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CETACEAN MEDICINE

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Introduction

The aim of this chapter is to provide an outline of cetacean medicine as it is currently practiced. It is not intended to be an exhaustive review of the scientific literature on cetacean health and diseases. This chapter is written with a keen eye on practical tools that could not otherwise be shared via publications and presentations, that may or may not be scientific in their basis, but are thought to be useful by at least one of the authors. It includes tips to help translate scientific evidence, based on significant numbers of replicates, to the individual cetacean with its unique set of conditions and needs. From here, the cetacean clinician will have to decide how to apply the science, these tools, and these tips to each individual animal in the prevention and treatment of disease.

Cetacean Husbandry

The scientific basis for marine mammal husbandry is an ever-expanding body of knowledge that includes anatomy, biology, physiology, water quality, nutrition, behavioral science, and veterinary medicine. Of these, husbandry training, social interaction, appropriate facilities, and nutrition are recognized, among others, by the marine mammal welfare research community as key components for a successful wellness program for those cetaceans that live in an environment controlled by man (Clegg, Borger-Turner, and Eskelinen 2015).

Husbandry Training

Husbandry training uses positive operant conditioning to modify an animal's behavior in order to more readily assess a cetacean's health, and is described in the previous chapter (see **Chapter 39**). Not only do these behaviors yield valuable diagnostic samples, but even the response time and eagerness with which a cetacean performs a specific husbandry behavior can provide important clues to the clinician. The usefulness of the numerous husbandry behaviors may vary by species and facility and depend on the consistent proactive collaboration between the trainers and the clinician.

Medical Facilities

More invasive medical procedures, such as excisional biopsies and bronchoscopies, may not be feasible under positive operant conditioning alone. Similarly, as an ill cetacean deteriorates, it will lose interest in its environment and trainers and may refuse select trained husbandry behaviors. Husbandry training is neither practical nor advised when working with wild cetaceans in a rehabilitation setting. In those circumstances, the ability to "strand" (i.e., to put an animal in shallow water or remove it from the water completely) a potentially uncooperative animal is essential to safe medical treatment. It may also be important to strand an ill individual's healthy pool mates to maintain its sense of social support. A lifting bottom is the state-of-the-art tool to achieve this, and ideally, a medical pool with a lifting floor, or equivalent, should be part of every cetacean habitat. The medical pool should be of sufficient size to comfortably house a sick cetacean and companion animals for several days if needed. The facility should provide for stranding more than one animal at a time any time day or night. During the course of ordinary husbandry, the whales or dolphins should be provided routine access to such medical pools and desensitized to being lifted in order to reduce their anxiety and excitement when handling becomes necessary. Anorexia and decreased appetite are in fact some of the more common and potentially most serious complaints presented to a cetacean veterinarian. Trends in body weight provide an important background for interpreting these complaints. Cetaceans that live in human care need to be conditioned to be weighed without restraint on a routine basis, and a cetacean habitat needs to be equipped with a scale of sufficient size to weigh each animal. Regular girth measurements, even when combined with visual cues and/or ultrasound blubber thickness measurements, may help identify a weight trend, but these measurements are not a replacement for accurate weights.

Nutrition

A healthy, safe, and species-appropriate food source is a fundamental building block of animal wellness. Cetaceans require a properly stored and prepared, species-specific, and balanced mix of food fish of a quality suitable for human raw consumption.

There is no universal balanced diet for all cetacean species maintained under human care. For example, *Grampus* spp., *Globicephala* spp., and some older *Tursiops* spp. may require a minimum amount of squid (*Loligo* spp.) to avoid constipation, while other cetaceans may refuse to take squid. In general, a minimum of three species of food items should be available to ensure a varied, high-quality diet that is balanced in volume, available nutrients, and caloric content, and that is not prone to interruptions in supply. Herring commonly makes up around 50% of the total diet by weight of bottlenose dolphins in human care, with the remainder comprised of capelin, mackerel, sardines, smelt, whiting, squid, and other equivalent species.

Proper food handling procedures are critical. It is recommended that frozen fish be moved from freezer to air-thaw refrigerator no more than 24 hours before bucketing. The fish are then moved to sinks for a quick final thawing, rinsing, and bucketing. Cetaceans are exquisitely sensitive to *Erysipelothrix rhusiopathiae* infection. The exact route of entry of the bacteria is unknown, but cetaceans are presumed to contract *E. rhusiopathiae* from the slime coat of their food fish. Removal of this slime layer is believed to have been a contributing factor in reducing the incidence of septicemic form and the severity of the nonsepticemic form of erysipelas in cetaceans (Walsh et al. 2005). Buckets must be made of stainless steel, or similar material, so as to be easily washed and sanitized. In warm regions, buckets should be equipped with a removable grid at the bottom to separate the fish from the thawing fluids. Once bucketed, the fish should be covered with a layer of ice adequate to cover the contents and maintain a temperature ≤4°C until feeding time.

Regardless of the initial qualitative evaluation made on sampled batches upon arrival, individual fish that appear badly damaged, show visible signs of storage degradation, or have a rancid smell should be discarded. Representative samples of fish to be fed to any cetacean should pass a basic sensory test by an experienced staff member utilizing appearance, feel, and smell. A suggested list of characteristics of fish that should be examined is provided in **Table 40.1**.

Each of these characteristics is scored, and fish that receive a score of 8 or more should not be fed to a cetacean. It is possible that fish with a score less than 8 may not be suitable for feeding. This judgment is best made by an individual experienced in cetacean husbandry.

Fish destined to feed cetaceans need to be tested for quality criteria upon arrival at the facility. Every effort should be made not to utilize fish frozen for more than 12 months to avoid nutritional degradation. Peroxide values and tissue

Table 40.1 A Suggested List of Basic Sensory Characteristics of Food Fish That Should Be Examined, Including Result Categories and Associated Scores

Characteristic	Result	Score	Characteristic	Result	Score
Skin	Bright, shining	0	Smell	Seaweed, metallic	0
	Bright	1		Neutral	1
	Dull	2		Musty, sour	2
				Stale, rancid	3
Overall feel	Elastic	0	Belly	Firm	0
	Firm	1		Soft	1
	Soft	2		Burst	2
Eye clarity	Clear	0	Eye shape	Normal	0
	Cloudy	1		Flat	1
				Sunken	2
Gill smell	Seaweed, metallic	0	Gill color	Red	
	Neutral	1		Discolored	
	Slightly rancid	2			
	Stale, rancid	3			

Note: Food fish that receive a score of 8 or more should not be fed to a cetacean.

histamine levels can be used to assess the effect of extended storage or to address concerns related to cold chain and hygienic practices. Peroxides form when fish lipids oxidize, and peroxide values are considered the most reliable chemical measurement of rancidity in fish (European Food Safety Authority 2010). Elevated peroxide values can indicate poor nutritional quality but do not usually indicate any toxic danger to the consumer. Histamine can form rapidly in fish tissues at warm temperatures, and tissue histamine levels can therefore be used to evaluate the integrity of the cold chain and good hygienic practices for handling fish (FAO/WHO 2012). Elevated levels can trigger toxicity, but susceptibility varies between marine mammal species and individuals. Maximum allowable peroxide values and histamine levels of 20 meq/kg of fish fat and up to 100 mg/kg, respectively, are often employed in cetaceans. However, these maximums have been set empirically, based on extrapolation from humans, and have not been formally validated for cetaceans.

The freezing of food fish results in the oxidation of vitamins B9 and C and the fat-soluble vitamins A, D, E, and K. Additional water-soluble vitamins and minerals may be lost due to water loss due to freezing. Cetaceans should therefore be supplemented with a daily multivitamin that contains at minimum these vitamins. The authors recommend that vitamin supplements be given with the first feeding of the day. The vitamin tablets should be loaded in the food fish immediately prior to administering, so thiaminases in the food fish cannot digest the supplemental vitamin B1. The multivitamin dose should not be decreased if a temporary food intake decrease is instituted or if food intake is decreased due to illness.

Cetaceans tend to avoid showing symptoms of illness, so decreased appetite is often the first and sometimes only observed clinical sign. This explains the utility of administering a stable, known, but adequate, total daily intake to an individual cetacean. This total daily intake can be tracked in food fish weight but is best monitored in calories, since the caloric content of food fish can vary greatly. There is no universal formula to determine the caloric or food fish need for a cetacean, as numerous factors can affect digestion and utilization of food available to the animal. The total daily intake should reflect the physiologic needs of the individual animal, which include growth, activity level, environmental temperature, reproductive status and changes in body weight (Slifka et al. 2013; see **Chapter 29**). Changes to the daily intake or food fish composition should be carefully planned and take into consideration all physiologic needs of the animal and differences in caloric content of the food fish. Behavior alone should rarely be the sole criterion for determining a change. Since decreased appetite may be the first indicator of a serious life-threatening illness, any change in appetite or acceptance of food should immediately be reported to the attending veterinarian.

Preventative Medicine Program

A successful cetacean medicine practice is based on a comprehensive preventative medicine program. The goals of a preventative medicine program are to prevent disease in the population, to diagnose and treat disease in its very early stages, and to reduce impacts of existing disease. This program consists of a structured and systematic plan for managing animal health and wellness through observation, communication with staff, diagnostic monitoring, and record keeping. The major components of a cetacean preventive medicine program will vary between species and facilities but will include daily behavioral assessments, routine wellness checks, nutritional assessments, social and environmental evaluations, vaccination, and parasite prophylaxis.

Wellness Checks

The frequency and elements that make up the routine health and wellness checks will depend on the species, specific health concerns, degree of conditioning, age group, and facility, not on convenience or the nature of the exhibit in which the animal is located. All cetaceans should be conditioned so all elements of the wellness checks can be performed frequently and without restraint.

The cetacean's trainer or keeper is responsible for the daily assessment of the animals' physical health and wellness, equivalent to the pet owner's in a standard veterinary practice. Additional wellness assessments are typically performed by the attending veterinarian on a weekly, monthly, quarterly, or annual basis (**Table 40.2**).

The veterinarian assesses body condition, physical health, complete blood cell count and serum chemistry parameters, behavior and lifestyle factors related to both the subject animal and other animals in the habitat, and reproductive health. The veterinarian may perform diagnostic imaging and serology. While not impossible, it is uncommon to detect an emerging or subclinical illness during these routine wellness checks. The main value of routine assessments is the availability of a sampling record during a time of health that can serve as a point of reference for assessments during periods of illness. Recommendations for health maintenance should not solely focus on management of medical conditions, but include behavioral management, daily exercise, play, and diet.

Vaccinations

At present, only one vaccine has been validated for use in cetaceans. *Erysipelothrix rhusiopathiae* is the causative agent of erysipelas in various animals. Disease caused by *Erysipelothrix* has been recognized and confirmed in several species of dolphins and whales, both in human care and in the wild (Young et al. 1997; Walsh et al. 2005). Two presentations of erysipelas have been reported in cetaceans. A cutaneous form, characterized by raised rhomboidal or diamond-shaped skin lesions, and a septicemic form. While the septicemic form can be treated successfully by the prompt administration of appropriate antibiotics, this condition often leads to death, since it is usually only preceded by very brief (hours) nonspecific clinical signs such as decreased activity levels and appetite (Walsh et al. 2005). The bacteremia is consequently often only recognized on necropsy. The exact portal of entry of the bacteria is unknown, but cetaceans, like humans, are presumed to contract *E. rhusiopathiae* from the slime coat of their food fish (Brooke and Riley 1999; Finkelstein and Oren 2011). Because of the bacteria's potential to cause death without obvious premonitory signs in dolphins, prevention of *Erysipelothrix rhusiopathiae* infection by vaccination has been of interest to marine mammal health professionals (Nollens et al. 2005, 2007). Since no bottlenose dolphin–specific vaccine is available, the use of commercial swine erysipelas vaccines has been explored (Lacave et al. 2001; Nollens et al. 2005). The recombinant p64 surface protein of *E. rhusiopathiae* that is employed in a commercial erysipelas vaccine for swine (ER BAC Plus, Zoetis Inc.) is immunogenic to bottlenose dolphins (Nollens et al. 2007a). A retrospective analysis after 10 years of vaccinating dolphins using the ER BAC Plus vaccine deemed the commercial pig bacterin effective in generating humoral immunity against *E. rhusiopathiae* in dolphins (Lacave et al. 2013; Nollens et al. 2016). The risk of transient adverse reactions toward the vaccine did increase with number of vaccines administered. The optimal intervaccination interval in animals that have received multiple vaccinations remains to be determined.

Table 40.2 Suggested Assessments and Their Minimal Frequency of a Cetacean Preventative Medicine Program

Assessment	*Orcinus orca*	*Delphinapterus leucas*	*Globicephala* sp.	*Tursiops* spp.	*Delphinus* spp.	*Lagenorhynchus* spp.	*Cephalorhynchus commersonii*
Wellness	D	D	D	D	D	D	D
Weight	W	2W	2W	2W	2W	2W	2W
Blowhole cytology	M	M	M	M	M	M	Q
Physical examination	M	M	M	Q	Q	Q	Q
CBC/chemistry	M	M	M	Q	Q	Q	Q
Urinalysis	M	–	–	M	–	–	–
Dental radiographs	A	–	–	–	–	–	–
Erysipelothrix rhusiopathiae vaccination	A	A	A	A	A	A	A

Note: 2W = every 2 weeks; A = annually; D = daily; M = monthly; Q = quarterly; W = weekly. All cetaceans should be conditioned so that all assessments can be performed without restraint.

Parasite Prophylaxis

Cetaceans that are exclusively fed frozen–thawed fish can be presumed to be free of parasites, as the freezing kills the intermediate tissue stages of the parasites. Parasite prophylaxis is not warranted in these groups of cetaceans. However, internal parasite prevention and control programs should be implemented for cetaceans that have access to live fish. Similarly, wild-caught and nonreleasable rescued cetaceans have been known to harbor *Crassicauda* spp., *Nasitrema* spp., and *Kayroikeus* spp. for extended periods. Cetaceans are susceptible to protozoan, coccidian, nematode, trematode, and cestode infestations. For these animals, a schedule for routine monitoring of feces and routine deworming should be developed in accordance with local risks and the life stage of the animal. Fenbendazole (10 mg/kg PO SID for 3 days), ivermectin (0.2 mg/kg PO once), praziquantel (2 mg/kg PO once for cestodes, 10 mg/kg PO once for trematodes), and rotations of these anthelmintics are considered safe and effective in cetaceans. Cetaceans are sensitive to the central nervous system side effects of levamisole, and the use of this anthelmintic should be avoided.

Physical Examination

The physical examination of a cetacean includes history, and the examination of the animal and its environment. These are the same components as with any other animal. When a veterinary clinician hears that the whale or dolphin is not acting normally, the steps necessary to understand the problem are similar to most other animal species.

History

One of our most important diagnostic tools is obtaining a thorough case history. In a review of 80 human medical cases, history was predictive of the diagnosis in 82.5% of cases (Hampton, Harrison, and Mitchell 1975). Clinicians need to adjust their thinking to accommodate a social animal that spends its entire life in water. A weak terrestrial animal will lie down, but this distinction is not as apparent in a cetacean, as its buoyancy allows it to maintain normal movement. Diarrhea leaves an easily recognized sign on land; in water, no sign is left. The same can be said for emesis, if no solids are found on the pool bottom. Hematuria in a land animal leaves a telltale stain; in water, the animal must be seen in the act of urinating. Direct observation of these events is often necessary to know they are occurring.

Clinicians need to spend enough time observing to understand the implications of what is and is not seen. This means paying close attention to normal behavior and bodily processes like buoyancy, breathing, defecation and urination (appearance, timing, and frequency), posture, activity budget, and social engagement, among others. When collecting history on small whales and dolphins, the social aspect cannot be overlooked. A sick animal may try to isolate itself, although in a social species, it is not unusual for conspecifics to stay near an ill companion. A terrestrial herd animal butting a companion may be seen as aggression. In a dolphin, this may be an attempt to aid or take advantage of a sick member of the pod. The quality of their interactions with trainers and pool mates can be just as important as their food intake when looking for clues to the beginning of a period of illness.

When taking a history, each major body system needs to be considered. Use the history to guide you to involved systems and ask questions to elucidate the systems that need to be revealed. When questioning trainers regarding their observations, avoid yes/no answers and, rather, try to ask open-ended questions. As an example, if asked whether "an animal has diarrhea," a "no" answer can mean it does not or the trainers did not see any. Here it would be better to ask the observer to describe the characteristics of the bowel movement. Where history and direct observation of events are lacking, it is often possible to ask the trainer or keeper to acquire some "prospective history," by asking him or her to spend the necessary time (hours) observing the animal to begin to identify features of behavior and activity that are not normal.

Visual Examination

A visual examination of the patient from a distance and up close before any handling should be the next step. During the visual examination, the animal's interaction with its conspecifics and its environment, and the animal's general appearance, swimming patterns, buoyancy, body posture, skin, and eyes, are evaluated. It is common for visual examination to reveal as much as, or more than, the hands-on examination.

It is the task of the cetacean clinician to sort out the subtleties of social behavior. A dolphin that does not have a positive social environment is likely to become a sick dolphin. There is evidence in humans and other social species that an individual's social environment is a primary determinant of long-term health (House, Landis, and Umberson 1988). To assess social behavior, it is important for the veterinarian to be familiar with the normal behavior of the group in question or at least identify (among keepers or trainers) a reliable observer familiar with the group's behavior. It can be beneficial to make observations when the animals are unaware of any trainers or veterinarians in the area. A cetacean's social behavior or interaction with conspecifics provides a useful insight into its sense of well-being. A social animal that is isolating itself is most likely not feeling well. Occasionally, other cetaceans will become very attentive to a pod member that is not feeling well, and as a result, the animal that has ceased eating may not be the sick one. If a dolphin or whale is being harassed by others, it deserves a second look, since it may be ill. A weak female may be chased by males as if she were sexually receptive. This probably occurs because of the female's decreased resistance to male advances.

Humans are a part of the social environment of captive dolphins. A change in the quality of interaction between trainer and dolphin is a potential early indicator of deteriorating health. A dolphin may actively avoid its trainer by staying as far away as it can, either because it is sick or because something is wrong with the environment or their relationship. Clues to the causes of such need to be examined.

Blepharoptosis, activity level, and alertness can serve as parameters for general appearance. Drooping upper eyelids can indicate feeling unwell, having very little interest in surroundings, sensitivity to light, or ocular pain. Most animals that are ill prefer to rest and are not inherently active. Although they may swim along with pool mates, the instinctive efforts of a weak animal to keep up with the pod are usually easy to distinguish from normal swimming behavior. If a cetacean is alert and responsive to its surroundings, it is most likely not feeling ill. However, diseases like nocardiosis, mycobacteriosis, or neoplasia can produce clinical laboratory indications of disease before the animal feels ill.

Buoyancy (i.e., floating higher or lower than normal, and/or listing) is a feature of physiology that is not examined in terrestrial animals. Buoyancy is best evaluated at rest during the normal inspiratory breath hold. A decrease in resting buoyancy is the result of diminished lung capacity. A space-occupying mass or fluid accumulation in or around the lungs is the probable cause of this alteration. Increased buoyancy usually results from abnormal gas accumulation in the gastrointestinal tract, abdomen, or thorax. A dolphin with a pneumothorax will appear much like a cork as it bobs on the surface and displays difficulty diving or difficult staying submerged. Increased buoyancy can also be observed as a result of pain, which is relieved by inhibiting the abdominal and thoracic pressure that occurs normally during the inspiratory breath hold. Therefore, pneumonia can have a positive or negative effect on buoyancy; observed changes in buoyancy do not lead to automatic diagnosis, but present differential possibilities. The clinician must be aware that a normal cetacean can decrease its buoyancy without expelling air by compressing its chest and abdomen, thereby decreasing its displacement. So the fact that the animal takes a deep breath and sinks to the bottom is not necessarily the result of a decrease in resting buoyancy. Individuals may choose to rest on the bottom of the pool for long intervals between breaths under normal conditions. A near-catatonic sinking to the bottom of the pool may indicate estrous in female *Tursiops* spp.

If listing is observed at rest, it is usually caused by a unilateral alteration in buoyancy, a postural aberration, estrous behavior, or a willful behavior. It is best to begin evaluating a listing animal by looking for any postural contributions. If the animal curves to one side, it may be inducing a list or compensating for one, depending on whether the curve is toward or away from the least buoyant side. Watching a listing dolphin swim at rest should reveal whether it has a righting defect. Even a dramatic unilateral buoyancy aberration can disappear when the animal is swimming, only to reappear when forward motion ceases. Normal newborn or early postpartum calves will often list at the surface if temporarily abandoned by the mother. Listing is common when dolphins are looking up, as occurs in a lowered pool, because rolling to one side makes viewing the activities above much easier. Cetaceans with unilateral impairment of vision may consistently roll to one side to make viewing activities around the pool easier. The causes of listing are usually differentiated by visual examination and history, with confirmation provided by ultrasonography, centesis, and/or radiography.

Hands-on Examination

The usual next steps, hands-on physical examination, phlebotomy, and other clinical sample collection, are generally performed together because they require direct contact with the animal. The value of hands-on examination is limited by cetacean anatomy, but it is still a viable source of information. Even auscultation has significant limitations; it is problematic due to the thick blubber layer, the rapid expiratory–inspiratory cycle, and loud transmitted sounds that can obliterate subtle rales. In spite of these limitations, auscultation is an occasionally useful tool for evaluation of the thorax, heart, and abdomen. Palpation may reveal sensitivity to touch and heat signatures associated with bruising or inflammation, or muscle tone.

Urinalysis Male and female dolphins can be catheterized for urine collection, although many cetaceans have been trained to provide these samples on request. In bottlenose dolphins, a 5-French (1.67 mm) catheter is suitable for males, while an 8-French (2.7 mm) works well for females. While normal ranges may differ, the interpretation of urinalysis in a cetacean is not different from that of other mammals. Urine from mature male dolphins will invariably contain spermatozoa.

Stool Analysis A stool sample can be collected using a 16-French Levin-type stomach tube (Professional Medical Products Inc., Greenwood, South Carolina) or equivalent open-ended tube with side ports. The tube is inserted into the rectum and advanced into the descending colon, where the sample is allowed to flow passively into the tube, after which the tube is clamped off before withdrawal. The tube should contain enough stool for cytology and culture. If the procedure is unsuccessful, a small volume of saline flush can be used. Do not apply suction as there is a high likelihood it will cause some bleeding. Samples collected with swabs are also likely to contain blood contamination.

Fecal occult blood tests will always be positive if done on stool from cetaceans fed a whole fish diet. If the patient is fed a diet consisting entirely of washed fish filets for 2–3 days, normal stool will convert to occult blood negative. This is a useful technique when there is an interest in determining if the patient is experiencing gastrointestinal bleeding that is not visible by endoscopy. Always use a clinically healthy animal as a control for this procedure.

Milk Analysis Milk samples are readily aspirated from the mammary glands of lactating females, with the assistance of external massage. A 60 ml catheter tip syringe with a short length of tubing attached to either an appropriately sized funnel or the tip of a second syringe provides the pieces necessary to make a dolphin milk sample collecting device. If a calf has recently nursed, it can be very difficult to obtain a useful sample. Clinically normal cetacean milk can contain white blood cells.

Upper Respiratory Tract Evaluation With adequate light, it is possible to visualize the nasal septum and passages. The view is usually fleeting because of the rapid respirations common to cetaceans. Video or digital photography through the open blowhole can provide a better look than is achievable with the naked eye. It will also yield documentation, which is useful for examining changes in a known condition. Grossly, the clinician should check for plaques that may be fungal in origin (see **Chapter 19**). Culture and cytology specimens can be collected directly by swabbing affected tissue, or indirectly by exposing an agar plate to exhaled breath. Cultures, especially those of exhalate, should always be evaluated in light of the cytologic findings. There should also be an effort to minimize seawater contamination of the blow plate. These samples may be useful for evaluating a condition affecting the upper respiratory passages, but should not be expected to provide accurate information about lower respiratory disease. Bronchoscopy and bronchoalveolar lavage are the most appropriate procedures for determining etiologic agents in lower respiratory tract disease. Both processes are performed with minimal difficulty on cetaceans (Harrell et al. 1996; Hawkins et al. 1996; Reidarson, McBain, and Harrell 1996).

Ultrasonography and Radiography Portable ultrasonography and radiography equipment are fundamental tools for the cetacean clinician. Virtually all organ systems can at least in part be imaged using ultrasonography, and radiography can help identify gastric foreign bodies; dental, mandibular, and maxillary fractures; and lung opacities. A thorough review of ultrasonography, radiography, and advanced imaging is presented in **Chapter 24**.

Body Weight Trends in body weight provide an important background for interpreting clinical signs, such as anorexia and decreased appetite. A cetacean habitat needs to be equipped with a slide-out scale, so the weighing of dolphins and whales can be trained as a routine husbandry procedure (see **Chapter 39**). It is difficult, even for experienced individuals, to detect weight loss in cetaceans without actual measurements. By the time weight loss is noticed on the basis of physical appearance, it is often excessive. Changes in axillary girth have been used for detecting changes in body weight, but these measurements are less accurate than body weights obtained via weighing on a scale.

Hematology and Serum Chemistry

Clinical laboratory test results are frequently the most informative part of a physical examination. Historic data accumulated during routine examinations are very useful when trying to interpret laboratory test results from an animal with a suspected illness. In fact, it is uncommon to detect an illness during routine blood draws. The main value of routine assessments is that a sampling during a time of health represents a point of reference for assessments during periods of illness.

The decision to proceed with clinical laboratory evaluation should be an easy one but often is complicated by the lack of access to an uncooperative patient or other difficulties. The ability to collect a blood sample from a captive cetacean, whenever needed, is essential. A dolphin trained to present its flukes voluntarily for blood sampling may be unwilling when it is feeling ill. Contingency plans, such as having a medical pool with a lifting floor that is useable anytime, including during guest hours, should be in place for these events. Blood sample collection must be followed by timely analysis. Broadly speaking, the interpretation of the hematology and serum chemistry results of a cetacean is similar to that of domestic mammals. The analytes that have proven to be most helpful as corroborative indicators of inflammatory disease are reticulocyte count, white blood cell count, differential count, erythrocyte sedimentation rate, plasma fibrinogen, serum albumin, serum globulin, alkaline phosphatase, and serum iron (McBain 1996; see **Appendix 1**). Ideally, these analytes can be run instantaneously in an on-site lab.

Plasma Fibrinogen

Plasma fibrinogen is currently the most reliable indicator of inflammatory disease in cetaceans, as long as the photo-optical test is used. The heat precipitation test for fibrinogen is prone to inaccuracy and has limited utility. Plasma fibrinogen is useful for early detection of inflammation and for determining when inflammation is under control. Elevations of as little as 20% above the animal's high normal levels are important, but they will usually be elevated 50% or more with significant inflammation.

Erythrocyte Sedimentation Rate

Elevations in erythrocyte sedimentation rate (ESR) are a traditional marker for detecting the presence and severity of inflammation. The ESR is easily run without expensive equipment, which is the primary reason for its continued use. It is also a useful tool for corroborating an elevated fibrinogen.

The test is prone to fluctuations, which accounts for the fact that it has lost favor in most other species. Most clinicians in cetacean medicine continue to use the ESR because of its historical familiarity.

Serum Iron

Serum iron decreases acutely in animals experiencing bacterial infection, presumably as a result of cytokine production by inflammatory cells. This response is dramatic in cetaceans. It can plummet to levels 20% of normal, or less, in a matter of 24 hours. As a result, iron can be an excellent indicator of infection, but the test will not necessarily be a good indicator of the severity of the problem. Ferritin may be an alternate indicator (Loos et al. 2017). Serum iron level is at times the first analyte to start normalizing, when appropriate treatment has been initiated. However, iron will fluctuate during the course of treatment, so it appears to be less reliable than fibrinogen for evaluating therapeutic progress. It is important to understand that this decrease in iron is protective for the host. The animal's body is sequestering iron in the liver in a form that is not available to pathogenic bacteria that can readily utilize transferrin-bound iron in the serum (Lowenstine and Munson 1999). Iron supplementation is therefore not indicated. Hepatocellular damage is often associated with higher-than-normal serum iron levels.

Reticulocyte Counts

Most clinicians do not routinely request reticulocyte counts, as they are not traditionally thought of as an indicator of inflammatory disease. Reticulocyte counts in cetaceans, however, are often low when the animal is experiencing a chronic low-grade infection, resulting in decreased serum hemoglobin levels (anemia of chronic disease). In the bulk of cetacean cases, chronic low hemoglobin is due to either a slow chronic blood loss or decreased red cell regeneration. The reticulocyte count will usually provide the information needed to differentiate blood loss from decreased regeneration. Reticulocyte counts derived from routine blood samples from the same animal during times of health are the best source of comparative data. This test is prone to variation between labs, so the test should be run by the same lab or at the very least using the same methodology for consistency.

Chronic low-grade pneumonia is not rare in cetaceans. The pneumonia is often only clinically apparent because of slight elevation of inflammatory parameters and the presence of a low-grade nonregenerative anemia. Many cetaceans have been treated for gastric ulcers because serum hemoglobin was low with no other parameters significantly out of normal ranges. This has led to the common misconception that many captive dolphins have gastric ulcers. The reticulocyte count will usually aid in differentiating these two etiologies.

Serum Albumin

Serum albumin levels regularly decrease below normal in the presence of bacterial infection. The decrease can occur rapidly over a period of a few days. Serum albumin is not the first test to consult for evidence of infection, but it is good for confirming the results of other tests. As in domestic mammals, numerous other potential causes of a drop in serum albumin exist. Hereditary bisalbuminemia has been reported in two groups of related bottlenose dolphins (*Tursiops truncatus*) identified by means of capillary zone electrophoresis (Gili et al. 2016).

Alkaline Phosphatase

Decreasing alkaline phosphatase is a reliable indicator of inflammation. Alkaline phosphatase levels in cetaceans are usually much higher than would be expected based on terrestrial species. Alkaline phosphatase is elevated in growing cetaceans and normally declines with age and with a decrease in food intake. Even though alkaline phosphatase drops dramatically during illness, it is important to remember that it is affected by many other things (Dover, McBain, and Little 1993; Fothergill et al. 1991). Alkaline phosphatase has also been considered a reliable prognostic indicator. Clinicians historically considered an alkaline phosphatase of less than 50 U/L in a killer whale to be indicative of very serious disease, and values less than 25 U/L to be equivalent to a death sentence.

Total White Blood Cell Count

As in domestic mammals, total white blood cell count is understood by most veterinarians to be a reliable indicator of inflammatory response. The cetacean clinician needs to be aware that life-threatening, chronic, low-grade pneumonia in cetaceans is frequently associated with an unremarkable total white blood cell count.

Differential Blood Cell Count

The differential count is the means by which most veterinarians evaluate the nature and significance of a change in the white blood cell count. Differential counts in cetaceans are interpreted in much the same way they are in terrestrial animals. However, cetacean neutrophils mature and segment much faster than those of terrestrial mammals. If the terrestrial mammalian definitions of banded and segmented neutrophils are employed, the band count of a cetacean will often be zero, even in the presence of inflammation and active neutrophil recruitment. The authors recommend that a segmented neutrophil is more conservatively defined as a neutrophil that has at least two of its lobes separated by a filament of nuclear material. A filament has length but no breadth as one focuses up and down. A band neutrophil has either a strand of nuclear material thicker than a filament connecting the lobes or a U-shaped nucleus of uniform thickness.

Both total white cell and differential counts may fluctuate unpredictably over a very short interval of time in cetaceans. Two blood samples taken from the same fluke vein less than 30 seconds apart may have different total white cell and differential counts. These variations are large enough to affect interpretation. The clinician must look to other clinical data to corroborate findings and to support diagnostic conclusions (McBain 1996).

Serum Transaminases

Elevations of serum transaminases, especially ALT, are indicative of hepatocellular leakage or damage (Venn-Watson et al. 2008a). While acute liver disease often presents with a spike in liver enzymes, chronic liver disease may involve elevations in liver enzymes that wax and wane and progress in severity over time. Additional blood-based indices that may help confirm liver disease as the cause for elevated transaminases include GGT, alkaline phosphatase, LDH isoenzymes, ferritin, iron, triglycerides, cholesterol, and bile acid levels.

Intervention

It is unpleasant to think behavioral change in a cetacean is due to illness, because medical interventions very quickly present escalating logistical challenges. Adhering to the following principles should help avoid common traps that present themselves in the practice of cetacean medicine: if you think there is a problem, deal with it; if you know there is a problem, it may be too late—the best day to begin the search for answers is today; and finally, if there is clinical evidence that a cetacean has an illness, assume it is serious.

Medications

The medications used to treat a cetacean are generally equivalent to the medications used in domestic animal or human medicine. The guiding principles for starting, selecting, changing, and discontinuing medications are the same as those in domestic animal medicine. There are no medications for exclusive use in cetaceans. Most, but not all, medications available for humans and domestic animals can be administered to cetaceans. The cetacean clinician should be familiar with those medications that have caused fatal adverse reactions in cetaceans. Medications to be avoided include, but are not limited to, sulfamethoxazole, phenothiazines, haloperidol, and levamisole (Lavergne et al. 2006). A list of medications that are more commonly used by the authors and dosages that yielded safe, but therapeutic, serum levels, is found in **Chapter 27**. Of the listed medications, amoxicillin, with or without clavulanic acid, is often the empiric first-line antibiotic of choice because of cetaceans' susceptibility to the often fatal, peracute form of erysipelas.

Routes of Administration

The oral route is preferred for the administration of pharmaceuticals to cetaceans. Feeding medication hidden in fish is the simplest and most common approach used for per os (PO) administration. Conditioning the cetacean to take medications without food as a husbandry behavior can be useful for the administration of some therapeutics, such as gastric protectants. If anorexic, a stomach tube becomes the best means for administering oral medication including fluids. Many medications require the enteric coating to pass the acidic stomach and be absorbed in the small intestine, and therefore should generally be loaded in the food fish immediately prior to administering. A pectoral fin can be torn from the medicated fish to help its identification in the food bucket. The authors further recommend that when a cetacean is receiving oral medication with a narrow safety margin in the presence of a smaller companion animal, the total medication dose be distributed across two or more medicated fish. As such, the smaller companion animal is not put at risk when it accidentally consumes a medicated fish intended for the larger animal. It is also important to be aware that small cetaceans can have very rapid gastrointestinal transit times. Oral delayed or slow-absorption tablets have been noted in the feces of Commerson's dolphins (*Cephalorhynchus commersonii*) and bottlenose dolphins. The liquid transit time can be as short as 1 and 2 hours in Commerson's and bottlenose dolphins, respectively.

Intramuscular (IM) injection requires a longer needle than might normally be considered necessary, due to the thickness of cetacean skin and blubber. The injections are made off the midline, slightly anterior to or parallel to the dorsal fin. It is the authors' rule to limit IM injection volume to a maximum of 20 ml per site. This arises from the concern that larger volumes have led to apparent ischemic necrosis at the site of the injection. Exercise care to avoid the thoracic cavity, if injecting in the dorsal musculature anterior to the dorsal fin. If the animal is wiggling or thrashing, the injection should be stopped and the needle withdrawn, as there is a real potential for the needle to be sheared off by the heavy fascial planes and muscle sheaths.

In cetaceans, the administration of long-term intravenous therapy is an option that is rarely used or considered. Intravenous (IV) injection of medication can be accomplished via a fluke vessel if the volume is low and the medication is not harmful if delivered perivascularly. If slow infusion or repeated administration of IV pharmaceuticals is necessary, an indwelling catheter may be required. An indwelling catheter is most easily placed in the lateral peduncle vein, but the maintenance of indwelling catheters is at best difficult in an animal that wants to be swimming. To accomplish long-term infusion, the animal must be confined to a very small pool or box such as a transport container. Neither of these options is well received by most cetaceans. A better option if IV therapy is required is to try to accomplish the needed infusions with short periods of confinement, allowing the animal to swim between treatments. This requires either leaving the catheter in place, in the hope that it will remain, or replacing it for each treatment. Both of these methods have been used with limited success (Van Bonn et al. 1996; Stetter et al. 1997; Robeck and Dalton 2000).

Topical treatment is often applied for corneal lesions, although there is a concern that ophthalmic drops wash away very rapidly, do not penetrate the tear plug, and do not reach the corneal epithelium. Admixing ophthalmic drops with mucolytic 20% acetylcysteine to a final concentration of 5% acetylcysteine allows fluorescein stain and medications to rapidly penetrate the full thickness of the tear plug. The pH of the mixture needs to be checked before its use. Cetaceans have very strong palpebral muscles that do not relax under mild sedation. As such, the authors have only been able to accomplish subconjunctival injections under general anesthesia. The palpebral conjunctiva is highly vascularized, and such injections can cause profuse hemorrhaging.

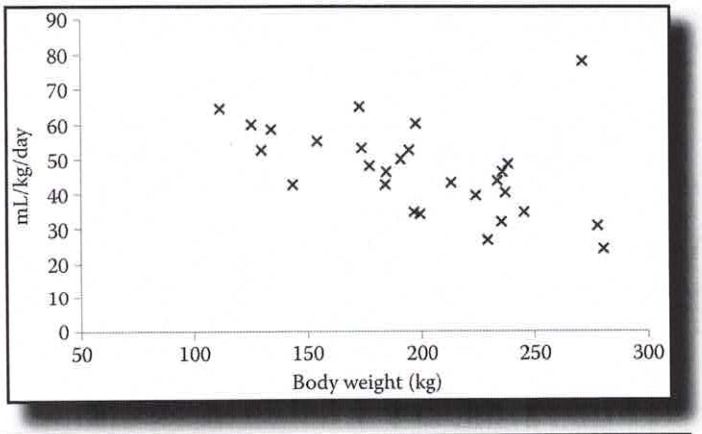

Figure 40.1 The total available daily fluid volume (in mL/kg body weight per day) from food fish for bottlenose dolphins, calculated based on the nutrient analysis of 1 month's worth of consumed fish, indicates that bottlenose dolphins consume an average of 47 mL/kg of water per day.

Fluid Therapy

Marine cetaceans almost exclusively obtain water from their food fish and as a metabolic by-product of fat, protein, and carbohydrate metabolism, although they may also drink small amounts of seawater (Telfer, Cornell, and Prescott 1970). The total available daily fluid volume from the food fish for bottlenose dolphins, calculated based on the nutrient analysis of 1 month's worth of consumed fish and excluding metabolic water, indicated that bottlenose dolphins consume an average of 47 mL/kg of water per day (**Figure 40.1**).

Larger cetaceans have comparatively less, and smaller cetaceans have comparatively more, oral fluid volume available to them (**Figure 40.2**).

It is important to note that we do not know how much of this available fluid is absorbed; these calculations are the total available fluid and may not reflect the daily fluid requirements. However, these calculations may be useful as a starting point for calculating fluid volumes for ill cetaceans requiring fluid supplementation.

A normal cetacean with some surplus body fat can fast for some time with metabolic water and a little seawater as the total water supply. However, if a cetacean is sick, its fluid needs may outpace the available innate metabolic water supplies. The blood hemoglobin concentration of entirely anorexic cetaceans may increase by as much as 1 g/dL/day. If no fluid therapy is provided, these cetaceans may start

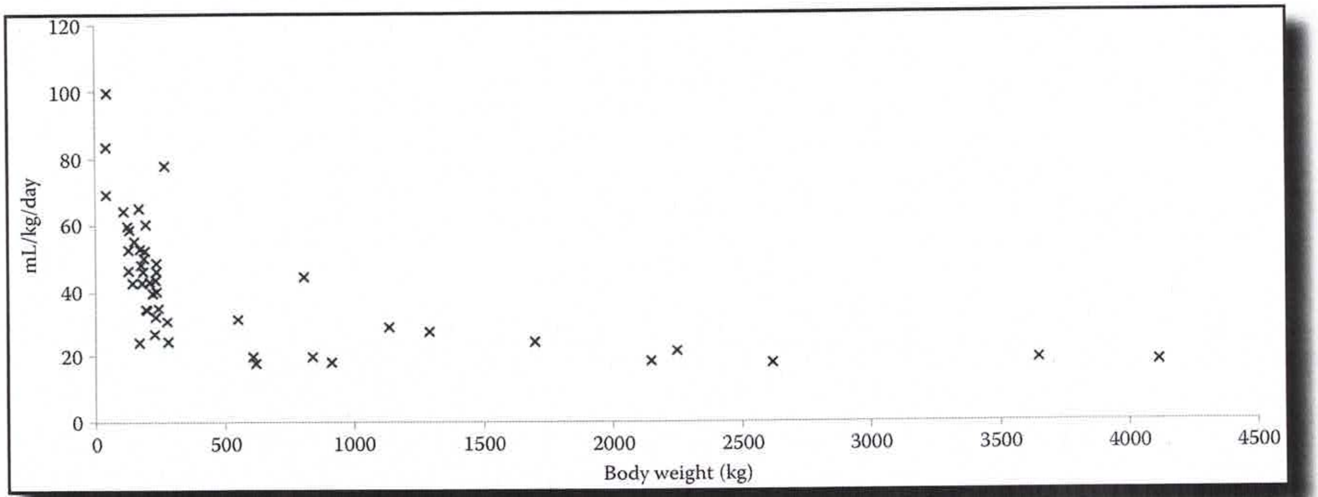

Figure 40.2 The total available daily fluid volume (in mL/kg body weight per day) from food fish for five species of cetaceans (*Cephalorhynchus commersonii, Tursiops truncatus, Globicephala macrorhynchus, Delphinapterus leucas*, and *Orcinus orca*), calculated based on the nutrient analysis of 1 month's worth of consumed fish. The total available daily fluid volume, and presumably the daily minimum fluid requirement, decreases with size.

consuming excessive amounts of seawater, leading to sodium toxicity and death. Other markers of dehydration are packed cell volume, total protein, BUN-to-creatinine ratio, and serum sodium and chloride levels. Unfortunately, skin tenting or volume of tear production cannot be utilized as a physical indicator of cetacean hydration status. The capillary refill time (CRT) test performed in the back of the throat has been suggested and is utilized by some clinicians as an index of intravascular volume (Butterworth, Kestin, and McBain 2004).

Dehydrated cetaceans usually respond very well to oral fluids, and the administration of fluids via the oral route using a foal or large animal stomach tube is preferred. Tubing volumes of 2 and 4 L are well tolerated by bottlenose dolphins and beluga whales, respectively. Some individuals may only tolerate half that volume if they are anxious or ill. Tap water is used by some, but the authors recommend using a commercial oral electrolyte solution. If vomiting of oral fluids occurs, the subcutaneous route can be used effectively. The virtual subcutaneous space at the interface between the blubber layer and the skeletal muscle layer, especially the area overlaying the lateral thorax immediately caudal to the scapula, can receive fluid amounts equivalent to the subcutaneous space in many terrestrial animals. To administer subcutaneous fluids to a cetacean, use fluid bags with a standard IV infusion setup. Advance the needle through the blubber with the fluids under pressure and the tubing clamp released. The fluids will begin to flow freely when the needle enters the subcutaneous space. Most cetacean practitioners use pressure cuffs to speed the flow, once the needle is in the proper location. In a bottlenose dolphin, 1–2 L of fluids can be infused per injection site. IV fluid therapy beyond the administration of IV boluses is generally not an option, because of the abovementioned challenges in maintaining indwelling catheters. However, fluids have been bolused at a shock volume of 10 mL/kg, without adverse effects, in a limited number of patients.

Managing Inappetence

Healthy cetaceans rely predominantly on food fish for hydration. An inappetent cetacean may need to be handled two or three times daily to administer medications and meet daily fluid requirements. Repeated handling will often be counterproductive in getting the cetacean patient to take food fish voluntarily. Where the use of steroids is now usually frowned upon in domestic animal medicine, steroidal drugs like prednisone and dexamethasone are the most effective and possibly only true appetite stimulants in cetaceans through a mechanism of iatrogenic insulin resistance (Reidarson and McBain 1999). Dexamethasone and prednisone doses of 0.07 mg/kg (once daily) and 0.15 mg/kg (twice daily), respectively, administered either PO or IM, are good starting doses that will indicate whether this approach to appetite stimulation will work on the patient. Clinicians may start these appetite stimulants at these initial doses, but the dose should be tapered within just a couple of days to the lowest effective dose. Dexamethasone and prednisone have the real potential to mask severe or worsening clinical signs, so the authors want to caution that steroids should be used very judiciously and only where voluntary food intake is essential to a positive treatment outcome. Steroids should not be administered prior to getting a full set of diagnostics, including blood samples. Regular patient monitoring should continue, even when clinical signs appear to resolve. Both the duration of treatment and dosage should be kept to a necessary minimum; steroid therapy is best tapered down much more gradually than in domestic animals, at a minimum in cetaceans using five or more tapering stages. Diazepam is not an effective direct appetite stimulant in cetaceans. The sensitivity of cetaceans to the sedative effect of diazepam is similar to humans and lower than the sensitivity of domestic dogs and cats; thus, doses required to stimulate appetite in dogs and cats are not suitable for cetaceans. However, the administration of anxiolytic doses of diazepam (0.1 mg/kg, twice to three times daily) may be appropriate, and in the patient's best interest, for confirming anxiety rather than illness as the cause of inappetence, for maintaining appetite during periods of transition (e.g., social change), or for alleviating anxiety during repeated handling when treating an illness.

Managing Weight Loss

Cetaceans live in a medium that wicks away body heat at a rate much faster than experienced by land mammals. Water conducts heat roughly 25 times more efficiently than air. As a result, a cetacean with prolonged decreased appetite can rapidly lose weight due to a combination of fluid loss and a negative caloric balance. An ill cetacean with a negative body weight trend will be slow to respond to treatment, so it is an important treatment objective to halt the weight loss in these patients. Once the weight loss has been halted, a spontaneous weight gain will usually follow. Appetite stimulants are not the only tool for countering weight loss. Dolphins normally adapt to changes in water temperature by adjusting the thickness of their blubber layer (Yeates and Houser 2008). The ambient pool temperature for a cetacean with an inadequate blubber layer can gradually be raised to well above the usual thermal comfort zone to counter body heat dissipation, and lower the caloric needs. Patients can be tube-fed whole fish blended in oral electrolyte solution; and mostly thawed, semirigid, larger food fish can be used to force-feed or assist-feed a patient. It is difficult at best to meet the caloric requirements of an ill cetacean via tube or assist feeding alone. It is feasible, however, even in adult dolphins, to maintain weight and even support weight gain by tube feeding with a cetacean neonatal milk replacer formula (see **Chapter 30**). The prognostic implications and the difficulties managing weight loss highlight the need for collecting regular body weights, even if this requires handling, stretchering, and craning.

Immediate Care of Stranded Cetaceans

The processes of beaching and no longer being neutrally buoyant trigger several progressing physiological changes. Some indicators may serve as prognostic indicators and decision keys, including blood work parameters (i.e., K^+ higher than 5–6, alkaline phosphatase lower than 30, Na^+ higher than 180), major injuries to the head, high respiratory rate (every 3–4 seconds), open thoracic or abdominal wounds, etc., paired with evaluation of baseline indexes of sensibility (Butterworth, Kestin, and McBain 2004). Once the decision to rehabilitate has been made, every effort must be made to get that stranded cetacean to the rehabilitation center as rapidly as possible. Minimizing the time from stranding to being lowered in the rehabilitation pool should be the first responders' priority, since it keeps anxiety, exertion, secondary trauma, and the effects of gravity on the cetacean's perfusion and ventilation to a minimum.

A stranded cetacean can be assumed to be dehydrated and will benefit from tubing a small volume of a commercial oral electrolyte solution during initial handling. If the animal is a dependent calf or if it is in poor body condition, an oral electrolyte solution admixed with up to 50% dextrose can be used. Hypoglycemia often accompanies hypothermia. If a cetacean is hypothermic, weak, and rapidly declining, the probability of hypoglycemia is high.

Time and resources permitting, blood can be collected for analysis on a point-of-care glucometer or iStat. Glucose levels, hematocrit, pH, lactate, and sodium levels will help guide the initial care after arrival at the rehabilitation center. If IV access can be maintained, a larger sample of blood can be collected for complete blood cell count, serum chemistry, and blood culture, and fluids (lactated Ringer's solution or 0.9% NaCl) can be bolused at a rate of 10 ml/kg while in transport. Unless severely depressed, diazepam can be administered (0.1–0.15 mg/kg, IV or IM), both to relieve some of anxiety associated with the stranding event and to provide muscle relaxation.

Secondary to stranded related myopathy, stranded cetaceans often develop contracture of the epaxial and/or hypaxial muscles at the level of the peduncle (Nollens et al. 2014). Continued oral diazepam administration (0.1–0.15 mg/kg PO, twice daily), combined with selenium, vitamin E, and an anti-inflammatory agent after arrival in the rehabilitation center, may further aid in preventing stranding myopathy. For patients that are unable to remain buoyant, the water in the rehabilitation pool can be lowered to a level that allows the animal to breathe while resting on the bottom, but also allows for the choice and control to move around the pool. Alternatively, such patients can be fitted with custom neoprene float jackets to provide buoyancy support and correct listing if necessary. Once a wild cetacean is in the grip of a human or a buoyancy device, it is not unusual for the animal to submit or give up. The clockwise and counterclockwise swimming direction while in a buoyancy device should be alternated and range-of-motion exercises implemented to further reduce the risk of stranding myopathy and subsequent scoliosis. Being supported by humans should be the last choice of method for supporting a buoyancy-challenged wild cetacean, as it greatly increases the level of anxiety and its subsequent adverse effects on muscle relaxation and food intake. Shade should be provided and protective creams applied to the dorsal thorax and melon to avoid sunburn in floating debilitated animals.

Surgery

Until recently, the majority of surgery reports in cetaceans were limited to dentistry, wound management, abscess treatment, superficial biopsy, liver biopsy, endoscopic procedures, and mandibular and maxillary fracture repair. There are a couple of features regarding abscesses in cetaceans that are worthy of attention. Purulent infections deep to the blubber layer will tend to dissect along the muscle blubber interface rather than rupturing through to the surface. These infections are often difficult to identify visually. Based on a small number of cases, abscesses in cetaceans dissect or migrate dorsally (rather than ventrally as in terrestrial species). The tendency to migrate contrary to land animal rules may be related to the water pressure gradient on the animal. In a normal swimming posture, the water pressure on the ventrum of a cetacean will be greater than on its dorsal aspect.

With the successful application of moderate to deep sedation (midazolam 0.08 mg/kg IM or 0.05 mg/kg IV) and general anesthesia (Schmitt et al. 2014; Bailey 2016), surgery is expected to become more readily employed for the diagnosis and management of ill cetaceans (**Chapter 26**). In particular, minimally invasive laparoscopic approaches seem to hold tremendous potential for advancing cetacean medicine.

Pain Management

Pain management is an important component of animal welfare. Robust advances in pain management research in companion animals have led to the revision of the pain management guidelines for dogs and cats (Epstein et al. 2015). These advances in pain management are now spilling over into marine mammal medicine. Analgesics seem indicated where pain is affecting activity, appetite, or cooperation with husbandry behaviors. However, before administering an analgesic, the clinician should consider that analgesics have the significant potential to cover up signs of deterioration, which may further complicate coming to a diagnosis or assessing a patient already evolved to mask clinical signs. Both pharmacologic and nonpharmacologic modalities, such as cold laser, are now more routinely used in cetacean practice. It is becoming apparent that the pharmacodynamics of analgesic drugs are very different in cetaceans compared to domestic animals. A pharmacokinetic study of the NSAID meloxicam in bottlenose dolphins showed that the general mammalian dose of 0.1 mg/kg yields a plasma level that is considered therapeutic in other species (Simeone et al. 2014). However, in cetaceans, drug elimination is very prolonged, and drug levels were detectable for up to 7 days. Opioids, such as tramadol, can be used alone or in combination with an NSAID. In the authors' experience, cetaceans are very sensitive to opioids, and opioid drug elimination may also be prolonged. A single dose of 0.22 mg/kg tramadol PO was empirically found to provide a good analgesic effect in a killer whale, and the sedative effect of a single dose of 0.05 mg/kg butorphanol delivered IM in a Commerson's dolphin was reversible using naltrexone more than 7 hours after the drug's administration.

Respiratory Disease

Due to the limited anatomy of the upper respiratory tract and the cetacean's inspiratory vigor, pathogens are easily introduced into the lower respiratory tract, and, as a result, pneumonia is one of the most common causes of illness in cetaceans (Venn-Watson et al. 2012a). Chronic low-grade pneumonia is not uncommon in cetaceans and is often only clinically apparent because of elevations in some inflammatory parameters. The working diagnosis for an illness of unknown origin in a cetacean can therefore be pneumonia until proven otherwise. Confirming pneumonia can be challenging but has been successful using ultrasonography (Smith et al. 2012), radiography (Dalton, Mathey, and Hines 1990), bronchoscopy (Harrell et al. 1996; Hawkins et al. 1996), and CT imaging. Culturing the etiologic agent and determining in vitro antibiotic sensitivities is best attempted via bronchoalveolar lavage and aspirates of pleural effusion, if present. Cultures of blow swabs and exhalates and cultures that yield mixed bacterial isolates are overwhelmingly unreliable (Venn-Watson, Smith, and Jensen 2008b). Pneumonia is consequently most often treated using empiric oral broad-spectrum antibiotic combinations. The oral systemic therapy can be augmented using aminoglycoside or fluoroquinolone aerosol therapy (Ballmann, Amyth, and Geller 2011; Claus et al. 2014). Blood inflammatory parameters should be frequently monitored. In those cases where pneumonia appears refractory to treatment, infections with *Pseudomonas aeruginosa*, nontuberculous mycobacteria, primary or opportunistic fungal infections, and respiratory nocardiosis need to be considered (see **Chapter 19**). In these cases, a course of injectable amikacin therapy may be appropriate. Serology for select fungal agents on paired or a time series of serum samples can be useful for confirming a fungal presence (Reidarson, McBain, and Harrell 1996). The presence of *Mycobacterium* spp. and *Nocardia* spp. can at times be confirmed via PCR on bronchoalveolar lavage or exhaled phlegm. *Mycobacterium* spp. infections require multimodal drug treatments specific to each species and even isolates. Nocardiosis can be managed using the bacterial folate inhibitor trimethoprim–sulfadiazine. Fungal coinfections are common (Nollens et al. 2007b; Venn-Watson, Smith, and Jensen 2008b), in some cases due to increased susceptibility after prolonged antibiotic therapy. The clinician should therefore contemplate starting azole therapy in any cetacean with suspected pneumonia.

Gastrointestinal Disease

Gastrointestinal disease is likely underdiagnosed, since evidence like emesis or defecations can disappear in seconds in an aquatic environment and will be missed without routine, focused direct observation. In dolphins, the normal postprandial gastric pH of 1.5 will rapidly demineralize fish bones, and the appearance of a fish skeleton on the pool bottom will usually only have occurred as a result of emesis. The presence of gastrointestinal disease can be confirmed via gastric fluid cytology, gastroscopy, and fecal cytology.

Gastritis with or without the presence of a gastric foreign body may progress to ulcerative gastritis. Emesis of a buoyant and nonsharp foreign body can be attempted via depositing 1 L of hydrogen peroxide (H_2O_2) directly in the stomach. In most cases, endoscopic removal of foreign bodies, buoyant or otherwise, using an assortment of endoscopic retrieval devices (ASGE Technology Committee 2009) is more reliable. H_2 blockers and proton pump inhibitors are the mainstay of treating ulcerative gastritis, although the resulting increases in gastric pH may interfere with demineralization of fish bones. If the pH is too high, bones will not demineralize and will begin to accumulate in the stomach until they produce gastric upset and vomiting. This warrants monitoring the feces of a cetacean on H_2 blockers or proton pump inhibitors for the presence of undigested bone spicules. In the authors' experience, in cetaceans, sucralfate suspensions preferentially bind fish skin over gastric mucosa, and it may be administered using an orogastric tube or in the mantle of a squid, and, preferably, at some time prior to the first meal of the day. The progression of gastritis can be monitored using fasted gastric fluid samples (preferably collected under operant conditioning) or via repeated gastroscopy, so the duration of treatment is kept to the necessary minimum. Blood inflammatory parameters and markers of red blood cell loss should be closely monitored.

Lower gastrointestinal disease may trigger few changes in a traditional blood panel. Confirmation of diagnosis is based on abnormal fecal cytology results; the measurement of serum folate and cobalamin levels appears to hold diagnostic potential as well (Tang et al. 2015). Like in other mammals, lower gastrointestinal disease can be managed using a combined approach of a broad-spectrum antibacterial, such as a fluoroquinolone, increased oral hydration to make up for fluid loss, and temporarily lowering the total daily food intake. Based on a limited number of cases, administration of the smooth muscle spasmolytic, butylscopolamine may provide some relief of abdominal discomfort. Similarly, simethicone may provide relief by decreasing the surface tension of gas bubbles, thereby dispersing and preventing gas pockets in the gastrointestinal tract. The presence of yeast organisms on fecal cytology and Gram stain indicates yeast overgrowth and warrants administering nystatin. The presence of large Gram-positive rods warrants a course of oral metronidazole or clindamycin. Metronidazole can occasionally cause gastric upset as demonstrated by a decreased appetite. In these cases, the total daily dose can be administered as part of the last meal at the end of the day. Metronidazole therapy should not be long term, based on clinicians' reports of potential CNS side effects after 2 weeks of treatment.

Ocular Disease

Blepharoptosis and blepharospasm can be nonspecific symptoms of generally feeling unwell or in response to corneal injury or ocular discomfort. To confirm that corneal injury and pain is causing a closed eye, instill ophthalmic local anesthetic between the eyelids. This is accomplished by squirting the liquid, with a syringe, at the orbital fissure from a few centimeters' distance. If some of the local anesthetic finds its way to the cornea, it will temporarily relieve the pain and allow the animal to open its eye for examination. This procedure is helpful because it is difficult, if not impossible, to visualize a closed cetacean eye by forcing the lids open.

Corneal disease is the primary ophthalmic problem in dolphins (Colitz, Walsh, and McCulloch 2016). Corneal disease can consist of traumatic lacerations, edema, ulcerations, and perforations. Good water quality, with low residual oxidants, is paramount for both prevention and treatment of corneal injuries. Shade and darker pool colors may alleviate a UV component in the pathogenesis, if present (see **Chapter 31**). Systemic and topical antibiotics can be used as needed to prevent secondary bacterial infections. Oral fluoroquinolones are common broad-spectrum antibiotics selected for treatment and prevention of bacterial eye infections because of their excellent penetration in the aqueous and vitreous, and their tendency to concentrate in the tears. Oral tetracyclines similarly concentrate in the periocular oil and Meibomian glands but may take longer to take effect, and prolonged treatments may be required. Systemic treatment of corneal injury can be augmented with topically applied commercial ophthalmic antibiotics drops. As noted earlier, ophthalmic drops can be admixed with the mucolytic 20% acetylcysteine to a final concentration of 5% acetylcysteine to allow the medications to penetrate the full thickness of the cetacean's tear plug, but only after ensuring the end solution's pH. Treatment trials with ophthalmic drops consisting of autologous platelet-rich plasma in a very limited number of bottlenose dolphins were unrewarding. However, subconjunctivally administered combinations of autologous platelet-rich plasma, adipose-derived stem cells, and antimicrobials may be a more useful clinical tool (Simeone et al. 2017). Raising the ambient water temperature to 26.7°C appears to allow faster and more complete healing of corneal injuries. Cataracts are rarely reported in cetaceans (Colitz, Walsh, and McCulloch 2016) and are usually left untreated, as impaired vision can be supplemented with echolocation (see **Chapter 23**).

Skin Disease

Traumatic multiple parallel lacerations, or rake marks, caused by the sharp teeth of conspecifics are common in some cetacean species. This type of superficial trauma usually does not require treatment. Cetaceans are good innate wound healers (Zasloff 2011), and even more extensive skin and peripheral soft tissue trauma can generally be left to heal unassisted. Wound healing rates may benefit from both systemic antibacterial therapy aimed at managing secondary bacterial infections, and some frequency of wound cleaning. Topical creams are challenging to adhere sufficiently to cetacean skin, but can be used. One such compounded cream contains raw honey and platelet-rich plasma.

Cutaneous pox lesions are commonly encountered by the cetacean clinician. They are benign infections of viruses in their natural host. The effect of these infections is aesthetic only, and treatment is therefore unnecessary. The conditions, including water parameters, that allow these cutaneous infections to become established or recrudesce are not yet understood. Empirically, changes in water temperature may lessen the appearance of the pox lesions, through a mechanism that has again not yet been clarified (Croft et al. 1996).

Liver Disease

Liver disease is common in wild and managed dolphins (Jaber et al. 2004; Venn-Watson et al. 2015a). Causes of liver disease in cetaceans can include exposures to toxins, response to medications, active infections, and metabolic conditions. In wild cetaceans, exposure to petroleum products from oil spills, polychlorinated biphenyl (PCB), dioxins (from forest fire smoke, runoff, and contaminated fish), and chronic mercury accumulation have been associated with elevated liver enzymes and liver abnormalities (Rawson et al. 1993; Schwacke et al. 2011, 2013). Medications that may negatively impact the liver in terrestrial species have the same potential to elevate liver enzymes in small cetaceans; this includes, but is not limited to, specific classes of antimicrobials, steroids, and other anti-inflammatory agents, and analgesics. While bacterial and fungal infections are not typically limited to the liver, the liver is often affected if there is systemic disease. Viral hepatitis is presumably underdiagnosed, with only one case of adenoviral hepatitis recognized in belugas (Mihindukulasuriya et al. 2008). Viral infections may be suspected during acute spikes

Table 40.3 Summary of Suggested Diagnostic Tests and Threshold Values for Liver, Renal, and Metabolic Conditions in Bottlenose Dolphins

Metabolic Condition	Test	Suggested Values
	Liver Disease	
Elevated liver aminotransferases	Alanine aminotransferase (ALT)	>60 μ/L
	Aspartate aminotransferase (AST)	>386 μ/L
	Renal Disease (Nephrolithiasis)	
Mild to Advanced Disease (no obstruction)		
Azotemia	Blood urea nitrogen	>59 mg/dL
Elevated creatinine	Serum creatinine	>1.9 mg/dL
Anemia	Hematocrit	<38%
Hematuria (advanced cases)	Erythrocytes, occult blood	Present
Visualized collecting duct (advanced cases)	Ultrasound	NA
Obstruction		
Acute and progressive azotemia High creatinine Electrolyte imbalances	As above but acute, progressive, and more severe	
	Metabolic Syndrome	
Hyperferritinemia	Serum ferritin	>500 ng/mL
Hypertriglyceridemia	Lipid panel	>75 mg/dL
Hyperinsulinemia	Serum insulin (2 hours postprandial)	>11 μIU/mL
Elevated glucose (+/−)	Plasma glucose (2 hours postprandial)	>100 mg/dL
Low serum C17:0	Serum total C17:0 (2 hours postprandial)	<0.4%
	Iron Overload	
Hyperferritinemia	Serum ferritin	>500 ng/mL
High transferrin saturation	Transferrin saturation	>50%
Hyperferremia	Serum iron	>300 ng/dL
Hepatic hemosiderosis	Histology—H & E stain	
Hepatic iron overload	Histology—Prussian blue stain	
	Fatty Liver Disease	
Hepatic lipid deposits	Histology—oil red O staining of frozen tissue	
Chronic hyperglycemia	Serum glucose (2 hours postprandial)	>140 mg/dL
Chronic inflammation	White blood cell count	>11,000 cells/dL
	Hyperglobulinemia	>3.5 g/dL
	Low Vitamin D and Hyperparathyroidism	
Low vitamin D	Serum 25-hydroxyvitamin D_3 (nmol/L)	<360 nmol/L
Hyperparathyroidism	Parathyroid hormone (pmol/L)	>7.4 pmol/L

Sources: Johnson, S. P. et al., Use of phlebotomy treatment in Atlantic bottlenose dolphins with iron overload, *J Am Vet Med Assoc* 235: 194–200, 2009. Meegan, J. M. et al., An investigation of ionized calcium, vitamin D, and parathyroid hormone in Bottlenose dolphins, in *Proceedings of the 45th Annual International Association for Aquatic Animal Medicine Conference*, Gold Coast, Australia, 2015. Schmitt, T. L., and R. L. Sur, Treatment of ureteral calculus obstruction with laser lithotripsy in an Atlantic bottlenose dolphin (*Tursiops truncatus*), *J Zoo Wildl Med* 43: 101–109, 2012. Venn-Watson, S. et al., Clinical relevance of urate nephrolithiasis in bottlenose dolphins (*Tursiops truncatus*), *Dis Aquat Org* 89: 167–177, 2010. Venn-Watson, S. et al., Blood-based indicators of insulin resistance and metabolic syndrome in bottlenose dolphins (*Tursiops truncatus*), *Front Endocrinol* 4: 10.3389/fendo.2013.00136, 2013. Venn-Watson, S. et al., Increased dietary intake of saturated fatty acid heptadecanoic acid (C17:0) associated with decreasing ferritin and alleviated metabolic syndrome in dolphins, *PLoS One* 10: e0132117, 2015.

in liver enzymes, but confirmation of viral hepatic infections remains elusive due to the lack of liver biopsies within the short infection window. It is not uncommon for cetaceans to have nonspecific chronic reactive hepatitis that may be a residual condition from previous infections or other liver injury. Further, approximately 30% of stranded wild, free-ranging bottlenose dolphins have moderate to severe hepatic fibrosis, most of which have an unknown etiology (Jaber et al. 2004; Venn-Watson et al. 2015a).

Recognized components of liver disease in free-ranging and managed bottlenose dolphins are lipid deposition (fatty liver disease), iron deposition (iron overload), hepatitis, and fibrosis (Jaber et al. 2004; Venn-Watson et al. 2012b, 2015a). There may be underlying nutritional and metabolic drivers for these changes, which are discussed further in the Metabolic Diseases section below.

Liver disease can be readily detected by testing for elevated serum liver enzymes (Venn-Watson, Smith, and Jensen 2008a; **Table 40.3**). While acute liver disease often presents with a spike in liver enzymes, chronic liver disease may involve elevations in liver enzymes that wax and wane and progress in severity over time. Additional blood-based indices that may help identify causes for liver disease include gamma glutamyl transferase, ferritin, iron, triglycerides, cholesterol, and indicators of inflammation (see Metabolic Syndrome below).

A management regimen for acute liver disease may include supportive fluid therapy, appetite stimulants, nutritional support, and antimicrobials (e.g., doxycycline + rifampin). Gastroscopy may be indicated, as a moderate to severe ulcerative gastritis has been identified in a number of dolphins with acute hepatitis. Longer-term interventions include phlebotomy (Johnson et al. 2009), and potential dietary changes for iron overload and fatty liver disease (Venn-Watson et al. 2015b).

Renal Disease

Bottlenose dolphins can develop nephrolithiasis, typically consisting of ammonium acid urate (AAU) stones (Venn-Watson et al. 2010a; Argade et al. 2013). In general, AAU stones in terrestrial animals can be caused or exacerbated by high-purine diets, low urinary pH, and other conditions that foster supersaturation of ammonium in the urine. Potential contributors to nephrolithiasis in cetaceans could include dietary fish types high in purines, nutrient or metabolic states that lead to more acidic or concentrated urine, and larger meal sizes that may cause greater fluctuations in postprandial urinary ammonia (Smith et al. 2013, 2014). Additionally, hypocitraturia and older age have been identified as risk factors for stone formation in dolphins (Venn-Watson et al. 2010b; Smith et al. 2013).

Nephrolithiasis can be detected in small cetaceans using renal sonography and computed tomography (**Table 40.3**; Venn-Watson et al. 2010a; Smith et al. 2013). Ultrasound exams can be performed in real-time B-mode either in water or on land using units with 2–5 MHz variable frequency and curvilinear transducers. Nephroliths are defined as hyperechoic foci with distinct acoustic shadows (Smith et al. 2013). Visualization of the collecting duct is indicative of an animal with advanced disease (greater than 20 nephroliths; Venn-Watson et al. 2010a). Bottlenose dolphins with nephrolithiasis, without obstruction, may have limited changes in blood values, including anemia (hematocrit less than 38%), high blood urea nitrogen (greater than 59 mg/dL), high creatinine (greater than 1.9 mg/dL), and low estimated glomerular filtration rate (less than 150 mL/min; Venn-Watson et al. 2010a). Advanced cases (greater than 20 nephroliths detected on ultrasound) may also have urinary erythrocytes, occult blood, and lower pH (Venn-Watson et al. 2010a). Animals with stone obstruction can present with acute anorexia, progressive azotemia, high creatinine, and electrolyte abnormalities (Schmitt and Sur 2012).

Training cetaceans to accept daily oral hydration may help in the prevention and management of nephrolithiasis. As noted earlier, tap water (0.5–1 L) can be used, but the authors recommend using a commercial oral electrolyte solution. While terrestrial animals with AAU stones may be effectively treated using potassium citrate, evidence to date has not supported its efficacy in small cetaceans. Current potential management options under investigation include modified diets using fish with lower purines and lower acidity, and adapted potassium citrate dosing. Upon obstruction, laser lithotripsy has been successfully used in dolphins to identify and remove stones (Schmitt and Sur 2012).

Metabolic Syndrome

Metabolic syndrome is a spectrum condition of both wild and managed bottlenose dolphins, in which they have mild to advanced elevations in insulin and lipids (Venn-Watson et al. 2013). Similar to humans, metabolic syndrome in dolphins is associated with fatty liver disease and iron overload (discussed below; Venn-Watson et al. 2012b; Neely et al. 2013). Without treatment, metabolic syndrome appears to progress with age. As such, while it is not associated with mortality, it is believed that alleviation of metabolic syndrome and its associated conditions can improve the overall health of an animal.

Metabolic syndrome is best detected by feeding one-third of the animal's daily diet in the morning and collecting 2-hour postprandial blood samples for the measurement of ferritin, insulin, glucose, and triglyceride levels (**Table 40.3**; Venn-Watson et al. 2015b). During the early stages of metabolic syndrome, dolphins may have mildly elevated serum ferritin (500–800 ng/mL; Mazzaro et al. 2012; Venn-Watson et al. 2015b). It is not unusual, however, for dolphins in advanced stages to have ferritin levels exceeding 10,000 ng/mL. Ferritin is an indicator of amount of iron stored, which appears to contribute to insulin resistance in dolphins (see Iron Overload below; Neely et al. 2013; Sobolesky et al. 2016). As metabolic syndrome advances, elevated postprandial triglycerides (greater than 78 mg/dL) and insulin (mild = 8–10 μIU/mL; advanced = greater than 11 μIU/mL) may be present. While mild elevations in glucose may be seen in dolphins with metabolic syndrome, this appears to be the least remarkable of blood changes.

Dietary fatty acids, including heptadecanoic acid (C17:0), have been identified that may help prevent and manage metabolic syndrome (Venn-Watson et al. 2015b). Initial studies have demonstrated that feeding a diet with approximately 6 mg/kg of C17:0 daily through fish can successfully raise serum total C17:0 levels higher than 0.4% within 1–3 months. Fish with C17:0 include mullet (67 mg/100 g), pinfish (41 mg/100 g), mackerel (22 mg/100 g), and herring (19 mg/100 g). Capelin and squid have no detectable C17:0. In an initial study, achieving a therapeutic target of greater than 0.4% serum total C17:0 on this modified diet was associated with lowered ferritin within 1 month and normalization of triglycerides, insulin, and glucose within 6 months (Venn-Watson et al. 2015b).

In addition to dietary changes, phlebotomy to treat iron overload (see section below) may also alleviate metabolic syndrome (Johnson et al. 2009). This effect is consistent with human literature, in which phlebotomy successfully treats insulin resistance and metabolic syndrome (Valenti et al. 2007). While phlebotomy can result in relatively rapid normalization of insulin, it does not appear to treat the underlying driver for iron overload and metabolic syndrome (Mazzaro et al. 2012). As such, metabolic syndrome can continue to progress over time, requiring periodic phlebotomy treatments if other interventions are not employed.

Iron Overload

Iron overload in bottlenose dolphins is typically limited to the liver and may progress to hepatitis and hepatic fibrosis (Venn-Watson et al. 2012b). Hepatic iron overload is present in both wild and managed dolphin populations, with reported prevalence of disease ranging from 18% to 67% (Venn-Watson et al. 2012b). Iron overload in dolphins closely mimics dysmetabolic iron overload syndrome (DIOS) in humans, including associations with insulin resistance, metabolic syndrome, and fatty liver disease (Dongiovanni et al. 2011). Like DIOS, in dolphins, iron preferably deposits within the Kupffer cells (reticuloendothelial cells) of the liver versus in hepatocytes, and this condition does not appear to be driven by variations in the human hemochromatosis protein (HFE) gene, a common genetic mutation causing human iron overload (Venn-Watson et al. 2012b; Phillips et al. 2014).

Iron overload in dolphins is characterized by high serum ferritin (suspect = 500–800 ng/mL; highly likely = greater than 1,000 ng/mL), serum iron greater than 300 μg/dL, and transferrin saturation greater than 50% (**Table 40.3**; Johnson et al. 2009; Mazzaro et al. 2012). It is not unusual for dolphins with advanced iron overload to have a transferrin saturation between 80% and 100% and phasic elevations in liver enzymes (ALT greater than 60 μ/L; AST greater than 386 μ/L), as well as elevated triglycerides (greater than 139 mg/dL,) total cholesterol (greater than 280 mg/dL), globulins (greater than 3.8 g/dL), and 2-hour postprandial insulin (greater than 11 μIU/mL; Venn-Watson et al. 2008a, 2013; Johnson et al. 2009; Mazzaro et al. 2012; Neely et al. 2013). The presence of dark staining in liver tissue stained with hematoxylin and eosin (H & E) is indicative of hemosiderin deposition; use of Prussian blue staining can confirm the presence of iron (Venn-Watson et al. 2012b).

Dolphins with iron overload may benefit from phlebotomy treatment as described by Johnson et al. (2009). Briefly, 1–3 L of blood is removed weekly until serum transferrin saturation is less than or equal to 20%, or hematocrit is less than 30%. During the induction phase, phlebotomy procedures for advanced cases may be 20–30 weeks. Shorter-term maintenance phlebotomy procedures can be used as needed (e.g., when transferrin saturation rises back to 65%, or serum iron is over 300 μg/dL). This treatment protocol has been repeatedly demonstrated to successfully and safely lower iron, liver enzymes, and indicators of inflammation to normal levels (Johnson et al. 2009). It is not unusual, however, for transferrin saturation to return to prephlebotomy treatment levels 3–6 months after completed phlebotomy treatments (Mazzaro et al. 2012). In addition to phlebotomy, recent studies suggest that a modified fish diet may help to correct underlying drivers for iron overload in bottlenose dolphins (Venn-Watson et al. 2015b). Specifically, a diet with less capelin (e.g., 25% of total daily kcal) and more mullet or pinfish (25–50% of total daily kcal) has resulted in decreased ferritin within 3 weeks, which continued through 6 months (Venn-Watson et al. 2015b). Rise in dietary intake of C17:0 (heptadecanoic acid) through this modified diet is directly associated with decreasing ferritin (see section on Metabolic Syndrome; Venn-Watson et al. 2015b; Sobolesky et al. 2016). While research on modified diets and iron overload is ongoing, there have been multiple reports of dolphins with histories of chronic iron overload that have stopped needing maintenance phlebotomy treatments once placed on this modified diet.

Fatty Liver Disease

Fatty liver disease is a metabolic disorder in which lipid is abnormally deposited and stored in the liver. Similar to humans, some dolphins may have mild to moderate fatty liver disease with no morbidity or clinical relevance, while other dolphins may have fatty liver disease that can advance to steatohepatitis with clinically relevant elevations in liver enzymes (Venn-Watson et al. 2012b). Fatty liver disease, typically involving multifocal hepatocellular lipid deposition, is present in both free-ranging and managed bottlenose dolphin populations, with prevalence ranging from 12% to 39% (Venn-Watson et al. 2012a,b). In other animals, fatty liver disease has been associated with metabolic syndrome and associated lipid disorders, including hypertriglyceridemia (Dongiovanni et al. 2011). It is likely that dolphins have these same associations among metabolic conditions.

Fatty liver disease is confirmed through histopathology of liver biopsies (**Table 40.3**). The presence of clear "bubbles" in liver tissue stained with H & E is indicative of fatty liver disease; use of oil red O staining of frozen liver tissue can confirm the presence of lipid (Venn-Watson et al. 2012b). A retrospective study demonstrated that dolphins with fatty liver disease are more likely to have had a history of chronic postprandial hyperglycemia (>140 mg/dL) and chronic inflammation (elevated white blood cell count and hyperglobulinemia) compared to dolphins without fatty liver disease (Venn-Watson et al. 2012b). As such, there may be benefit to retrospectively evaluating the prevalence of fatty liver disease in dolphin populations to help guide prevention and management strategies. In addition, chronic elevations in postprandial glucose, paired with chronic inflammation, may be suggestive of fatty liver disease.

Due to the difficulty of confirming fatty liver disease antemortem, management of fatty liver disease may be guided by the known retrospective prevalence of fatty liver disease in the population. While there is currently no specific guidance to treat fatty liver disease in dolphins, addressing associated metabolic syndrome may have mutual benefits to managing fatty liver disease (see previous section on Metabolic Syndrome).

Hypovitaminosis D and Hyperparathyroidism

Vitamin D and its role in calcium homeostasis have been gaining increasing attention in human and veterinary medicine. In terrestrial animals, chronically low vitamin D and associated low calcium and high parathyroid hormone can increase susceptibilities to bone fragility, kidney stones, fatigue, bone and joint pain, or inappetence. Vitamin D concentrations in marine mammals vary greatly among species and appear to be associated with species-specific feeding habits and prey species (Keiver, Ronald, and Draper 1988; Kenny et al. 2004). As such, dietary sources and targeted blood levels of vitamin D specific to bottlenose dolphins have been under investigation (Meegan et al. 2015). Importantly, vitamin D_3 content in fish varies: with capelin having low to no vitamin D_3; mackerel, croaker, and herring having approximately 200–400 IU/100g vitamin D_3; and mullet and pinfish containing approximately 600 to 1,000 IU/100 g vitamin D_3. Vitamin D and parathyroid hormone analysis should be considered where calcium and phosphorous disturbances are detected. Potential causes for these conditions include gastrointestinal malabsorption, lactation, chronic renal disease, decreased dietary intake, insufficient supplementation, or diets low in vitamin D or calcium.

Vitamin D status can be assessed in cetaceans by testing for serum 25-hydroxyvitamin D_3 (25-OHD_3; **Table 40.3**). Reference values for free-ranging bottlenose dolphins are 25-OHD_3 = 598 ± 240 nmol/L; PTH = 3.2 ± 2.8 pmol/L; and total calcium = 9.4 ± 0.4 mg/dL (Meegan et al. 2015). However, vitamin D_3 levels vary greatly among marine mammal species (Keiver, Ronald, and Draper 1988; Kenny et al. 2004). If a diagnosis of low vitamin D or calcium deficiency is diagnosed, dietary modifications or vitamin supplementation may be implemented to correct any abnormalities detected. It is important to note that some commercially available marine mammal vitamins already contain vitamin D_3, while others do not.

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