CHAPTER

30

Diseases and parasites

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Introduction

Inupiaq, Siberian Yupik, and Inuit communities of the Arctic have a tradition in hunting bowhead whales that reaches back several thousands of years (Fig. 30.1). Central to Inuit culture, hunted bowhead whales have undergone rigorous health evaluation by hunters and communities through various iterative processes guided by traditional customary practices. These traditional customary practices are similar to western meat hygiene designed to provide a thorough health assessment of the catch and by default, a public health judgment on food safety. With the establishment of the bowhead whale harvest monitoring program in Utqiaġvik in 1972, led by the North Slope Borough leadership, Alaska Eskimo Whaling Commission (AEWC), and the North Slope Borough Department of Wildlife Management (NSB-DWM), collaborative research on the health of bowhead whales between the AEWC, Village Whaling Captains Association, Whaling Captains Wives Association, veterinarians and research scientists have continued to build on the in-depth Inuit knowledge of the bowhead whale. This collaborative effort between indigenous hunters, scientists, and regulatory agencies has provided a unique opportunity to study natural causes of morbidity and mortality of this extraordinary Arctic baleen whale. This chapter synthesizes historic and current knowledge about disease conditions and parasites of the bowhead whale. The information provided is a coproduction of knowledge reflecting perspectives of Inuit indigenous and local knowledge, veterinary medicine, and biology.

The Bowhead Whale
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FIGURE 30.1 A bowhead whale has been caught by Utqiaġvik Iñupiat, and the butchering has started on the ice edge. Much of what is known about the health of bowhead whales comes from the study of animals caught in this way. *Source: Photo by North Slope Borough.*

Infectious diseases

Viruses and bacteria

Few infectious agents are present that could impact bowhead health or pose a public health risk. Among the viral agents previously identified by serology, vesivirus (family Caliciviridae) figures prominently. In summary, neutralizing antibodies in serum (Smith et al., 1987; O'Hara et al., 1998) and colostrum (Harms, 1993) have been detected against San Miguel sea lion virus (SMSV strains 1, 4, 5, 8, 9, 10, 12), vesicular exanthema of swine virus (VESV strains B, C 1934B, F55, J56, K), and mink calicivirus. Other viral agents tested but failed to be detected included SMSV serovars (2, 6, 7, 11, 13), VESV serovars (A48, B51, C52, D53, E54, G55, H54, I55, K54) Tillamook calicivirus, dolphin morbillivirus, orthomyxoviruses (influenza A and B viruses), and paramyxovirus (Newcastle disease). Based on findings by O'Hara et al. (1998), prevalence for VESV strains (F55; J56; 1934B) was 47% (17/36), 8% (3/36), and 14% (5/36). For SMSV (8, 12), prevalence was 6% (2/36) and 3% (1/36). Although titers indicate prior exposure and/or infection, no disease was recognized in these bowhead whales. Type-specific antibodies to various caliciviruses have been detected in other baleen whales from the North Pacific (Bossart and Duignan, 2018). In a recent retrospective study where select tissues (liver, kidney, spleen, and lung) from bowhead whales ($n = 59$; 2011–15) were tested by polymerase chain reaction (PCR) for a suite of viral pathogens (morbillivirus, adenovirus, paramyxovirus, influenza A virus, Pan-corona virus; herpes virus); adenovirus (10%; 6/59) was the only viral agent detected. Adenoviruses were previously isolated from bowhead and sei whales during the early 1980s (Smith et al., 1987). Sequencing of current viral isolates and comparison with available Genbank material revealed diverse genotypes, with three of the adenoviruses detected being novel (Sanchez and Stimmelmayr, unpublished data). For the other three specimens, a comparison search of a 292 bp sequence in NCBI/BLAST/Blastn database revealed the best match (89% query coverage; 72% similarity) with vespertilionid adenovirus 2 (Genbank accession KM043097.1). Comparison of a 310 bp sequence in NCBI/BLAST/Blastn database revealed the best match (66% Query coverage; 75% similarity) with bat adenovirus; Genbank accession JX065124.1. Comparison search of a 313 bp sequence in NCBI/BLAST/Blastn database revealed the best match (99% query coverage: 75% similarity) with bottlenose dolphin adenovirus (Genbank accession KR024710.1). No histopathological lesions were observed in adenovirus-positive bowhead whales. There is only limited evidence that adenovirus infection causes disease (e.g., self-limiting gastroenteritis) in cetaceans (Rubio-Guerri et al., 2015). A cetacean pox virus (CePV-2) specific to the bowhead whale was previously isolated from skin lesions of one bowhead whale (4.5%; 1/22 examined) (Bracht et al., 2006). In a recent retrospective study, 2.2% (3/139) of examined skin lesions were suspected for viral etiology. Combined data suggests that most skin lesions in bowhead whales are not caused by poxvirus infection.

Bacterial agents that have epizootic and/or zoonotic potential (e.g., *Brucella* sp., *Leptospira* sp.) have not been found in the BCB stock of bowheads. This is based on early serological studies (Smith et al., 1987) and recent studies using PCR (Sanchez and Stimmelmayr, unpublished data). Leptospirosis is an important infectious disease of pinnipeds; however, evidence for interspecies transmission to cetaceans is lacking. A novel halophytic *Leptospira* has recently been isolated from a dead Southern right whale calf (*Eubalaena australis*, Grune Loffler et al., 2015). Marine *Brucella ceti*, on the other hand, appears to be widespread, having been isolated from various cetacean hosts and ocean regions (Guzmán-Verri et al., 2012). Three *Brucella* isolates (*B. ceti* porpoise type, *B. ceti* dolphin type, and *Brucella pinnipedialis*) have been reported in baleen whales, suggesting equal susceptibility to either of the marine strains. Brucellosis-associated lesions in cetaceans can involve the central nervous system (meningoencephalomyelitis), cardiovascular system (endocarditis), reproductive system (placentitis; abortion, epididymitis, and orchitis), integumentary system (abscessation), immune system (hepatomegaly, splenomegaly, and lymph node enlargement), and skeletal system (osteomyelitis; arthrosis). Recent serological and gross pathological evidence indicates active *Brucella* infections (granulomatous testis) in several baleen whales (common minke whale, Bryde's whale, and sei whale) in the western North Pacific (Ohishi et al., 2016). As the Arctic ecosystem continues to undergo a system-wide transformation, regularly updated surveys of bowhead whales on the prevalence of microbial agents known to globally impact cetaceans (Bossart and Duignan, 2018) are crucial to provide current baseline health data.

Parasites and commensals

Similar to other baleen whales, the bowhead whale carries parasitic and commensal organisms (Table 30.1; Fig. 30.2). Parasitism of the bowhead whale is characterized by low

TABLE 30.1 Host–parasite and commensal list reported for bowhead whales.

Metazoan parasite	Organ infected	Distribution/region
Protozoa		
Entamoeba sp.	Colon, small intestines	Alaska, United States
Flagellate form	Colon	Alaska, United States
Giardia spp.*	Colon	Alaska, United States
Cryptosporidium	Skeletal muscle	Alaska, United States
Sarcocystis sp.*		Alaska, United States
Cestoda		
Phyllobothrium delphi	Blubber	Europe
Phyllobothrium physeteris (possibly identical with delphini)	Blubber, skin	Europe
Trematoda		
Ogmogaster plicatus	Intestines	Alaska, United States
Brachycladium goliath	Liver	Europe
Acanthocephala		
Bolbosoma balaenae	Intestines	Europe
Nematoda		
Anisakis type larvae	Forestomach	Alaska, United States
Anisakid		
Contracaecum or Anisakis	Forestomach	Alaska, United States
Crassicauda sp.*	Kidney, renal arteries	Alaska, United States
Amphipoda		
Cyamus ceti	Skin, body orifices, scars, wounds	Alaska, United States
Diatoms	Skin, baleen	
Cocconeis		Alaska, United States
Stauroneis		Alaska, United States
Navicula		Alaska, United States
Gomphonema		Alaska, United States

Asterisk indicates unpublished data from authors.
*Data from Delyamure, S.L., 1955. Helminthofauna of marine mammals (Ecology and Phylogeny). Skrjabin, K.I. (Ed.) [Gel'mintofauna morskikh mlekopitayuschchikh v svete ikh ekologii i filogenii] Translated from Russian by the Israel Program for Scientific Translations, Jerusalem, 1968; Migaki, G., Heckmann, R.A., Albert, T.F., 1982. Gastric nodules caused by "Anisakis type" larvae in the bowhead whale (*Balaena mysticetus*). *J. Wildl. Dis. 18, 353–357; Heckmann, R., Jensen, L., Warnock, R., Coleman, B., 1987. Parasites of the bowhead whale,* Balaena mysticetus. *Gt. Basin Nat. 47, 355–372; Henk, W.G., Mullan, D.L., 1996. Common epidermal lesions of the bowhead whale,* Balaena mysticetus. *Scanning Microsc. 10, 905–916; Hughes-Hanks, J.M., Rickard, L.G., Panuska, C., Saucier, J.R., O'Hara, T.M., Dehn, L., et al., 2005. Prevalence of* Cryptosporidium *spp. and* Giardia *spp. in five marine mammal species. J. Parasitol. 91, 1225–1228. Erratum 91, 1357.*

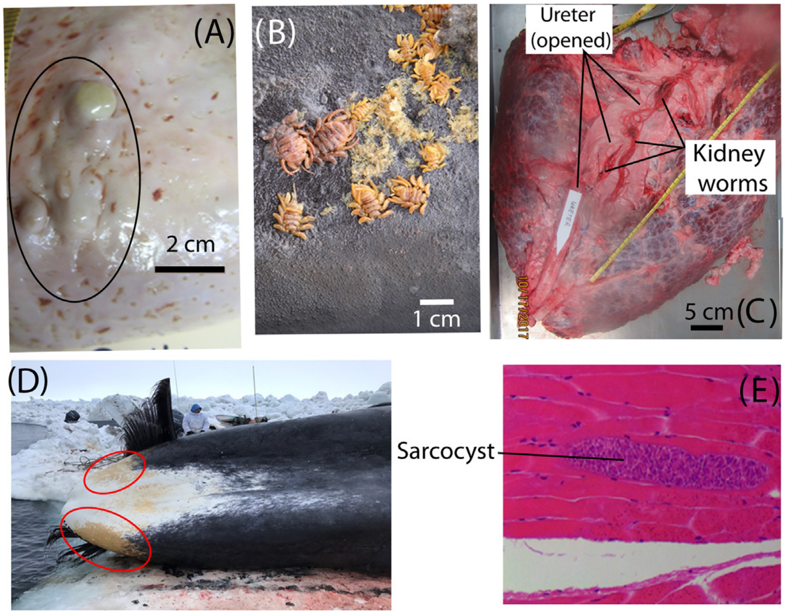

FIGURE 30.2 Parasites and commensals on bowhead whale. (A) Gastric nodules in the forestomach (NSB-DWM 2016B4). (B) Cyamids (whale lice) on skin of whale (NSB-DWM 2004B3). (C) Kidney and opened ureter with kidney worms (NSB-DWM 2017B21). (D) Yellow patches on chin caused by diatoms. (E) Sarcocyst in histological slide of muscle tissue. *Source: Photos by R. Stimmelmayr except E by D. Rotstein and B by C. George.*

species diversity with none of the described species being unique to the bowhead whale (Delyamure, 1955; Felix, 2013; Flores-Cascante et al., 2019). Most information about the bowhead whale parasite ecology comes from long-term assessment of the Bering–Chukchi–Beaufort Sea (BCB) stock (Chapter 3 and comparative analyses with other stocks are not yet possible. Parasites, like other infectious agents, are considered climate-sensitive, and thus their distribution, prevalence, and host range in the Arctic and subarctic are expected to change (Chapter 27).

Protozoa

Cryptosporidium and *Giardia* are parasitic single-celled protozoans implicated in infectious diarrheal episodes in a variety of mammals, including humans. Negative health effects due to persistent protozoal infection in cetaceans are not known. Both agents have been reported in the North Atlantic right whale, bowhead whale, and common minke whale (Hughes-Hanks et al., 2005; Reboredo-Fernández et al., 2015). Based on findings from a recent retrospective parasite screening study in BCB bowhead whales ($n = 159$; 2002–15), prevalence for both protozoa in bowhead whales has decreased over time: in *Giardia* from 33% (1998–2001) to 22% (2002–15), and in *Cryptosporidium* from 5.1% (1998–2001) to 0% (2002–15) (Stimmelmayr et al., 2018). Most current *Giardia* spp. prevalence estimates in bowhead whales are comparable to *Giardia* prevalence observed in free-swimming fin and sei whales (17.6% combined) from the Archipelago of the Azores (Hermosilla et al., 2016). Of 47 positive *Giardia* cases, 5 yielded amplification products and shared sequence similarity with Assemblage A and B (Lappin and Stimmelmayr, unpublished data). Marine contamination with human feces is recognized as a potential pathogen pathway for the introduction of *Giardia* assemblages A and B (both known to infect humans) to marine mammal populations (Heyworth, 2016; Reboredo-Fernández et al., 2015). Two unknown types of Protozoa, one amoeba form, *Entamoeba* sp. and one flagellate form have been described in bowhead whales (Heckmann et al., 1987). *Entamoeba* has also been described for free-ranging blue whale, fin whale, sei whale with a prevalence of ~65% (Hermosilla et al., 2016).

Sarcocysts are rare in skeletal muscle tissue of bowhead whales (Fig. 30.2E). No gross lesions were associated with their tissue presence. Cysts were irregular round to elongate, with a length of 100–200 μm, a wall of 50–100 μm thick, and numerous dacryoid bradyzoites. No inflammatory response was observed, though there were occasional myofibers that were disrupted and infiltrated by inflammatory cells with no cysts present in the degenerate myofibers. Cysts have not been genetically characterized. The marine life cycle of *Sarcocystis* species remains unknown. Only a few of its intermediate hosts including ringed seal (Migaki and Albert, 1980), bearded seal, polar bear, and beluga whale (Stimmelmayr and Rotstein, unpublished data) have been identified in northern Alaska. Rare occurrence of intramuscular sarcocysts in bowhead whales suggests that they are accidental intermediate hosts for this parasite. Exposure of bowhead whales through environmental marine contamination with sporulated sporocysts excreted by a definitive host is a likely source. Intramuscular sarcocysts have been previously described in the sei whale (Akao, 1970) and small cetaceans (De Guise et al., 1993; Ewing et al., 2002).

Helminths: cestodes

The cestode fauna of the bowhead whale is limited to one species. Phyllobothriid cysts of the *Phylobothrium delphi* type, that preferentially parasitizes the perigenital blubber region in cetaceans have been reported from bowhead whales from Europe (Delyamure, 1955) but not in the BCB stock. It is possible that cyst detection during postmortem examination of Alaskan bowhead whales has been biased as the perigenital blubber skin region is removed in toto and discarded as it is not consumed by the hunters. Adult worms have been found in sharks suggesting predation and scavenging of infected cetaceans play a role in the life cycle of this parasite.

Helminths: trematodes

Of the 10 digenea genera known to occur in cetaceans, only two species, *Brachycladium goliath* (van Beneden, 1858, homotypic synonym: *Lecithodesmus goliath*) and *Ogmogaster plicatus* have been identified in bowhead whales from Europe (Delyamure, 1955). Pathological lesions associated with liver fluke infection (*Lecithodesmus goliath*) in small cetaceans include chronic cholangitis and chronic hepatitis (Dailey and Stroud, 1978). In gray whales, rare fluke infection was associated with chronic cholangitis (Rice and Wolman, 1971). *Ogmogaster plicatus* specimens have been isolated from ingesta of several BCB bowhead whales (Shults, 1979; Heckmann et al., 1987), but neither eggs nor adult specimens were detected during a recent retrospective fecal parasite survey ($n = 159$; 2002–15; Ballweber and Stimmelmayr, unpublished data). Trematodes, in low numbers, associated with mild gastroenterocolitis were observed on histopathology in an individual bowhead whale (NSB-DWM 2010WW4; unpublished data). Transmission of these parasites, as with all other cetacean trematodes, has not been studied in detail. Fish may be a second intermediate host. Bowhead whales ingest fish only occasionally and probably accidentally (Chapter 28).

Acanthocephala

The acanthocephalan genus *Bolbosoma* has only been reported in bowhead whales from Europe (Delyamure, 1955). Pathological lesions associated with acanthocephalan infection, including intestinal mucosal ulceration and localized mucosal abscessation, have been described for small cetaceans (Dailey and Stroud, 1978) and gray whales (Rice and Wolman, 1971; Dailey et al., 2000). In recent years, intestinal lesions in humans due to rare *Bolbosoma* infection (Acanthocephaliasis) have been reported from Japan and indicate a rare zoonotic potential (Kaito et al., 2019), probably linked to the ingestion of undercooked and raw fish and squid.

Nematodes

Only two nematode species, *Anisakis* and *Crassicauda* have been identified in bowhead whales of the BCB stock. *Anisakis* roundworm infection consists of the larvae and/or adults in bowhead whale stomach contents and occurs at 17% of individuals (Sheffield et al., 2016). Adult *Anisakis* worms are found in the lumen of the forestomach and do not seem to affect the health of the whales, but infection with *Anisakis* larvae has been associated with gastric lesions (Migaki et al., 1982). Single to multiple granulomas caused by anisakid type larvae have been observed in immature bowhead whales (NSB-DWM 2016B3 and 2016B14; Sheffield et al., 2016). In gray whales with mature and larval *Anisakis*, no gastrointestinal lesions have been reported (Dailey et al., 2000). Gastrointestinal anisakidosis (human infection with *Anisakis* larvae) is linked to the consumption of raw/undercooked fish and squid. Bowhead whales most likely acquire infection through consumption of marine krill and copepods which are intermediate hosts, and less likely through fish and squid, which are paratenic hosts.

A variety of *Crassicauda* species have been documented in various baleen whales, including the southern right whale and the bowhead whale (Delyamure, 1955; Skrjabin, 1969). The previously ascribed presence of *Crassicauda crassicauda* in bowhead whales has been contested by Baylis (1916) and others due to marked inconsistencies between subsequent authors as to the species of whale (i.e., blue whale, fin whale, minke whale, bowhead whale, and sei whale) from which the original specimen was obtained. Since 2014, kidney worm infection has been documented in BCB bowhead whales (Stimmelmayr, 2015; George et al., 2017; Stimmelmayr et al., 2018). Species identification was based on morphological criteria and phylogenetic analysis performed on 18S sequences of two specimens, which allowed us to assign them to *Crassicauda* spp. (Stimmelmayr, Verocai, and Baird, unpublished data). Morphologically, the two specimens had cephalic papillae arrangement similar to that of *Crassicauda boopis*, *C. crassicauda*, *Crassicauda costata*, and *Crassicauda tortilis* (Baylis, 1916; Skrjabin, 1966, 1969; Lambertsen, 1985). The egg size range (length between 52.5 and 57.5 μm, and diameter between 32.5 and 37.5 μm) partially overlaps with that of the mentioned species. Spicules were absent in the caudal extremity of the one male specimen, similar to *C. boopis* and *C. tortilis*. Vestigial spicules are present in *C. costata*. Given the limitation of the 18S sequence for definitive molecular species identification (see Marcer et al., 2019), additional nematode molecular markers have been added to improve species discrimination, and morphological features are being analyzed. The life cycle of *Crassicauda* is not well understood. For its indirect life cycle, proposed host infection occurs by larval ingestion through various intermediate hosts (prey items) and for the direct transmission, calves are infected by larval ingestion through urine-contaminated milk (Lambertsen, 1985, 1986). Presence of adult nematodes in the kidneys of weaning fin whale calves has provided support for the whale to calf transmission. Recent isolation of larval *C. boopis* from the intestinal lumen of a fin whale calf (Marcer et al., 2019) provides support for the direct life cycle. Gross and histopathological renal examination of a mature pregnant female bowhead whale (NSB-DWM 2019B9) with severe *Crassicauda* infection and her full-term fetus (NSB-DWM 2019B9F) did not provide evidence for in utero transmission (Stimmelmayr and Rotstein, unpublished data). Congenital transmission of nematodes with a tissue migratory phase has been shown for humans and dogs (Costa-Macedo and Rey, 1990) and a possible transplacental route of infection has been considered for *Crassicauda* in baleen whales (Lambertsen, 1992). Given the emerging nature of this host−parasite relationship and the incomplete understanding of the life cycle of *Crassicauda*, much research is needed to further characterize the ecology of this unique parasite. Arctic climate change (Chapter 27) may be setting the stage for an evolving host−parasite relationship in the BCB bowhead whale stock.

Renal lesions associated with mild to severe *Crassicauda* infection have been confirmed in 23 bowhead whales landed in Utqiaġvik (2013−19 spring), predominantly in immature whales (76%). In fin whales, a high prevalence was also seen in calves (Lambertsen, 1986). It is unclear whether the age distribution reflects sampling bias (~70% immature; Chapter 32) or indicates age-related host−parasite effect. A sex-biased parasitism, a common phenomenon among many host−parasite relationships (Klein, 2004) cannot be ruled out as of yet. Predominant gross renal lesions in bowhead whales with mild to severe crassicauda infection include renal arteritis with and without partial lumen occluding thrombi, single to multiple renal granulomas and renal cysts (Stimmelmayr and Rotstein, unpublished data). Such lesions are similar to what has been described for Cuvier beaked whales (Díaz-Delgado et al., 2016) and less similar to what has been reported for fin, humpback, and blue whales (Lambertsen, 1986). Results from analysis of limited serum chemistry for two bowhead whales (NSB-DWM 2016B16 and 2016B22) suggest that renal lesions were unlikely to have impacted renal function. Creatinine values (1.9 mg/dL; 4.0 mg/dL) were within reported ranges for bowhead whales, while BUN (blood urea nitrogen) for both whales (110 mg/dL; 97 mg/dL) exceeded reported ranges (Chapter 11). Serum electrolytes of NSB-DWM 16B22 (potassium 9.0 meq/L; chloride 122 meq/L) were within the previously reported ranges. Redundancy of kidney tissues (i.e., size and weight) and mild to moderate *Crassicauda* infection may explain the apparent lack of an effect of these lesions on kidney function markers in the two bowhead whales. Renal failure due to severe *Crassicauda* infection has been described for fin whales (Lambertsen, 1992).

Amphipoda

Cyamids, commonly known as whale lice, are benign skin feeding cetacean ectoparasites (Fig. 30.2B). They range in size from 3 to 30 mm and spend their entire lives on a whale (Rowntree, 1996). Based on morphological identification, bowhead whales carry

Cyamus ceti (synonym of *Cyamus mysticeti* Liitken, 1870; Dall, 1872), as do gray whales and right whales (Felix, 2013). Cyamids are associated with natural body crevices (blowholes, genital slit, palpebral fissure, mouth gape, gum line, flipper insertion), scars, and wound cavities. Since cyamids have no free-swimming stage, infection depends on direct physical contact between whales. Cyamid prevalence and body burden of BCB bowhead whales is around 20% with an average body burden of 1−5 whale lice (Von Duyke et al., 2016). Heavy cyamid infestations (∼50−100 cyamids) are uncommon, but have been observed in bowhead whales entangled in fishing gear, bowhead whales with old entanglement injuries, and previously harpooned bowhead whales. In right whales, blowhole-associated cyamid burden is correlated with long-term entanglement events and other injuries (Rolland et al., 2007a). Cyamid burden has been visually assessed on free-ranging Okhotsk Sea (OKS) stock of bowhead whales and appears to be greater than what is known for BCB bowhead whales (Shpak and Stimmelmayr, 2017).

Diatoms

Diatoms, single-celled benthic microalgae, are present in the aquatic environment and known to colonize whale skin. Diatoms are considered epizoic organisms of cetaceans. Eroded skin areas tend to harbor more diatoms (Heckmann et al., 1987; Henk and Mullan, 1996). Heavy colonization of whale skin with diatoms results in yellow to ochre skin discoloration, mostly notable on any white skin and is occasionally observed in BCB and OKS bowhead whales (Fig. 30.2D). During commercial whaling, large balaenopterid whales with heavy loads of diatoms turning them yellow were called "algae whales" (Japan), and "sulfur bottoms" (Alaska; blue whale). Epizoic diatoms species identified from bowhead whale skin include the genera *Cocconeis*, *Stauroneis*, *Gomphonema*, and *Navicula* (Heckmann et al., 1987; Henk. and Mullan, 1996). Diatom species composition on large whales is reflective of their feeding grounds (Nemoto, 1956).

Seasonal skin molting as reported for three bowhead whale stocks (OKS, Chernova et al., 2016; Eastern Canada-West Greenland, Fortune et al., 2017; BCB, Rehorek et al., 2019) could provide a regulatory mechanism for shedding cyamids, epizoic diatom, as well as photo-damaged skin (Martinez-Levasseur et al., 2013; Shpak and Stimmelmayr, 2017).

Noninfectious diseases

This section describes noninfectious lesions in the bowhead whale, except for those that are anthropogenic (bycatch; shipstrike; blast injury, see Chapter 36), predatory (Chapter 29), and toxin related (Chapter 37). Lesions are described by organ system with the exception of neoplastic lesions which are discussed separately. Reported findings are based on gross examinations and study of standard and abnormal tissue samples (Table 30.2) collected for histopathological examination from landed bowhead whales harvested between 1979 and 2019 in Utqiaġvik, Kaktovik, Wainwright, Saint Lawrence Island (Gambell, Savoonga), Cross island, and Point Hope.

TABLE 30.2 Summary of range of lesions observed in tissue specimens collected from hunted bowhead whales ($n = 382$; 1979—2019).

	Lesions observed	% Affected
Cardiovascular system *(n = 200)*		
Contraction band necrosis	8	4.00%
Granulomatous myocarditis	1	0.50%
Interstitial myocarditis	3	1.50%
Attenuation	2	1.00%
Hemorrhage	2	1.00%
Respiratory system *(n = 262)*		
Congestion	8	3.1%
Hemorrhage (harvest related)	63	24.0%
Alveolar histiocytosis	4	1.5%
Interstitial fibrosis	6	2.3%
Pulmonary edema	1	0.4%
Iatrogenic intravascular skeletal muscle and bone (harvest related)	1	0.4%
Bronchopneumonia	1	0.4%
Thrombosis	1	0.4%
Interstitial pneumonia	1	0.4%
Pleural tags	1	0.4%
Angiomatosis	1	0.4%
Pulmonary vernix caseosa	5	1.9%
Pleural fibrosis	1	0.4%
Fetal atelectasis	2	0.8%
Nervous system *(n = 6)*		
Subdural hematoma (harvest related)	2	33.3%
Endocrine system *(n = 39)*		
Adrenalitis	1	2.6%
Adrenal cortical hyperplasia	2	5.1%
Adrenal hemorrhage	1	2.6%
Adrenal gland cortical attenuation	1	2.6%
Thyroid gland follicular cysts	1	2.6%
Thyroid gland adenoma	1	2.6%
Thyroid gland atrophy	1	2.6%

(*Continued*)

TABLE 30.2 (Continued)

	Lesions observed	% Affected
Hemato/lymphoreticular system *(n = 268)*		
Sinus histiocytosis	27	10.1%
Hemosiderosis	1	0.4%
Congestion	11	4.1%
Eosinophilic lymphadenitis	1	0.4%
Lymphoid hyperplasia	20	7.5%
Fibrosis, lymph node	5	1.9%
Extramedullary hematopoiesis	3	1.1%
Reactive lymph node	1	0.4%
Lymphoid depletion	1	0.4%
Preneoplastic	1	0.4%
Lymphadenitis	2	0.7%
Lymph node edema	2	0.7%
Splenic periarterial hemorrhage	3	1.1%
Hyalinosis spleen	2	0.7%
Thymic cysts	1	0.4%
Digestive system *(n = 57)*		
Pancreatitis	2	3.5%
Pancreatic atrophy	1	1.8%
Pancreatic nodular hyperplasia	1	1.8%
Granulomatous and eosinophilic gastritis/gastroenteritis	2	3.5%
Gastritis	6	10.5%
Gastric fibrosis and mucosal epithelial hyperplasia	2	3.5%
Gastric submucosal abscessation	1	1.8%
Gastroenteric trematodiasis (Ogmogaster)	1	1.8%
Alimentary lymphosarcoma	1	1.8%
Mucosal-associated lymphoid hyperplasia	1	1.8%
Enteritis	10	17.5%
Small intestine congestion	1	1.8%
Colitis	5	8.8%
Colonic submucosal fibrosis	1	1.8%

(*Continued*)

TABLE 30.2 (Continued)

	Lesions observed	% Affected
Epidermal inclusion cyst (glossal)	1	1.8%
Palate compression and erosion	1	1.8%
Rope injury: glossal compression, fibrosis, glossitis	3	5.3%
Glossal epithelial hydropic swelling	1	1.8%
Intraepithelial vesicular stomatitis (fetus)	1	1.8%
Glossal hyperplasia and fibroplasia	2	3.5%
Musculoskeletal system *(n = 303)*		
Hemorrhage with or without myofiber necrosis (harvest related)	14	4.6%
Myofiber degeneration (harvest related)	43	14.2%
Sarcocystis	3	1.0%
Compression atrophy (adipose)	1	0.3%
Urinary system *(n = 288)*		
Intraductal mineral	23	8.0%
Granulomatous nephritis	1	0.3%
Congestion	9	3.1%
Interstitial fibrosis	14	4.9%
Hemorrhage (harvest-related)	3	1.0%
Chronic infarct	1	0.3%
Interstitial nephritis	3	1.0%
Perirenal hemorrhage	1	0.3%
Periglomerular fibrosis	1	0.3%
Crassicaudiasis	12	4.2%
Renal fibrosis	2	0.7%
Cystitis	1	0.3%
Hydronephrosis	1	0.3%
Renal nephrolithiasis	1	0.3%
Renal cyst with atrophy and hydronephrosis	1	0.3%
Umbilical congestion	1	0.3%
Reproductive system *(n = 200)*		
Testicular atrophy	8	4.0%
Testicular fibrosis	1	0.5%

(*Continued*)

TABLE 30.2 (Continued)

	Lesions observed	% Affected
Epididymal fibrosis	1	0.5%
Ovarian congestion/hemorrhage	1	0.5%
Mesovarial angioleiomyoma	1	0.5%
Mesovarial abscess	1	0.5%
Mastitis	1	0.5%
Placenta congestion and hemorrhage	1	0.5%
Placenta edema	2	1.0%
Endometrial hyperplasia	1	0.5%
Penile epithelial hyperplasia	1	0.5%
Hepatobiliary system *(n = 293)*		
Congestion	63	21.5%
Hemosiderosis	13	4.4%
Hemosiderosis subset: Kupffer cell hemosiderosis	13	4.4%
Periportal hepatitis	2	0.7%
Extramedullary hematopoiesis	4	1.4%
Hepatitis	4	1.4%
Portal fibrosis	4	1.4%
Fibrosis	2	0.7%
Central vein fibrosis	1	0.3%
Bile duct hyperplasia	2	0.7%
Hepatic lipidosis	6	2.0%
Lipomatosis w/ or w/o heterotrophic bone formation	14	4.8%
Extracapsular fatty adhesion	1	0.3%
Chronic passive congestion (hepatocellular atrophy)	1	0.3%
Sinusoidal distension	1	0.3%
Capsular fibrosis	1	0.3%
Integumentary system *(n = 139)*		
Erosive dermatitis	7	5.0%
Erosion (noninflammatory)	4	2.9%
Blubber congestion and hemorrhage	3	2.2%
Fat necrosis and saponification	2	1.4%

(*Continued*)

TABLE 30.2 (Continued)

	Lesions observed	% Affected
Steatitis (infarcted adipose)	2	1.4%
Sclerosing (infarcted adipose)	1	0.7%
Dermatitis	18	12.9%
Bacterial dermatitis (subset of dermatitis)	2	1.4%
Mixed (protozoal/bacterial/algae)	3	2.2%
Pox virus	3	2.2%
Perivascular dermatitis	1	0.7%
Suppurative and ulcerative dermatitis	2	1.4%
Dermal fibrosis (eschar)	9	6.5%
Epidermal laceration/trauma	2	1.4%
Hyperkeratosis	10	7.2%
Epithelial depression (trauma)/superficial	1	0.7%
Epithelial degeneration	1	0.7%
Edema (intercellular)	1	0.7%
Epithelial hyperplasia	10	7.2%
Epithelial necrosis	4	2.9%
Hydropic degeneration	2	1.4%
Fibroma	1	0.7%

Not all organs were collected for every individual sampled, hence totals vary. Sample includes 73% (262/359) immature (<40′; 12.2 m), 27% (97/359) mature (>40′ >12.2 m), 52% (190/363) females, and 48% (173/363) males. These statistics exclude fetuses, calves, and specimens with incomplete data.

Neoplasia

Similar to other baleen whales, observation of neoplastic lesions in bowhead whales are rare occurrences. Affected organs include the liver, the female genital tract, the small intestines, the kidney, and the thyroid gland. With the exception of liver-associated benign neoplastic lesions, respective tumors represent single cases.

Benign fatty masses (lipomas; myelolipomas; Fig. 30.3A) of the liver are common in bowhead whales (Stimmelmayr et al., 2017). Observed lesions, single or multiple white to yellow pink white nodules, are well demarcated ranging in size 0.5–3 cm and are commonly found on the diaphragmatic aspect of the liver. The masses extend into the liver tissue. Observed hepatic lesions are not associated with extensive atrophy and/or destruction of surrounding hepatic parenchyma. Furthermore, lesions are not associated with other significant disease in examined bowhead whales. The pathogenesis and exact

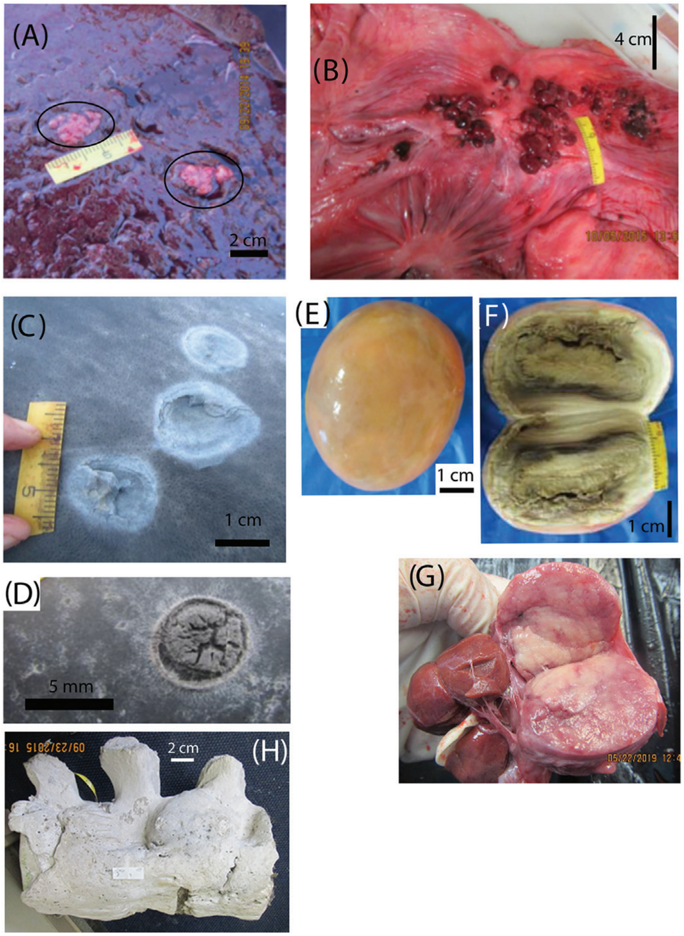

FIGURE 30.3 Neoplasia, integumentary, and skeletal lesions of bowhead whale. (A) Hepatic lipoma (NSB-DWM 2014B8). (B) Angioleiomyoma of the mesovarium (NSB-DWM 2015B24). (C) Ulcerative circular depressions on skin. (D) Raised skin plug. (E and F) Encapsulated fat mass, with internal necrosis (F). (G) Renal carcinoma (opened) with two normal reniculi (NSB-DWM 19B6). (H) Ankylosed thoracic vertebrae. *Source: Photos by R. Stimmelmayr.*

cell origin of these benign fatty tumors in bowhead whales remain undetermined. Lipomas in various anatomical locations (brain, stomach, intestines, muscle) have been reported in other baleen whales (Newman and Smith, 2006).

A case of an angioleiomyoma, a rare vascular variant of leiomyoma, was observed in a mature pregnant female (NSB-DWM 2015B24; Fig. 30.3B; Stimmelmayr and Rotstein, unpublished data). The benign tumor presented as multiple (100) discrete sessile burgundy red round masses ranging in size from 0.5 to 1 cm arising from the mesovarium. Uterine leiomyoma, but not angioleiomyoma are among the most commonly reported benign tumors of the female genital tract in cetaceans (Newman and Smith, 2006; St. Leger et al., 2018). A single stalked and pedunculated cystic white vaginal fibroma ($4 \times 2.5\ cm^2$) was observed in a mature female bowhead whale (NSB-DWM 2004B11). Fibromas of the vagina are uncommonly reported in cetaceans (Newman and Smith, 2006). A discrete thyroid gland adenoma was observed on histopathology in a bowhead whale (NSB-DWM

2014B7; Stimmelmayr, 2015). Thyroid adenomas (adenomatous hyperplasia) have been previously reported in aged toothed whales (Newman and Smith, 2006; St. Leger et al., 2018) but not baleen whales.

A renal carcinoma (4 × 3.5 cm) involving a single renicule was observed in a mature pregnant female (NSB-DWM 2019B6; Fig. 30.3G, Stimmelmayr and Rotstein, unpublished data). The neoplastic lesion was concurrent with bilateral moderate to severe kidney worm infection. Chronic inflammation caused by urogenital parasitism has been associated with urinary tract malignancy in humans (Kuehn et al., 2016). Neoplastic lesions associated with crassicauda infection in other whales have not been reported. Rare renal adenomas but not renal carcinoma have been described in dolphins (Gonzales-Viera et al., 2015). A suspect alimentary lymphosarcoma with no evidence for metastasis to other organs was diagnosed on histopathology in a large mature lactating female bowhead whale (NSB-DWM 1996B4; Stimmelmayr and Rotstein, unpublished data). Immunohistochemical examination for lymphoid markers failed, most likely reflecting the length of tissue storage in formalin (~24 years). Lymphosarcoma has been rarely reported in small cetaceans involving the lymph nodes, uterus, and central nervous system (Bossart et al., 1997; Arbelo et al., 2014; Díaz-Delgado et al., 2015a).

Integumentary system

A variety of epidermal lesions (shallow lacerations, circular depressions, and epidermal sloughing; Fig. 30.3) of mostly unknown etiology commonly occur in bowhead whales (Henk and Mullan, 1996; Haldiman et al., 1985; Philo et al., 1993). Specific microbiome alterations were associated with lesioned versus nonlesioned skin (Shotts et al., 1990). For example, *Corynebacterium* spp., *Acinetobacter* sp. and *Moraxella* sp. isolates dominated lesional skin, while yeast, *Candida* spp. were found on both normal and lesional skin. Most of these epidermal lesions range in color from gray to the typical black of bowhead whale skin. Untypical yellow discoloration from heavy diatom colonization involving the white chin patch area is occasionally observed (see "Diatoms" section). Anomalous white coloration (albinism) of bowhead whales, one in a full-term fetus and in two free-ranging bowhead whale, have been reported by Iñupiat hunters (McVay, 1973; Nerini et al., 1984; Eugene Brower, Charlie Hopson, Harry Brower Jr., personal communication). Pigmentation disorders including albinism have been observed in other baleen whales (blue, gray; humpback, fin) and in a broad range of toothed whales (Fertl et al., 2004; Methion and Díaz López, 2019).

Encapsulated fat necrosis in bowhead whales are a rare lesions associated with external (subcutis) and internal (body cavities) fat depots (Stimmelmayr et al., submitted for publication). These firm ellipsoid to round nodules present as whitish to pink in color, smoothly surfaced, and ranging in diameter from 6 to 15 cm (Fig. 30.3E and F, NSB-DWM 2014B15 and 2015KK1). Histopathologically, the nodules are composed of variably degenerated and necrotic adipocytes covered by a dense fibrous connective tissue capsule. The exact mechanisms of development of these encapsulated peritoneal and subcutaneous bodies in bowhead whales remains to be determined. Similar type lesions were described in other baleen whales during the time of commercial whaling in the Antarctic and southern Africa (Cockrill, 1960; Uys and Best, 1966).

Musculoskeletal system

Two cases of presumed congenital scoliosis (deformed vertebral column) without noticeable impact on swimming behavior have been observed in free-swimming bowhead whales (Mocklin et al., 2012; Vicky Beaver, personal communication). Rare cases of spinal ankylosis affecting multiple vertebrae have been observed in a Danish museum specimen (St. Leger, personal communication) and in two BCB bowhead whales (Nader, personal communication; Fig. 30.3H). Ankylosis of the axial skeleton has been reported in a southern right whale (La Sala et al., 2012). Since whole skeletons were not available, impact on locomotion and underlying etiology (degenerative; congenital, inflammatory/infectious, and trauma) of the observed vertebral abnormalities could not be assessed. Skeletal and body wall defects (rostral deformities; various abnormal deviations of the vertebral column; spina bifida, rib fusion, hernias) have been reported in baleen whales (for review see Lockyer, 1984; Kompanje, 1999; Groch et al., 2012) and small cetaceans (Berghan and Visser, 2000). The prevalence and etiology of congenital defects in cetaceans have not been determined, but similar to other species, multiple factors (genetic, infectious, and environmental) probably play a role. Other lesions associated with skeletal muscle were limited to myofiber degeneration (harvest related) and sarcocystosis.

Cardiovascular and respiratory system

Few myocardial lesions have been observed in harvested bowhead whales. With the exception of one unusual case of granulomatous myocarditis (NSB-DWM 2002B3; Stimmelmayr, 2015) with apparent gross lesions in a mature female bowhead whale, the remainder of myocardial lesions including myocardial contraction band necrosis (CBN) and interstitial myocarditis were strictly histological findings. CBN is part of a suite of pathological changes (myocardial renal lesions) brought on by massive catecholamine release (alarm reaction) in stranded cetaceans (Cowan and Curry, 2008; Groch et al., 2018). Respiratory lesions recorded in bowhead whales include isolated observations of lesions likely indicative of previous inflammatory processes of viral, parasitic or bacterial origin (i.e., alveolar histiocytosis; interstitial fibrosis; bronchopneumonia; interstitial pneumonia; pleural fibrosis; angiomatosis). Amniotic pearl aspiration was present in fetal lung tissue. In a mature whale that had been previously struck, a chronic reactive process in the thoracic cavity which involved the lungs was associated with an unexploded bomb that had penetrated the thoracic cavity (NSB-DWM 1998B23; unpublished data).

Digestive system

Upper digestive lesions involving the baleen feeding apparatus, tongue, and oral cavity in bowhead whales are rarely observed (Fig. 30.4A and B). Fractures of baleen plates causing lip and tongue abrasions were observed as a sequela to the unilateral fracture of the mandible in an immature female bowhead whale (Philo et al., 1990). Two other cases of ulcerated skin with secondary infection, located at the caudal aspect of the mouth were similarly attributed to physical trauma from baleen tips (Migaki, 1979 cited in Philo et al., 1993; Fig. 30.4B). Hypertrophy of the gray gum line seems to be mostly cosmetic without any obvious effect (NSB-DWM 2014B9; Stimmelmayr, 2015). Oral abscessation with

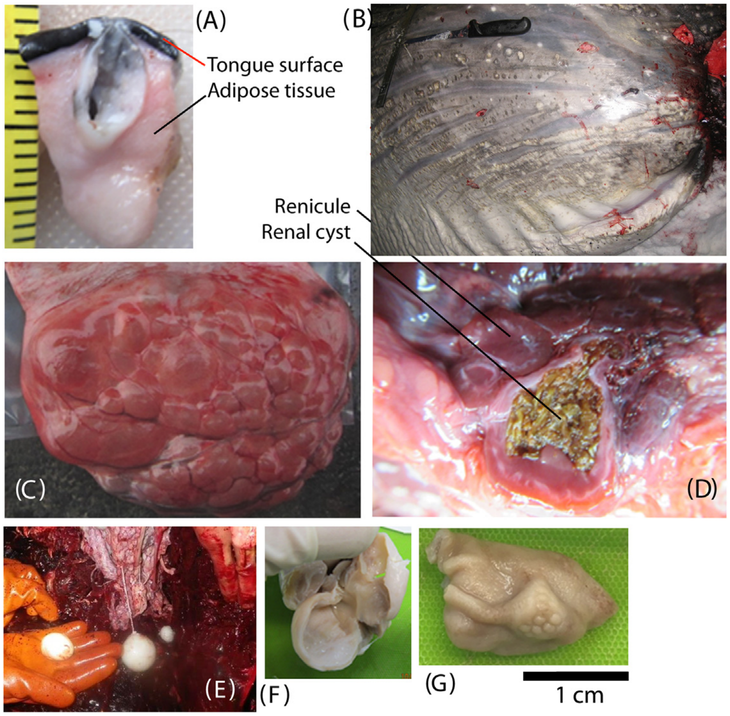

FIGURE 30.4 Lesions of the digestive and urogenital system of the bowhead whale. (A) Inclusion cyst of the tongue (NSB-DWM 2017KK2). (B) Ulcers on the surface of the tongue (NSB-DWM 2011B11). (C) Cobblestone liver (NSB-DWM 2016B19). (D) Renal cyst with worm debris. (E) Cavitary encapsulated fat necrosis (NSB-DWM 2015KK1). (F) Renal cyst (NSB-DWM 2003B5). (G) Lymphoid hyperplasia in intestine (with scale bar). *Source: Photos by R. Stimmelmayr except E by G. Sheffield.*

Clostridium perfringens and an unspecified *Fusobacterium*, involving the gumline and baleen plates of the right rostrum in a mature female has been reported (Philo et al., 1993). Baleen plate shedding of unknown etiology has been observed in sei, blue, and fin whales (Tomilin and Smyshlyayev, 1968). A single case of multiple epidermal inclusion cysts of the tongue has been observed in an immature bowhead whale (NSB-DWM 2017KK2; Fig. 30.4A). It is likely that these glossal cysts were acquired (traumatic implantation of epidermal tissue); however, the clustered presence of multiple cysts could suggest a genetic background. Epidermal inclusion cysts of the neck have been reported in two killer whales (Kamiya et al., 1979). Extensive acute and chronic circular depressed and raised ulcerative lesions of unknown etiology involving the oral cavity, anterior dorsal body of the tongue, and skin along the jawline were observed in an immature male bowhead (NSB-DWM 2011B11; Stimmelmayr, 2015).

With the exception of a suspect intestinal volvulus with marked tissue necrosis and peritonitis in an immature female bowhead whale (Heidel and Albert, 1994), inflammatory disease conditions of the gastrointestinal tract (i.e., gastritis, enteritis, and colitis) are mostly uncommon (Fig. 30.4E), generally mild and appear self-limiting. Isolated lymphoid hyperplasia of gut-associated lymphoid tissue alone or in combination with ulcerative enteritis is sometimes observed by whaling captains' wives during traditional food preparation in the small intestines and is most likely caused by parasite larvae tissue migration (NSB-DWM 2019B1and 2015B13). Gastric nodules associated with anisakid larvae infection described elsewhere (see "Parasites and Commensals" section).

Nonfood item ingestion by bowhead whales has been documented, including wood, mud, stones, and plastics (Lowry et al., 2004; Chapter 28). Plastics found in the intestines from four immature bowhead whales included clear plastic sheeting and black plastic from industrial type garbage bags (NSB-DWM 2013B6; NSB-DWM 2019N1 Thomas Napageak, personal communication). Obstructive potential of ingested plastic was low given their small size (less than 20 cm in greatest length). Bottom feeding of young bowhead whales (Chapter 28) may increase the likelihood of ingesting marine debris.

Liver lesions recorded in bowhead whales are probably indicative of previous inflammatory processes of parasitic, viral, or bacterial origin (i.e., hepatic lipidosis, hepatitis, bile duct hyperplasia, and fibrosis). Excessive stored intracytoplasmic iron (hemosiderosis) and extramedullary hematopoiesis were infrequently observed. In the absence of other indicators of systemic and hepatic disease, it is likely that they are physiological in nature and reflective of diving physiology associated processes of iron metabolism and red blood cell demands. A single case of a broad adhesion of liver to abdomen was observed in an immature whale. There was focally limited distorted liver architecture with cobblestone appearance and cysts contained yellowish fluid (Fig. 30.4C; NSB-DWM 2016B19). Histopathology was without significant findings. The pancreas in bowhead whales, a relatively small organ has been infrequently sampled. A few pancreatic lesions have been observed, including pancreatitis, pancreas atrophy, and pancreatic nodular hyperplasia.

Urinary system

Tissue samples from kidneys are regularly collected from landed bowhead whales and a variety of nonspecific findings associated with various etiologies have been observed in bowhead whales over the years including renal intraductal mineralization, renal/interstitial fibrosis, interstitial nephritis, congestion and hemorrhage, hydronephrosis, and chronic renal infarct. Given the enormous size and weight of kidneys (∼70−120 cm length; 21−48 kg, 42−108 lb), limited tissue sampling without complete external examination and dissection probably underestimates prevalence of subtle renal lesions. The emergence of kidney worm infections has led to a more thorough examination of complete kidneys of harvested individuals (see "Nematodes" section).

Renal fibrosis is commonly encountered lesion in older bowhead whales (Rosa et al., 2008). The potential contributory role of renal cadmium levels in the development of renal fibrosis (interstitial fibrosis) remains unresolved (see Chapter 37). Renal intraductal mineralization is not uncommon and has been observed in immature and mature bowhead whales. Similar type lesions have been observed in dolphins (Mackey et al., 2003). In dogs, excess phosphorus in the diet has been linked to renal mineralization. It is possible that this is the case for the bowhead whale too, as it primarily feeds on euphausiids which are characterized by a high phosphorus and calcium levels (seeChapter 28). The source of the interrenicular nephritis in two immature female and one immature male immature whales was not determined, but parasitic infection was likely based on the presence of eosinophils. A single case of localized renal infarction (interstitial fibrosis with tubular loss and periglomerular fibrosis) was observed in a mature male bowhead whale (NSB-DWM 2011B16). Renal infarction has occasionally been reported in other cetaceans (Díaz-Delgado et al., 2018;

Jepson et al., 2005). A simple renal cyst with atrophy and hydronephrosis was observed in a large mature female with concurrent multiple myocardial abscesses (NSB-DWM 2002B3). Renal cysts (Fig. 30.4F) have been mostly observed in bowhead whales with concurrent kidney worm infection, but *Crassicauda* infection was absent in this animal. Cystic renal disease is a common condition in small cetaceans (Gonzales-Viera et al., 2015).

Cases of renal nephrolithiasis (kidney stones) have been observed in bowhead whales (e.g., NSB-DWM 2018B15; Stimmelmayr, 2015). Renal calculi (~20) were composed of 100% calcium oxalate and varied in size (<1–4.1 mm in diameter). Calcium oxalate crystals have been previously described for bowhead urine (Chapter 11). No parasites were found in the kidneys of whale NSB-DWM 2018B15. Nephrolithiasis is common in captive bottlenose dolphins with a 100% ammonium acid urate stone composition (Venn-Watson et al., 2010). Bladder-associated lesions are rare with only two cases of cystitis observed one grossly in an immature female (NSB-DWM 2013B7) and one on histopathology in a large (~57′10″; 17.62 m) mature female bowhead whale (NSB-DWM 2017G2). Enlarged bladders, probably of neurogenic etiology with 20–50 L of urine content were observed in two bowhead whales (NSB-DWM 2015B2; 2018KK2).

Reproductive system

Reproductive disorders are uncommon in both sexes. Two cases of developmental sexual disorders (DSD) due to impaired androgen synthesis or action have been reported for bowhead whales (Tarpley et al., 1995). External genitalia were unambiguously female (short genital slit; presence of mammary slits with teats; see Chapter 7) with presence of hypoplastic gonads (testes) and absence of prostate gland, epididymides, and Muellerian duct derivatives. A single case of Muellerian agenesis/hypoplasia complex has recently been observed in a full-term female bowhead whale fetus (NSB-DWM 2019B9F). This abnormality was characterized by a noncommunicating uterine horn with abnormal uterine folding pattern (cobblestone vs normal longitudinal folds; Fig. 30.5C) and ipsilateral renal hypoplasia. DSDs are rare in cetaceans (Stimmelmayr et al., 2019).

The presence of vestigial nipples in male bowhead whales has not been systematically assessed, but mammary slits with or without rudimentary nipples do occur (see Chapter 10). In blue, fin and gray whales, male nipples appear to be consistently present (Clarke, 2005).

Signs of testicular atrophy in a mature bowhead were likely associated with senescence (14.91 m total body length), but were also observed in a few immature, most likely pubertal bowhead whales (total body length 12.4–13.4 m; O'Hara et al., 2002). Given that no other comorbidities/reproductive anomalies were present in these pubertal whales, underlying etiology of testicular atrophy remains undetermined. Single cases of testicular fibrosis and focal epididymis fibrosis of unknown etiology in an immature whale (NSB-DWM 2012B11) have been observed. With the exception of testicular lesions associated with *Brucella* infection testicular lesions (e.g., orchitis, epididymal necrosis) are rare in baleen whales (Tomilin and Smyshlyayev, 1968; Uys and Best, 1966). Penile disorders include shortened penis (~30 cm length) with "contorted penile glans" and marked atrophy of the testes in a mature bowhead whale (NSB-DWM 1990B2; Philo et al., 1993) and a case of penile epithelial hyperplasia concurrent with pigmentation disorder of unknown etiology in an immature bowhead whale (NSB-DWM 2011B11).

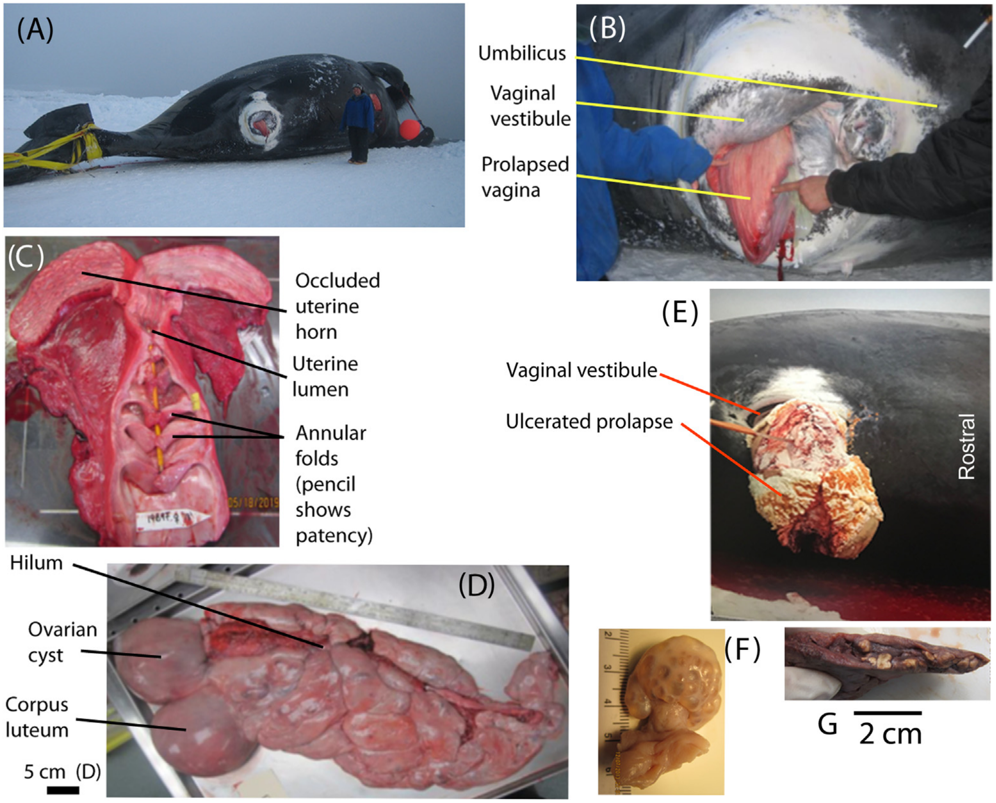

FIGURE 30.5 Disorders of the reproductive and immune systems. (A and B) Prolapsed vagina (NSB-DWM 2007B9) in overview (A) and close-up (B). (C) Noncommunicating uterine horn in fetus (NSB-DWM 2019B9F). (D) Ovary with cyst and corpus luteum (NSB-DWM 2013B1). (E) Ulcerated vaginal prolapse. (F) Cystic vaginal fibroma (NSB-DWM 2004B11, scale in mm), (F) Focal fibrosis of epididymis (NSB-DWM 2012B11). *Source: Photos by R. Stimmelmayr except A and B by J. C. George and E by Herbert Kinneeveauk.*

Single ovarian fluid-filled and solid cysts (possibly follicular and luteinized cysts) have been observed in two large females with early pregnancy (NSB-DWM 2013B1 and 2012S7; Stimmelmayr, 2015) and one nonpregnant mature female (Lara Horstmann, personal communication). In the pregnant females cyst diameter was comparable to the active corpus luteum ($\sim 14.5 \times 13.5$ cm) on the same ovary. Ovarian cysts are rare in baleen whales (fin whale Tomilin and Smyshlyayev, 1968).

Dystocia is suspected in one whale with a full-term fetus (NSB-DWM 2007B9) which showed vaginal prolapse (first pseudocervix; Fig. 30.5A and B). In a similar case, a large female presented with an ulcerated necrotic prolapsed vagina, however, pregnancy was not confirmed (2018, Point Hope, Herbert Kinneeveauk, personal communication). Parturition-associated complications (dystocia, stillbirth, abortions, perinatal death) have been documented in various baleen whales stocks (Slijper, 1949; Cockrill, 1960; Stephen et al., 1978, McAloose et al., 2016). An unusual endometrial type lesion was observed in a mature postpartum female (NSB-DWM 2002B2; Stimmelmayr, 2015). Multiple pedunculated masses (polyps) ranging in size 1−3 cm and smaller sessile masses were present in the left uterine horn. The polyps on the endometrial surface were fibrovascular with interspersed erythrocytes, collagen, hemosiderophages, and basophilic mineral. Hemorrhage had taken place in the endometrium with associated hemosiderosis being consistent with a postpartum/involuting uterus. We speculate that the endometrial fibrovascular nodules are likely regressed sites of placental/maternal connection in a diffuse epitheliochorial placenta (see Chapter 13).

Immune and endocrine system

Mesenteric lymph nodes (MLNs) are regularly collected from landed bowhead whales and a variety of nonspecific findings associated with various etiologies have been observed in individual bowhead whales including sinus histiocytosis (sinus hyperplasia), congestion, lymphoid hyperplasia (Fig. 30.4G), lymphnode fibrosis, lymph node edema, lymphoid depletion, activated lymph node, and hyaline deposits. Extramedullary hematopoiesis (EMH) within MLN was observed in two immature whales (NSB-DWM 2006B14 and 2006B16).

Few endocrine lesions are present in bowhead whales including thyroid gland follicular cysts, thyroid gland atrophy, thyroid gland adenoma (see "Neoplasia" section), adrenalitis, adrenal cortical hyperplasia, and adrenal cortical atrophy (Table 30.2). A similar suite of lesions have been reported in beluga whales (Lair et al., 2016).

Special senses

Lens yellowing (Fig. 30.6B and C) occurs with aging in baleen whales (blue and fin whale Nishiwaki, 1950; bowhead whale George et al., 1999; gray whale Stimmelmayr, 2019). Although brunescent lenses still transmit light, short wavelength light transmission is reduced (Artigas et al., 2012; Najjar et al., 2014). Cetaceans have a blue light shifted

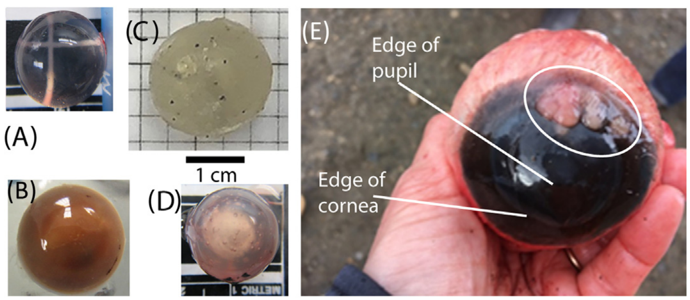

FIGURE 30.6 Disorders of the visual system of the bowhead whale. (A) Clear lens of a healthy individual. (B) Brunescent lens (NSB-DWM 2001B10). (C) Yellow lens of a gray whale (NSB-DWM 2018GW0815FD). (D) Lens with cataract (NSB-DWM 2017B6). (E) Eyeball with nodular granulomatous episcleritis (NSB-DWM 2019KK2). *Source: Photos by R. Stimmelmayr except E by G. Sheffield.*

photopigment rhodopsin which improves visual acuity in dim light environments (Chapter 18). Similar to other baleen whales (Nishiwaki, 1950; Harms et al., 2008; Panfilov, 1975, Stimmelmayr, 2019) cataracts (NSB-DWM 2017B6 and 2019KK2; Rolland et al., 2019, Fig. 30.6D) and corneal clouding (NSB-DWM 1996B14; Qian, 1997) are rare ocular disease conditions in the bowhead whale (Fig. 30.6C). An unusual case of bilateral nodular granulomatous episcleritis was observed in an immature female bowhead whale (Fig. 30.6E; NSB-DWM 2019KK2). Rare lesions of the spiral ganglion of the ear in bowhead whales have been documented (Sensor, 2017) and are consistent with hearing damage.

Conclusions

Over the last 40 years the basic knowledge of diseases in bowhead whales has continued to expand, and it provides valuable baseline data to assess future trends. In the face of the dramatic ecosystem transformation that the subarctic and Arctic are undergoing, continued health assessment of the bowhead whales is essential. This will provide timely data for the Inuit communities who depend on this whale for nutritional, cultural, and spiritual well-being; and for the scientists and agencies engaged in management and conservation of the bowhead whale.

Acknowledgments

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