VI. Interactions With Humans

Harp seals have been hunted by humans for centuries and some hunting continues today. In recent years, however, sealing activities have declined sharply, largely due to the imposition of trade bans (e.g., the 2009 European Union ban) and a lack of markets for seal products (see ICES, 2014). Canada recently increased its total allowable catch for Northwest Atlantic harp seals from 330,000 in 2010 to 400,000 for 2011–13, but landed catches nonetheless declined to an average of about 65,000 harp seals per year for 2010–14. Greenland’s hunt for Northwest Atlantic harp averaged 75,000 harp seals per year for 2010–12.

Previous concerns that overexploitation and largely unregulated trade in seal products (seal skins, oil, and penises) which represented potential threats to the species have largely abated with reduced harvests. Concerns persist, however, about unnecessary pain and suffering experienced by individual seals in sealing operations (EFSA, 2007). Other frequently cited threats include: proposals to cull harp seal populations, ostensibly to benefit commercial fisheries, including the creation of “sea exclusion zones,” incidental catches in fishing gear, environmental contaminants, and reduced food availability due to overfishing. However, the most serious threat to harp seals today is global warming (Johnston et al., 2005; Kovacs et al., 2011). Lack of suitable ice during the pupping season, combined with violent storms, and early ice break-up, disrupts the harp seals’ normal pupping season. If warm years with reduced ice coverage become the norm, as appears to be happening, there will be additional effects including impacts on their fish and invertebrate prey, which will have ripple effects on seal condition, growth, reproductive success, and survival.

See Also the Following Articles

Arctic Marine Mammals ★ Earless Seals (Phocidae) ★ Hunting ★ Pinnipeds

References


Because of their longevity and high trophic status within ecosystems, marine mammals have rightly been seen as sentinels for ocean health. Their health can be viewed at different levels of organization including: Molecular (endocrine disruption and persistent pollutant load); cellular (wound repair or evidence of viral skin disease); organism (body condition and reproductive history); population (demographics, status and trends in the context of pre-exploitation size); species (extinct, extirpated, endangered, threatened or thriving); and ecosystem (El Niño impacts on nutrient availability and algal blooms that clinically manifest in marine mammals, which prey on many fish species harvested for human consumption). Each level reflects complex and dynamic processes. Although health is much more than simply the absence of disease or disability in an individual, most of our insights into marine mammal health are afforded at the individual level. This is the “unit” that is most tractable, readily defined and approachable. Individuals can be examined alive within a captive display or research collection, as live or dead stranded/beached animals, as restrained wild animals that are examined and released, or by remote sampling or observation of free-swimming animals.

I. Individual Physical Examination

Body Condition—The most fundamental parameter for health assessment is that of body mass index. Ratios of weight to length (if available), or length to girth if mass measurements are not available, can immediately signal the overall long-term health status of an individual. Consider a live, stranded, emaciated large whale on a beach. Well-meaning individuals will often clamor for efforts to refloat such animals, but without an understanding of the cause of the emaciation, an informed disposition for the animal cannot be rendered. Indeed, it is very rare that such emaciated animals can survive if refloated, as buoyancy is compromised, metabolic exhaustion may supervene and the cause of their emaciation is almost certainly not reversible without long-term managed rehabilitation. This management option is practical in very few incidents for marine mammals, usually involving smaller species. Thus, the most useful tools for assessing the health of a marine mammal are a tape measure and an educated observer. Beyond these basics, there is an array of diagnostic tools and approaches one might consider,
the choice of which will depend on your perspective, expertise, and available resources.

**External Appearance**—Whether in a tank, on a beach, or free swimming, the external appearance of an animal is readily observed and is a major indicator of individual health. For a review of cutaneous lesions in cetaceans see Mouton and Botha, (2012). Knowledge of the normal skin color and texture of each species allows for contextualizing observations. Conspicuous tooth rake marks are common and normal for some odontocete species such as *Turnipops* spp. and *Grampus griseus*; whereas, killer whale and shark teeth marks may reflect increased susceptibility to predation. Moreover, skin color in chronically entangled right whales (*Eubalaena* spp.) can often appear patchy gray and swollen as opposed to their normal mostly black dorsal surface. Furthermore, a proliferation of orange whale lice (*Cymis erraticus*) in wounds and over the skin surface of emaciated right and gray whales (*Eschrichtius robustus*) is a poor prognostic sign. Certain bacterial (*Erisipelus rhuthrophathiae*), fungal (e.g., *Lacazia loboi* and lobomycosis-like lesions), and viral (herpes, parapox and papilloma) infections that may manifest as cutaneous lesions, have been associated with environmental degradation. These pathogens can be visualized by histopathology of tissue biopsies, cultured by conventional microbiology, or identified with polymerase chain reaction (PCR) probes. More recent studies have employed deep sequencing of bacterial communities on cetacean skin to assess variability in community composition in the context of habitat, nutritional status, and presence of entanglement (Aprill et al., 2014). Similar assays have been used to assess orifice swabs in restrained wild dolphins (Nelson et al., 2015).

**Clinical Assessment**—A more detailed analysis involves assessment of behavior; examination of the ears, eyes, and nares; if accessible, palpation of peripheral lymph nodes; observation of respiratory characteristics, including rate, quality of expiration, and collection of any nasal discharge or expectorated mucus; auscultation of the lung and heart; examination of the abdomen; collection of gastric contents, fecal and urine samples; and evaluation of muscular and neurological systems. Blood samples are often informative with regard to hematology (cellular components) and clinical chemistry profiles, potentially indicating acute or chronic infection, anemia, dehydration, tissue perfusion, hepatic and renal function, musculoskeletal injury, and serological status. Although microbiological swabs can be used to examine external lesions for evidence of infection, caution should be exercised with interpretation of results and isolates should be placed in clinical context. Likewise, skin/blubber biopsies can be assayed for histological change, presence of pathogens, as well as a range of biological markers, such as endocrine indicators of pregnancy or stress and presence of and biomarkers for persistent organic pollutants (POPs).

**Necropsy**—Where mortality is involved, systematic examination of the carcass, with routine tissue sampling for histopathology and ancillary diagnostics, such as microbial, toxicologic, life history, and molecular assays is critical. Such studies are most informative when decomposition is minimal; however, some tissues (such as bone and blubber) are remarkably resilient to putrefaction, thus insight can often be gained even from cases that present in advanced autolysis. In cases of mass strandings in remote areas, animals should be triaged and tissue sampling prioritized. With field necropsies in these circumstances, the head should be removed, ears collected for microscopic and ultrastructural studies, and any intravascular gases aspirated for chemical analysis (Bernaldo de Quirós et al., 2013).

**Imaging**—Health can also be imaged at various scales. Body condition can be measured photogrammetrically using manned or autonomous aircraft (Fig. 1). Ultrasound can measure blubber thickness and assess a range of internal health parameters, such as lung, renal, and hepatic condition, and stage of pregnancy. Plain film radiography is routinely used in managed care and rehabilitation settings and has been used in field capture assessments. When logistically feasible and accessible, more advanced imaging modalities, such as computed tomography, magnetic resonance and tracer-based imagings, have also been used in live stranded and fresh dead animals to assess for gas bubble formation and embolization, ear pathology, multisystemic hemorrhage, skeletal fractures, chronic neurologic effects of domoic acid exposure in the hippocampus, and other disorders.

**Functional**—As more baseline data are compiled over time and across species, physiological tests may provide a valuable adjunct to assess system specific and individual health. Pneumotachography and expired gas measurements (Fahlman et al., 2015) provide excellent perspectives on respiratory function. Electrocardiography, tissue perfusion, and blood pressure (if practical) can yield valuable data on cardiac function. Similarly, auditory-evoked potentials can gauge hearing sensitivity over a range of frequencies. Functional magnetic resonance imaging can assess neurological function in more chronic stages of disease, such as domoic acid toxicity (Cook et al., 2015).

**II. Measures of Population Health**

**Demography**—Measures of fecundity, perinatal survival, recruitment, mortality, and population trends over time can reveal invaluable insights into overall status of specific populations. Where
major impacts on populations or ecosystems have occurred, such as viral disease outbreaks or chemical spills, epidemiological modeling has proved a valuable tool to assess population health, status, and prognosis, as well as identify potential vectors and reservoirs of infection.

Assessment—Scenarios where health can be assessed include single and mass live beach stranding (Sharp et al., 2014). Stranding health assessment enables better informed triage of live animals. With more guarded prognoses, candidate animals may be admitted to a rehabilitation center; whereas, individuals that are more suitable may be relocated to a deep-water beach for release. If the opportunity for satellite tracking of release animals is available, review of the stranding outcome should be undertaken (Sharp et al., 2016). Examination of temporarily restrained wild animals can be very informative (Schwacke et al., 2013) and has become the foundation for evaluating health impacts of environmental disasters on wild populations.

Diagnostic Approach

Given the above tools, the best way to investigate the potential cause(s) of suboptimal health or mortality is to undertake comprehensive clinical, pathologic and epidemiologic studies to rule in or out specific disease entities. To undertake this process, it is helpful to run through a potential checklist of disease processes in each case. This might include both infectious (bacterial, fungal, viral, protozoan and metazoan parasites) and noninfectious entities (nutritional, traumatic, genetic, developmental, congenital, degenerative, toxic, neoplastic, idiopathic, ischemic, allergic, endocrine, metabolic, and immunologic). It is important to note that it may be difficult to define the chronological progression of preexisting versus supervening disease entities, as well as assign a significance to their respective contributions to antemortem morbidity and subsequent loss of the animal (proximate vs immediate cause of death). Current and emerging examples of some of the above infectious and noninfectious diseases and their health implications from an individual to population level perspective are described below.

Important and Emerging Conditions in Marine Mammals

Brucella—Brucellae are Gram-negative facultative intracellular bacteria that are increasingly being detected in cetaceans. Animals infected with Brucella cetti may present initially with bacteria in the bloodstream, subsequently developing infection of the reproductive, neural and/or skeletal systems. It is zoonotic and of concern for those individuals responding to and necropsying beached cetaceans and pinnipeds. At present, the risk to humans is unclear. In a review of Brucella isolates and brucellosis in cetaceans (Moreno et al., 2012), this genus was detected in 28/42 (67%) of surveyed cetacean species. In odontocetes, the bacteria was most prevalent at 13% (32/248). Although the bacteria appear to be worldwide, many geographic areas and species have not been adequately sampled. The majority of test-positive, live-stranded, or field-sampled animals was asymptomatic and may reflect host adaptation or prior protective immune response. However, animals with neurobrucellosis may present with dorsal arching of the neck, tremors, seizures, disorientation, and lack of buoyancy. Special laboratory culture for Brucella spp. requires a sterile sampling technique and should include gonads, spleen, liver, lymph nodes, synovial, brain, lung, and cerebrospinal fluid. In harbor seals (Phoca vitulina) and harbor porpoises (Phocaena phocoena), lungworms have been implicated as vectors for transmission and screening of collected helminths may be a proxy for other tissues, when tissue sampling may not be feasible. Additional diagnostic modalities include serology, PCR, and immunohistochemistry. Ante- or postmortem heart blood samples can be examined serologically for evidence of prior exposure, preferentially using competitive or indirect enzyme-linked immunosorbent assay (ELISA) tests. Test selection should be based on application for either confirmation, screening, or serosurveillance. Necrotizing placentitis, orchitis with abscessation, epididymitis, metritis, salpingitis, fetal death and resorption or abortion, meningoencephalitis, vertebral osteomyelitis, and erosive arthritis with remodeling, especially of the occipital condyles, vertebrae and scapulohumeral joints have been documented in marine mammals. Bacterial transmission may be vertical (placental or via suckling) or horizontal (venereal, consumption of contaminated fish, or exposure to ocular secretions). B. pinnipedalis has been recovered from pinnipeds and also isolated from stranded cetaceans.

Lobomycosis—Infection with Lacazia loboi has been reported in humans ( Francesconi et al., 2014) and as chronic skin disease in Delphinidae ( Van Bressem et al., 2015). The organism has not yet been cultured, but genetic studies suggest that the organism is phylogenetically close to Paracoccidioides brasiliensis. Infection typically presents as persistent, raised, ulcerated, gray or white verrucous to multinodular cutaneous lesions which may span more than 30 cm. Cetaceans afflicted with lobomycosis have died or presumed to have succumbed due to the infection. Histopathology of lesions feature numerous yeast-like organisms resembling L. loboi. Where biopsy samples cannot be obtained or examined microscopically, lobomycosis-like disease (LLD) has been presumptively recognized on the basis of photographic surveys of external lesions. These cases may reflect other disease agents, but appear comparable to those attributed to lobomycosis. Lobomycosis and LLD have been described in the United States, Brazil, Europe, Cuba, Venezuela, Colombia, South Africa, Ecuador, and Peru. Prevalence is variable, and may reflect sampling bias, but has also been shown to vary with salinity, and water quality (POP's and AHC's levels).

Morbillivirus—Members of this group of viruses have caused severe epizootics in both cetaceans ( Van Bressem et al., 2014) and seals ( Duignan et al., 2014). Other paramyxovirus-related diseases include distemper in canids and measles in humans. Clinical and pathologic findings are contingent on virus type, stage of infection, host species, intercurrent disease, and secondary bacterial or fungal involvement. Microscopic findings may include bronchointerstitial pneumonia, meningoencephalitis with lymphoid depletion, and synovitis. In cetaceans, the virus can be acutely fatal with bronchointerstitial pneumonia or survivors may succumb due to neurologic involvement or secondary infections often due to herpesviruses, Toxoplasma gondii, invasive ciliated protozoa, bacteria, and fungi. Population and ecosystem level of cetacean and pinniped mortality events have been described in Europe, Australia, and North America and in more restricted areas, outbreaks may have a significant impact on susceptible and geographically confined stocks. Viral detection and confirmatory testing often requires multiple diagnostic approaches and may be accomplished by tissue culture on SLAM cells, RT-PCR, electron microscopy, and immunohistochemistry. Follow-up serology can be informative for epidemiologic studies. In the initial stages of an outbreak, infected animals that present with ocularnasal discharge, pneumonia, and neurologic diseases should also be assessed for other differentials associated
with epizootics, including influenza virus, *Mycoplasma* spp., and domoic acid. In circumstances of depleted populations that may be threatened or endangered, vaccination in advance of exposure or ring vaccination during an outbreak may be considered. For example, Hawaiian monk seals (*Neomonachus schauinslandi*) are the first wild pinnipeds to be vaccinated for morbillivirus. From molecular and ecosystem health perspectives, it is imperative to differentiate canine distemper virus, which may suggest a terrestrially sourced pathogen, versus phocid or dolphin distemper virus that may cycle and persist exclusively within the marine environment.

**Blunt Trauma**—In marine mammals this is most commonly attributed to ship strike with impact along the bow, keel, or rudder, and less frequently with impact on moorings, dock or beach substrate (McLellan et al., 2013). These injuries may also occur following predation attempts or after inter- and intraspecific aggressions. With dark-skinned animals, clinical signs of physical trauma are often externally cryptic and thorough necropsy is required to reveal abrasions, shearing, degloving, bruising, hemorrhage, lacerations, or bone damage. Depending on the extent and anatomic location of injury, such trauma may or may not be lethal. Clinical signs can include abnormal locomotion, water logging, axial or appendicular skeletal displacements, swelling or depression at the point of impact, with or without local surface discoloration. Serous fluid or frank blood may accumulate, especially in the abdominal cavity and urogenital or gastrointestinal herniation or prolapse can occur. Cranial, scapular, rib and vertebral fractures are common. Histological examination of affected segments of bone for the evidence of healing and/or functional circulation at the time of trauma is important to rule out postmortem trauma. Multiple samples of skeletal muscle remote to the impact site should also be collected and evaluated microscopically for evidence of contraction band and coagulative necrosis associated with agonal or terminal adrenergic surge. Special stains for fat emboli may also be considered. Ancillary diagnostic tests to rule out other factors, or identify contributory causes could include virology, bacteriology, and biotoxin analysis. The Human Interaction form (Barco and Moore, 2013) should always be used with stranded marine mammals. With a documented history of a traumatic interaction, a confirmed case of blunt trauma is easier to diagnose and substantiate from a forensic perspective. Where necropsy data are insufficient or absent, and or decomposition is advanced, a diagnosis of probable or suspect blunt trauma may be made. Individual and sporadic cases of blunt force trauma may not have an immediate impact on population health. However, case series of large cetacean vessel strikes have been documented in California, northeastern Pacific, and Northwestern Atlantic regions and may pose a significant threat to population status.

**Sharp Trauma**—This type of injury is commonly observed after repeated chop or laceration wounds by one or more rotating propellers, or after contact with a sharp protruding structure such as a skeg or rudder (Costidis et al., 2013). With propellers, multiple parallel and equidistant incisions that are linear, curvilinear, or sigmoid are often observed. Depth of incision depends on size of structure, proximity to the animal, angle of impact and momentum. Clinical signs can include impaired locomotion and logging, listing, extruded blubber, muscle or herniated viscera, hemorrhage, and potentially appendage amputation. The immediate cause of death may be attributed to exsanguination, pneumothorax, amputation, evisceration, or secondary infections. Even when superficial and localized, injuries to the skin can be significant. Necropsy observations can include shearing and shredding of muscle fibers, laceration of large caliber vessels and soft tissues, generalized tissue pallor (anemia), and visceral damage or displacement. Death may be peracute with little hemorrhage or edema evident on histopathology; exposure to water can result in hemolysis and wound irritation.

**Fishing Gear Trauma**—This mostly follows impact or entanglement with actively fished gear, although it can involve abandoned ghost gear. It can either be peracutely fatal (Jepson et al., 2013a) due to drowning or cause chronic morbidity that may be lethal or nonlethal (Moore et al., 2013).

**Peracute Underwater Entrapment**—From a pathologic perspective, this can be a difficult condition to diagnose, but evidence of muscular exertion suggestive of a physical struggle may be present (Jepson et al., 2013a). All types of fishing gear pose a risk—including fixed structures such as gillnets, and mobile gear. The latter is especially cryptic where an animal may be surrounded by fish in a mobile trawl cod end. Evidence may include linear to hatched and occasionally circumferential furrows, around the body, head and/or appendages from contact with net and/or rope, subcutaneous bruises, fractures and soft tissue necrosis and compression. Evidence of hypoxia or drowning may include glistening heavy and wet lungs with stable tracheobronchial froth that may be red tinged. In fresh cases, pulmonary emphysema as well as massive intravascular gas bubbling may be present, following decompression stress. In more decomposed carcasses, this can be confounded with decomposition gas formation. Histology is required to differentiate preexisting conditions that may have contributed to the entanglement such as algal toxins, septicemia, or parasitism. Trauma may also result during live release from a net, such as crush injury, amputation, or a penetrating incision. It is important to differentiate gear trauma from other forms of physical injury, such as conspecific tooth rake marks, premortem predation, postmortem scavenging, and beach casting. It is also important to avoid confusion with skin markings caused by transport, storage, and/or freezing inside bags with a surface structure that can be imprinted on the animal’s skin.

**Persistent Entanglement in Fishing Gear**—Persistent entanglement and associated trauma can result from one or more earlier interactions and entanglements (Moore et al., 2013). It is the most common in seals and large whales. Death from chronic entanglement may result from traumatic injuries, secondary infections and sepsis, long-term energetic drain from the increased drag, and constriction by the entanglement or scarring. The most common attachment sites in cetaceans are mouth, flippers and tail, and the neck in pinnipeds. Evidence of gear wrapping more than one of these anatomic sites is significant. Peracute and acute cases present with little host response and few clinical signs; whereas, subacutely, the animal may be lethargic, partially submerged, at times anchored in place, with a loss of body condition. Chronic cases additionally have evidence of host response, secondary microbial involvement and often more generalized spread of ectoparasites such as whale lice throughout the carcass. Gear may be embedded in scar tissue, with the potential for contraction and musculoskeletal deformation. Terminally, these lesions may be accompanied by extreme emaciation.

**Acoustic Trauma**—Injury to the ears due to acoustic trauma (Fernandez et al., 2004; Romano et al., 2004) has become a popular presumptive claim for odontocete mass and occasional successive individual stranding events, often coincident or subsequent to military sonar exercises and seismic testing. It is a difficult diagnosis to make, relying to some degree on exclusion of other potential causes of strandings, and a history of recent substantial sound exposure (Jepson et al., 2013b). Investigations should rule
out epizootic viruses, toxic spills, algal blooms, and behavioral events associated with pelagic species that have had century long histories of mass stranding. Acoustic-related mass strandings can be atypical in that multiple animals may strand, but are distributed somewhat in time and space. The species most often involved are the deep-diving beaked whales, such as Cuvier’s (Ziphinus cavirostris), Blainville’s (Mesoplodon densirostris), and Gervais’ (Mesoplodon europaeus). Lesions include diffuse congestion, multifocal hemorrhage, especially associated with the jaw acoustic fat, ears, brain, and kidneys. Gas bubbles, from decompression stress, and fat emboli may be present in the mesenteric, meningeal, renal capsular, pulmonary and epicardial vasculature. The response to acoustic stressors may cause beaching and resultant death from cardiovascular collapse or gas embolization and infarction of vital tissues.

Oil Spill—The explosion of the Deepwater Horizon drilling rig in 2010 in the Gulf of Mexico provided an unparalleled opportunity to examine the effect of crude oil pollution on marine mammals, in particular of coastal bottlenose dolphins (T. truncatus). Studies of the impact are ongoing, but the history of massive crude oil exposure, along with case-control studies of exposed animals compared to unexposed populations has shown clinical disease and lesions consistent with known effects of oil. Conditions include adrenal toxicity, moderate-to-severe lung disease, with significant alveolar interstitial syndrome, lung masses and pulmonary consolidation (Schwacke et al., 2013). Uncertainty and calf recruitment was reduced from historic levels of 83% to 20% (Lane et al., 2015). These studies reflect the importance of ongoing baseline health studies from strandings and live capture-release projects, given that most of the related mortalities were seriously decomposed in the subtropical location.

Domoic Acid—This is an amino acid neurotoxin produced in algal blooms that affect marine animals such as California sea lions (Zalophus californianus), sea otters, birds, and small cetaceans. Affected animals may exhibit persistent seizures, loss of alertness, and acute death. Sublethal effects include loss of spatial memory resulting in aberrant movement patterns (Cook et al., 2015), cardiomyopathy and reproductive failure. Malacia of pitiriform lobes, myocardial pallor, bronchopneumonia, and complications related to pregnancy (Silvagni et al., 2005) are associated with exposure and chronic disease may present with bilateral hippocampal atrophy and cardiomyopathy. Prime differentials include morbillivirus infection and neurological diseases such as bacterial (Nocardiopsis, Listeria spp., Staphylococcus spp.), viral (morbillivirus, West Nile virus), fungal (Aspergillus fumigatus, Fusarium spp., Zygomycetes spp., Cryptococcus gatti), parasitic (Nasotrema spp.), and protozoal encephalitides (Toxoplasma gondii, Sarcocystis neurona, and Neospora spp.), and exposure to other biotoxins, heavy metals, and industrial chemicals.

Persistent Chemical Accumulation—Attributing morbidity and mortality in marine mammals to chronic exposure and accumulation of POPs, such as polychlorinated biphenyls (PCBs), is a challenge. Jepson et al. (2016) undertook a major meta-analysis of necropsied and biopsied odontocetes in European waters. They showed persistent exceedances of threshold levels, above which significant impacts of PCBs were known to occur in experimental systems. Documented population declines were well correlated to severely elevated PCB burdens; however, the attribution of cause and effect from high contaminant burdens must objectively exclude other conditions. Furthermore, the role of chronic persistent anthropogenic chemical accumulation may involve a contributory or potentiating role leading to these other, supervening causes of morbidity and mortality, such as significant immunosuppression or endocrinopathy by compounds like PCBs.

Neoplasia—Tumors are uncommon in marine mammals, although they have been shown to have significance in at least two species: (1) Beluga (Delphinapterus leucas) in the Gulf of St Lawrence, Canada (Beland et al., 1995), and (2) California sea lions (Browning et al., 2015). The belugas in the St Lawrence have 23% prevalence of a variety of tumors primarily localized to the digestive system; whereas, sea lions feature a 26% prevalence of urogenital carcinoma. The belugas were heavily exposed to PCBs and other persistent contaminants believed to be acquired through inadvertent ingestion of contaminated substrate from the environment. Whereas, with sea lions, the herpesvirus is widespread within the population and neoplastic transformation is seen in individuals with elevated POPs and inbreeding depression.

Multiple Etiologies—The last two examples of PCB accumulations and tumor development show that marine mammal health is a multifactorial and often complex and dynamic ecological process. It is important to consider primary causes of clinical disease or pathology along with contributing host, population and environmental factors. This expanded synthetic view is critical to integrating studies of the health of individuals and populations of marine mammals into a broader understanding of “One Health.” The ongoing study of marine mammal health enables better understanding of anthropogenic activities and the impact of climate change on oceanic ecosystems (Burek et al., 2008; Kaschner et al., 2011) and the globe (Gulland and Hall, 2007).

III. Conclusion

Documenting regional status and trends of marine mammal health involves a multidisciplinary approach to integrating different organizational levels from molecular to ecosystem, with detailed mapping of health, disease and epidemiological information. A recent study by Simeone et al. (2015) summarized the need for greater synthesis of available information as follows, “Peer-reviewed literature greatly underestimates the true magnitude of disease in marine mammals as it focuses on novel findings, fails to reflect etiology of multifactorial diseases, rarely reports prevalence rather than simple numbers of cases, and is typically presented years after a disease first occurs. Thus, literature cannot guide management actions adequately, nor inform indices of ocean health. A real-time, nationally centralized system for reporting marine mammal disease data is needed to be able to understand how marine mammal diseases are changing with ecosystem changes—before these animals can truly be considered ‘sentinels of ocean health.’”

See Also the Following Articles

Entanglement and Release ■ Parasites ■ Pollution ■ Whale Lice

References


HEARING

SIRPA NUMMELA AND MAYA YAMATO

Animals use their sense of hearing for communication, navigation, and detection of prey and predators. Cetaceans have superb aquatic hearing, and their ears have become the most important sense organ for life underwater. Sirenians have functional aquatic hearing, and marine carnivores rely on their auditory systems in both air and water. Adaptations for hearing in air differ from those for hearing in water; this has resulted in evolutionary compromises for those marine mammals that need to hear in both, and for the ancestors of those that are now fully aquatic.

I. Acoustics

Critical variables regarding hearing for mammals are frequency, loudness, and direction of sound. For pure tones, sound velocity ($c$) is the product of sound frequency ($f$) and sound wavelength ($\lambda$): $c = f\lambda$. Sound velocity in air is $343\, m/s$, whereas in water, sound velocity is $1500\, m/s$. Therefore, for a given frequency, the wavelength is almost five times longer in water than in air.

Sound velocity and wavelengths play an important role in sound localization. Animals determine the direction of a sound by means...