 blocks), dorsal wall of right ventricle at Level 2, ventral wall of right ventricle at Level 2, dorsal wall of left ventricle at Level 2, ventral wall of left ventricle at Level 2, interventricular septum at Level 2, dorsal wall of right ventricle at Level 4, ventral wall of right ventricle at Level 4, dorsal wall of left ventricle at Level 4, ventral wall of left ventricle at Level 4, and interventricular septum at Level 4. All tissues were placed in 10% neutral buffered formalin, routinely processed, embedded in paraffin, sectioned at 5 μm, and stained with hematoxylin and eosin. Special histochemical stains of selected tissues included Brown and Brenn, Warthin-Starry, Masson trichrome, and Grocott methenamine silver.

Results

All five whales had gross evidence of mild to moderate weight loss characterized by postnuchal depression and pronounced scapulae and peduncular vertebrae. Body weights were 160 kg (Case 1), 164 kg (Case 2), 163 kg (Case 3), 177 kg (Case 4), and 180 kg (Case 5). Case 1 had teeth uniformly worn to the gingival surface. Case 4 had 8 partially fractured teeth of the left mandible. Cases 2 and 3 had 6 to 11 skin lesions, ranging from 2.0 to 4.0 cm in diameter that were located bilaterally along the lateral thorax and peduncle. The lesions were characterized by central ulceration rimmed by a slightly elevated, white, firm fibrous tissue. Additionally, all whales had from 10 to 21 irregular, firm, slightly raised, pigmented to unpigmented ovoid dermal scars of the ventral thorax and abdomen, ranging from 5.0 to 7.0 cm in diameter, which were consistent with healed cookie-cutter shark (*Isistius brasiliensis*) wounds.

The gastric compartments of all whales contained from 6 to 20 squid beaks with no other solid food items present. Cases 1 and 3 had from 6 to 12 forestomach and fundic stomach superficial mucosal ulcerations that ranged from approximately 0.5 to 2.0 cm in diameter. Small and large intestinal digesta were minimal in all cases and consisted of a small to moderate amount of yellowish-tan watery fluid. The parietal peritoneum of all whales had many soft, whitish-tan cysts ranging from 2.0 to 4.0 cm in diameter and containing cestode parasites consistent with *Monorygma* spp. (Dailey, 2001). The left pterygoid sinus of Case 1 contained approximately 15 ml of tenacious, malodorous, yellowish-tan pus and parasites consistent with *Nasitrema* spp. (Dailey, 2001). No other significant gross lesions were noted.

Microscopically, alimentary tract lesions were present in all five cases. The large intestine of all whales had a moderate, diffuse, irregular thickening of the wall due to deposition of collagen between the muscularis mucosae and basement membrane of the surface epithelium in the lamina propria (Figures 1 & 2). The surface epithelium

and collagen layer also had mild multifocal infiltrates of neutrophils and eosinophils and mildly increased numbers of lymphocytes and plasma cells. The surface epithelium occasionally had colonies of large Gram-positive bacilli. Helminth parasites were not observed.

Gastroesophageal lesions were present in Cases 1 through 3. The fundic and pyloric stomach compartments of Case 1 had severe locally extensive, submucosal infiltrates of lymphocytes, plasma cells, and histiocytes, with ulceration, mineralization, fibrosis, and neovascularization. Case 2 had moderate, locally extensive esophageal erosions with necrosis and associated neutrophilic infiltrates. Case 3 had moderate, multifocal lymphoplasmacytic infiltrates of the fundic stomach compartment submucosa. Mild, multifocal
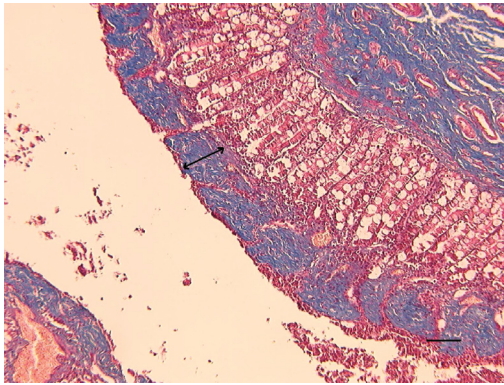
Figure 1. Photomicrograph of the large intestine from a melon-headed whale stranded in Florida; note the diffusely thickened subepithelium by deposition of collagen (arrow). Masson trichrome stain; bar = 200 microns.
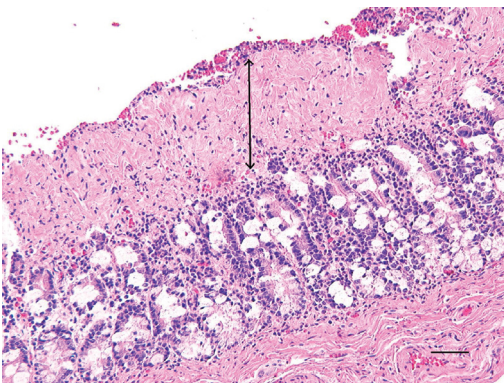

Figure 2. Higher power photomicrograph of Figure 1; note the diffusely thickened subepithelium by deposition of collagen (arrow) with scattered polymorphonuclear leukocytes, which is consistent with collagenous colitis. H&E stain; bar = 150 microns.

infiltrates of histiocytes, neutrophils, and occasional multinucleate giant cells were also present in the pyloric stomach compartments of Cases 1 and 3. A few granulomas contained pleomorphic, amorphous, eosinophilic debris of suspected parasitic origin. Intralesional Gram-negative bacilli were present in the nongranulomatous lesions of the pyloric stomach compartment of Case 1 and esophagus of Case 2.

Mild to moderate multifocal myocardial degeneration was present in all five cases. Anisokaryosis with karyomegaly and nuclear rowing of cardiomyocytes was the most common degenerative lesion. In descending frequency, there also was interstitial edema, fibrosis, loss of cardiomyocyte cross-striations, and myofiber cytoplasmic hypereosinophilia (Figure 3). In most cases, the global anatomic distribution of each lesion was relatively similar across the 12 sampling sites.

The gross skin lesions of Cases 2 and 3 were histologically similar and characterized by focal ulceration with associated superficial to deep infiltrates of neutrophils, histiocytes, lymphocytes, and plasma cells. Peripheral granulation tissue also was present. Case 2 had intralesional Gram-negative coccobacilli, and Case 3 had intralesional invasive ciliated protozoans that were consistent with *Kyaroikeus cetarius* (Figure 4).

The gross lesion of the left pterygoid sinus of Case 1 was characterized by severe diffuse submucosal infiltrates of neutrophils, eosinophils, histiocytes, and occasional lymphocytes and plasma cells. A suppurative exudate containing golden-brown trematode ova characteristic of *Nasitrema* spp. distended the sinus lumina (Figure 5). The remaining tissues had no microscopic lesions or had lesions that were mild, nonspecific, or agonal.
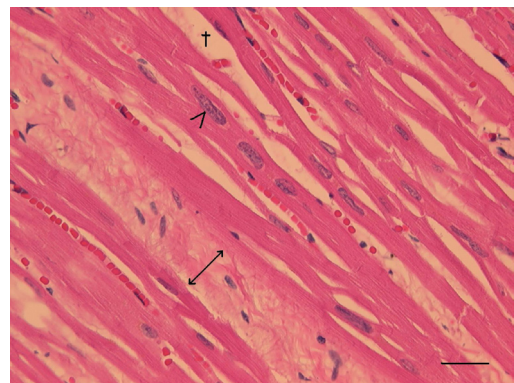

Figure 3. Photomicrograph of the heart from a melon-headed whale stranded in Florida; note anisokaryosis with karyomegaly (arrowhead), nuclear rowing of cardiomyocytes, interstitial edema (cross), and presumptive fibrosis (arrow). H&E stain; bar = 60 microns.
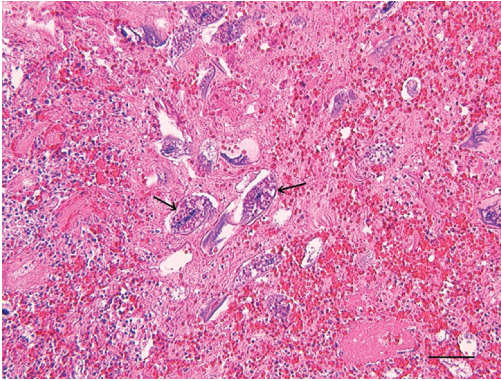
Figure 4. Photomicrograph of the skin from a melon-headed whale (Case 3) stranded in Florida; note dermal infiltrates of an admixture of leukocytes, hemorrhage, and intralesional ciliated protozoa (arrows). H&E stain; bar = 180 microns.
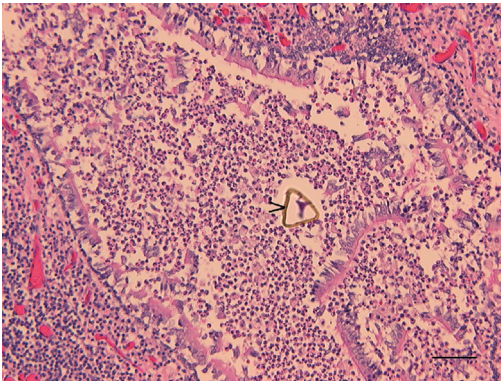

Figure 5. Photomicrograph of the left pterygoid sinus of a melon-headed whale (Case 1) stranded in Florida; note suppurative exudate that distends the sinus lumen and contains golden-brown trematode ova (arrowhead) characteristic of *Nasitrema* spp. H&E stain; bar = 180 microns.

Discussion

This first report of the pathological findings associated with a mass stranding of melon-headed whales provides important information as to the health status of the mass stranding group. All whales exhibited gross and microscopic changes of current illness and preexisting chronic, likely subclinical, disease with inanition.

The microscopic findings in the colon of all the whales were unusual and have not been described previously in marine mammals. After considerable discussion among consulting pathologists, the colonic changes were diagnosed as particularly florid examples of the collagenous stage of microscopic colitis known as collagenous colitis (CC), which has been reported in humans. Similar

to these whales, the characteristic microscopic feature of CC is an infiltration of lymphocytes into the colonic epithelium with a distinctive thickening of the subepithelial collagen table in the lamina propria. Clinically, this change is associated with diarrhea, sometimes watery diarrhea, which was noted as the intestinal content of these whales.

In humans, CC is a rare condition that first was described in 1976 and has been diagnosed increasingly over the past 20 years, but remains uncommon (Freeman et al., 1976; Goosenberg & Chaudhary, 2006). The disease occurs most commonly in people older than 40 years, with peak incidence in the sixth and seventh decades of life, and is up to 20 times more frequent in women than in men.

The etiopathogenesis of CC remains unclear, but hypotheses include autoimmune, colonic bacterial toxin and drug reactions (Goosenberg & Chaudhary, 2006). The etiology of the CC in these whales could not be determined. One possibility is a reaction to potential bacterial toxins produced by the observed surface epithelium, large Gram-positive bacilli. Additional rule-outs include a chronic resolved stage of inflammatory bowel disease or parasitism.

In humans, CC is not considered a life-threatening condition. Morbidity is limited to the consequences of diarrhea and malabsorption, including metabolic abnormalities such as hypokalemia and dehydration, weight loss, fatigue, and vitamin deficiencies (Schiller, 2004). The watery diarrhea intestinal digesta found in these whales may suggest a similar morbidity that could compromise health and be one confounding factor leading to the stranding event.

The gastroesophageal lesions in these whales are not uncommon in stranded cetaceans and may be caused by helminth parasites, bacterial infection, stress, or foreign bodies (Bossart et al., 1991; Gulland et al., 2001). These lesions could contribute to some functional compromise of the alimentary tract.

Heart lesions were mild to moderate and probably subclinical in nature as no gross or microscopic evidence of systemic myocardial decompensation was observed. Interestingly, similar but more severe myocardial lesions leading to cardiomyopathy and subsequent heart failure have been described in stranded pygmy (*Kogia breviceps*) and dwarf (*K. sima*) sperm whales (Bossart et al., 1985; Chiu et al., 2003). In *Kogia*, it has been postulated that the heart lesions represent a chronic, slowly progressive condition for which the etiopathogenesis is complex and includes metabolic factors such as excessive repeated sublethal episodes of catecholamine release, prolonged

glucocorticoid release, transient myocardial isch-emia, and nutritional deficiencies (e.g., thiamine, alpha tocopherol, selenium) (Bossart et al., 1985; Bossart, 2003). Thus, in these melon-headed whales, the heart lesions may represent the first stage of a similar condition as seen in *Kogia* and may share similar pathogenic mechanisms such as prolonged physiological stress and a subsequent nutritional component, the latter perhaps related to the intestinal lesions.

The dermatidites in Cases 2 and 3 and the unilateral sinusitis of Case 1 were likely second-ary, possibly incidental opportunistic diseases. Interestingly, the invasive ciliated protozoans seen in Case 3 were similar to those observed in stranded Atlantic bottlenose dolphins (*Tursiops truncatus*) with other debilitating infectious dis-eases (Schulman & Lipscomb, 1999; Bossart et al., 2003). *Nasitrema*-associated sinusitis has been reported in other stranded cetaceans and has been postulated to cause auditory dysfunc-tion leading to stranding (Daily & Walker, 1978; Morimitsu et al., 1992). Being limited to one case, the significance of this lesion in this mass strand-ing is uncertain.

A recent summary and analysis of 76 mass stranding occurrences in Florida between 1977 and 2001 emphasized the potential significance of some offshore pelagic species moving farther inshore, following prey migrations rather than prey directly (Walker et al., 2005). Further, both bathymetry and wind-induced water circulation were suggested to be important factors. Many of the chronic pathological lesions reported for these melon-headed whales are consistent with a displacement of the type described by Walker et al. (2005), which resulted in the loss of pre-ferred prey items and subsequent health compro-mise associated with the loss of needed nutrition.

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