# Elasmo II CH12: Elasmobranch Quarantine Overview

**Background**

* The primary goal of quarantine is to prevent the introduction of significant infectious diseases into living collections
	+ This goal is accomplished through isolation of new specimens, close monitoring and appropriate treatments
* Capture and transport stress can make subclinical diseases present clinically, and quarantine keeps animals isolated and accessible through this critical post-transport time period

**Planning**

* A designated quarantine area, isolated from collection animals, with multiple independent systems, will allow for the segregation of different quarantine groups
* It is essential to provide elasmobranchs appropriate space for normal swimming, gliding, and turning, to reduce stress and the risk of trauma
	+ Large, oval tanks are preferred for many pelagic shark and ray species
	+ Some species require cover for hiding, or sand/crushed gravel substrate; others do better with no obstructions
	+ Non-abrasive tank walls and floors are recommended, and any fiberglass surfaces should be checked for cracking or peeling
	+ It may be necessary to mark pale tank walls with dark patterns to help animals see and negotiate the aquarium
	+ Windows in the side of the tank and good overhead lighting help with the monitoring of specimens
	+ Jump barriers are required and should be inspected regularly for efficacy
* Each quarantine system should have dedicated equipment (e.g., nets, barriers, feeding poles) to minimize the risk of cross-contamination
	+ It is ideal to have a dedicated quarantine staff that does not work with animals within the main collection
	+ If this level of staffing is not possible, adjusting workflow to allow for the servicing of quarantine systems at the end of the day is recommended
	+ A work area should be provided near quarantine systems, where data recording and animal examinations can take place, and an additional isolated space should be available for performing necropsies.
* Each animal transport should be carefully planned to ensure sufficient experienced personnel are available
	+ Plans should include acclimation protocols, décor and substrate needs, animal diets, animal behavioral needs, and potential diagnostics and treatments
	+ For animals coming from other institutions, it is important to obtain their husbandry and medical history
	+ Quarantine systems should be run as ‘all in/all out’ groups
* For elasmobranchs, it may be best to limit quarantine tanks to a single species
	+ Elasmobranchs and bony fishes should not be quarantined together as this limits the medications that can be used to manage parasite outbreaks
* Quarantine systems should be clearly labeled with species, number of animals and quarantine status
	+ Good record-keeping is essential and should include:
		- (1) clear identifiers
		- (2) dates of arrival and significant events
		- (3) feeding ration and status
		- (4) behavior and changes to physical appearance
		- (5) water quality target parameters and results
		- (6) examinations, diagnostics, and treatments
		- (7) mortalities, gross necropsy and histology results, as well as any ancillary tests
* Many institutions use the 30-day minimum recommended by the Association of Zoos and Aquariums (AZA), although some use up to 90 days for quarantine (AZA; Hadfield and Clayton, 2011)
	+ Longer quarantine periods may be warranted for recently wild- caught animals.
	+ Contingency plans for rare events (e.g., major life support system failure, power- outage, disease outbreak that significantly extends the quarantine period) should be in place before quarantine commences

**Animal Identification**

* Possible external identifiers include physical markings, scars, animal size, sex, fin clips, and external tags (e.g., Floy, Peterson, or Rototags)
* Passive internal transponder (PIT) tags are routinely used
	+ The AZA recommends intramuscular placement of PIT tags on the left-hand side and typical tag sites are the epaxial muscle in sharks or pectoral fin in batoids

**Water Quality**

* It is helpful to test transport water (particularly temperature, pH, and dissolved oxygen) to document potential stressors in transit and to help determine acclimation needs
	+ Freezing a liter sample of transport water can allow further testing in case of health issues following transport
* A complete cation panel may be evaluated periodically to ensure suitable levels
* Life-support systems should be checked at least daily
* Automated sensors for water level, temperature and/or dissolved oxygen can be helpful
* Ultraviolet and ozone dis- infection reduce the number of some water-borne pathogens
	+ The goitrogenic effects of ozone use and high nitrates are unlikely to be an issue in short-term quarantine systems, but diets should include routine supplementation of iodide (Morris et al., 2012)

**Food & Feeding**

* It is essential to know the diet and feeding methods for the species in the wild, as well as the feeding history of the animal(s) during any time post-capture
	+ If an animal is showing a poor feeding response, it is important to review the husbandry, particularly temperature, water quality, water flow, number and types of refugia, social hierarchy if any, and feeding history (e.g., food types and sizes, food preparation techniques, frequency and timing of feeding, antecedents to feeding, and food presentation)
* Various techniques may be used to encourage food intake in recalcitrant animals, including:
	+ Offering a wide variety of foods
	+ Offering fresh foods
	+ Adding fish blood to the water prior to feeding
	+ Crushing or cutting stripes into the food prior to feeding
	+ Using a rod, grabber, or line to move the food in the water
	+ Offering live foods that have cleared quarantine
	+ Feeding at different times, ideally to match feeding times in the wild (many animals are crepuscular feeders) or at the previous institution
	+ Using antecedent feeding practices employed at the previous institution
	+ Avoiding potentially aversive stimuli (e.g., people leaning over the aquarium, loud noises, etc.)
	+ Isolating animals in suitable systems or parts of the system to reduce competition for food
* Many elasmobranchs chew their food, and close monitoring is needed to ensure they do not subsequently reject the chewed food item
* Various supplements and medications have been used to encourage feeding but these supplements have usually shown no effect
* The decision to use assisted feeding should be based on the species, life stage, and condition of the animal
	+ Body mass can be a useful decision-making tool
	+ In general, epaxial muscles and the muscles over the pelvic girdle should be rounded and firm, and the coelomic contours should be flat to slightly convex.
	+ Ultrasound can be used to evaluate liver size and echogenicity
		- A well-fed animal should have a large, lipid-laden liver
		- When animals are in a negative energy balance, the liver becomes smaller and denser
		- Grant et al. (2013) used an ultrasound- guided technique to measure the distance between the caudal margin of the liver and the cranial margin of the pelvis, in combination with an external measurement of coelom length, to calculate a liver-to-coelom ratio
			* This technique may be useful for evaluating lipid stores over time
* In the authors' experience has shown that urea and total proteins tend to de- crease with inappetence, although fasting studies have shown a more variable response
* Glucose and electrolytes are generally well regulated during prolonged fasting
* Assisted feeding typically involves gavage feeding with a blended slurry
* Commercial products (e.g., Mazuri Shark/Ray Gel or Meal, Purina Feed, USA; Emeraid Piscivore diet, Lefeber's, USA; A/D Canine/Feline Critical Care, Hill's Pet Nutrition, USA; Tomlyn Nutri-Stat, Vetoquinol, USA) may be offered in combination or as an alternative
* Force-feeding inappetent animals with normal prey items may also be used
	+ Food fishes are easier to force feed to inappetent animals than invertebrate prey items, particularly partially thawed larger fishes
* A good rule of thumb for a starting food ration, measured as a percentage of body mass (BM), is 2 - 4% BM per feeding
	+ Frequency of assisted feeding depends on the condition of the animal, as well as how often it is possible and practical to catch and restrain the animal
		- In general, juvenile (or small) stingrays and skates, require aggressive nutritional support, daily to every other day
		- Fast- swimming rays and sharks also require frequent feeding. Larger stingrays can be fed twice weekly
		- Demersal and slow-swimming sharks and cold-water elasmobranch species can often be managed with gavage or force-feeding once every one to two weeks
* In some cases, months of assisted feeding are required before an elasmobranch starts to show adequate food intake
	+ Many elasmobranchs will start eating voluntarily while being assisted
* Gastritis and enteritis are common in elasmobranchs under significant stress, and ulcerative lesions have been observed in the stomach and proximal intestine
	+ Theoretically, this phenomenon may be more common in elasmobranchs that secrete gastric acid continuously while fasting, i.e., in species that normally feed frequently
	+ Elasmobranchs may benefit from gastroprotectants, such as ranitidine or sucralfate, while on nutritional support

**Behavioral Conditioning**

* Introducing deliberate positive reinforcement training during quarantine helps develop basic husbandry- related behaviors–e.g., feeding from a pole, feed- ing at a specific target or swimming into a stretcher
* More advanced husbandry behaviors are also possible, such as stationing for voluntary blood samples or ultrasound imaging
* Animals that will be in ‘touch exhibits’ may benefit from positive reinforcement training for, and desensitization to, touching or handling

**Common Problems**

Infectious Disease

*Parasites*

* Monogeneans are common, particularly on the skin and gills
	+ Parasite loads can increase rapidly in aquaria and are often associated with significant morbidity and mortality
	+ Common monogoneans are:
		- Monopisthocotylean:
			* Monocotylidae (e.g., Dendromonocotyle spp.)
			* Capsalidae (e.g., Benedeniella spp., Entobdella spp., and Neoentobdella spp.)
			* Microbothriidae (e.g., Dermophthirius spp. and Neodermophthirius spp.)
		- Polyopisthocotylean:
			* Hexabothriidae (e.g., Erpocotyle spp. and Heterocotyle spp.)
	+ Many monogeneans are species-specific in the wild but have wider host ranges in aquaria
	+ Treatment typically involves praziquantel immersion, organophosphate immersion, or temperature or salinity changes
	+ Treatment plans must take into account the eggs (i.e., resistance to treatment, hatch period, etc.), host range, and host sensitivity to treatment
* Nematodes are common in animals that were wild-caught or fed fresh food
	+ Nematodes are often commensal, but larval nematodes from the orders Spirurida and Dracunculoidea have been linked to vasculitis, branchitis, pancreatitis, meningoen- cephalitis, oophoritis, and metritis
	+ If nematodes are found, the decision to treat is not straightforward due to the low safety index of common dewormers
* Copepods from the orders Siphonostomatoida and Poecilostomatoida are common external parasites, found primarily around the head and in the buccal and branchial cavities, and occasionally on the fins, cloaca, and claspers of elasmobranchs
	+ They can be associated with morbidity and mortality, but are principally an aesthetic issue in exhibits
	+ Treatment may involve physical removal, organophosphates, or chitin inhibitors
	+ The life cycle of some copepods can be broken in simple quarantine systems and this may be sufficient for management
* Leeches from the family Piscicolidae are rare but can be potentially serious pathogens
	+ They are often hidden in the buccal and branchial cavities and have potentially wide host ranges
	+ Leeches can cause severe morbidity and mortality in naïve animals, if the parasites are transferred out of quarantine
	+ Treatment may involve physical removal, organophosphates or chitin inhibitors
* Coccidia in elasmobranchs is most commonly from the genus Eimeria
	+ The most problematic species remains Eimeria southwelli in the coelom and gastrointestinal tract of myliobatid rays
	+ These parasites can be commensal, but are capable of causing significant morbidity and mortality secondary to stress, and should be avoided in collections where possible
	+ Treatment may include sulfadimethoxine, clindamycin, toltrazuril, or ponazuril, but elimination of the parasite is difficult
* Protozoal diseases are less common in elasmobranchs than in bony fishes, but they can be significant pathogens
	+ Invasive Scuticociliatida-like (Uronema-like) ciliates have been associated with morbidity and mortality
	+ Protozoan parasites have been reported in the skin, gills, brain, and liver of skates and demersal sharks
	+ Amyloodinium-like dinoflagellates have been associated with morbidity and acute mortality during the quarantine of sharks maintained with bony fishes
* Cestodes, myxozoa, and microsporidia may be seen in quarantine and are generally considered incidental
	+ Cestodes from the orders Tetraphyllidea, Diphyllidea, Lecanicephalidea, and Trypanorhyncha often reside within the spiral valve and may be noted in fecal samples from animals that were recently wild-caught or fed fresh fish
		- Cestodes are not usually considered a significant concern in healthy elasmobranchs
	+ Myxozoa are most commonly seen within the biliary tract and are considered incidental
	+ Microsporidia may be found in any tissues and are typically incidental, although morbidity and mortality have been reported

*Fungal*

* Fungal infections may be seen in quarantine, but are typically associated with individual animals
* Dermatitis due to Fusarium solani is the most commonly reported fungal disease
* Fungal diseases are often secondary to transport or trauma, and morbidity and mortality may be seen within days to weeks of animal acquisition
* Early and prolonged treatment with voriconazole is recommended, but treatment is often unrewarding

*Bacterial*

* Bacterial diseases, particularly sepsis, are also common and are often secondary to transport, trauma, or poor water quality
* While some species, particularly Vibrio spp. and Photobacterium spp., can be autochthonous flora, positive blood cultures in sick animals may be significant and warrant a response
* Chlamydiales have been associated with branchial epitheliocystis lesions, with subsequent morbidity and mortality

Noninfectious Disease

* Traumatic lesions are common, in particular bite wounds and abrasions
	+ Traumatic lesions are primarily managed by correcting environmental issues
	+ Correction may involve increased feeding, substrate modifications, addition or removal of physical or sensory barriers (e.g., bubble curtains), changes to water flow, adjustment to lighting conditions or moving animals
* Trauma from animal capture (e.g., from hook and line fishing) may need to be addressed, particularly in species that swallow prey whole
	+ Swallowed hooks are typically found within the distal esophagus or gastric wall and may perforate the liver or pericardium; hooks are less commonly found within the spiral valve
	+ Species that cut their prey into pieces before ingestion are more likely to have hooks in the buccal or branchial cavities

**Monitoring & Diagnostics**

* Regular visual examinations are essential during quarantine and should be carried out at least twice daily
	+ Life-support systems and water flow should also be checked twice daily at the time of visual examinations
* Hands-on physical examinations are commonly performed on elasmobranchs in quarantine
	+ During physical examinations, bright illumination helps with visualization of the buccal cavity, olfactory sacs, spiracles, cloaca and claspers
		- An endoscopic or laryngoscopic examination of the buccal and branchial cavities can help identify parasites
	+ Visible parasites should be removed using forceps or scrapes and examined under microscopy
		- Parasites can be fixed (e.g., in 95% ethyl alcohol) if further identification is needed
* Gill biopsies are less commonly performed in elasmobranchs than in bony fishes because of a potential for hemorrhage and the lower diagnostic value
	+ Gill biopsies may be primarily carried out in wild-caught specimens
	+ It is recommended to perform the gill biopsy under direct visualization (e.g., with an endoscope, otoscope or laryngoscope), but it can be done blindly
	+ Biopsy forceps help with the collection of small gill samples
* Fecal samples are sometimes collected to identify gastrointestinal parasites such as helminths and coccidia
	+ Fecal samples may be collected from the water or by cloacal wash, typically for direct analysis and flotation
* Coelomic aspirates or flushes are recommended in cownose rays to look for coccidia
* Ultrasonography can be used to assess liver size and echogenicity to help evaluate nutritional status
	+ Free fluid in the coelom may be indicative of inappropriate salinity, inanition, coelomitis, or bacterial or parasitic infection
	+ Ultrasound examination of the buccal and branchial cavities may show larger parasites
	+ Ultrasound examination of the female reproductive tract is essential to check gestational status, identify any pathology, and to obtain baseline images of the ovaries and oviducts
* Radiography allows the identification of hook foreign bodies and has been recommended to evaluate the vertebral spine in sand tiger sharks
* It is important that any animal that dies receives a full necropsy with squash preps and cytology and, where possible, cultures (often aerobic and fungal) and histopathology by a pathologist familiar with elasmobranch tissues

*Hematology & Phlebotomy*

* Blood can be collected for hematology, biochemistry, blood gases, lactate and ancillary tests
	+ Skin preparation prior to phlebotomy may involve a flush with sterile saline, or a single swipe of a swab with 70% alcohol; elasmobranch skin is extremely sensitive to more rigorous disinfection
	+ Phlebotomy sites include the ventral tail vein, posterior cardinal sinuses, and wing or radial veins
		- Venipuncture site affects the packed cell volume
			* The ventral tail vein appears less affected by the secondary vascular system than the posterior cardinal sinus
			* It is likely that white blood cell count is also affected by col- lection site
			* Dry heparin is the preferred anticoagulant for most hematology and biochemistry tests
* The modified Natt-Herrick technique is used for the manual white blood cell count
	+ The count must be carried out within a few hours of sampling to prevent sample degradation, which may negatively impact results, although the cells may be preserved in formalin for later evaluation
* In elasmobranchs, total dissolved solids are approximately twice the total proteins. Sodium, chloride, urea and osmolality are high in marine- adapted elasmobranchs, and their serum or plasma may require dilution, depending on the linear range of the blood chemistry analyzer
* Interpretation of stand- alone blood results is limited, so there is value in collecting samples to provide comparisons in in- dividual animals and cohorts over time

**Common Antiparasitic Treatments**

* Before using therapeutics that are novel to the institution or the species, the authors recommend a thorough review of the literature, discussion with colleagues and biotesting on a subset of a group
* The most commonly reported prophylactic treatment in elasmobranchs is the use of repeated praziquantel baths for monogeneans
	+ Manual dissolution of praziquantel is more common than chemical dissolution, because of the potential effects of ethyl alcohol on biofilter bacterial loads and dissolved oxygen
	+ Regardless of dissolution method, dissolved oxygen should be monitored during and after immersion treatment
	+ Where possible, praziquantel levels in the water should be monitored because the drug is rapidly degraded in some systems
	+ Praziquantel testing is available at the Georgia Aquarium Veterinary Services Water Quality Laboratory
* Salinity changes may be used for routine para- site control
	+ Stenohaline and pelagic species can be intolerant of salinity changes, but may handle slow decreases to not less than 20 g/L
	+ Some marine species can tolerate freshwater dips (where the water is matched to temperature and pH, with normal to high levels of dissolved oxygen), but adverse effects have been reported
* Organophosphates, particularly trichlorfon, are used prophylactically in some institutions to control monogeneans, copepods and leeches
	+ Possible side effects include skin changes, inappetence and mortalities
	+ Species that appear to be particularly sensitive to organophosphates include eagle rays (Aetobatus spp.) and guitarfish (Rhinobatos spp. and Rhina spp.).
	+ Animals may be medicated with atropine prior to treatment to reduce the risk of adverse side effects
	+ Appropriate human personal protective equipment (PPE) is required when using organophosphates
* Chitin inhibitors, particularly lufenuron or diflubenzuron, may be used for copepods and leeches
* Most institutions avoid the use of copper during elasmobranch quarantine due to concerns over toxicity
	+ Long-term immersion of copper sulfate has, however, been used successfully in lemon sharks infected with the monogenean Neodermophthirius harkemai and R. bonasus infected with the monogenean Benedeniella posterocolpa
* Fenbendazole use has been reported, but subsequent mortalities have been seen, in zebra sharks, yellow stingrays, C. taurus, R. bonasus, and freshwater stingrays, Potamotrygon spp.
	+ Side effects may be more common when the medication is gavage fed, potentially because no medication is lost on dosing
	+ Pyrantel and febantel were associated with the death of whitetip reef sharks in quarantine, from the inflammatory response associated with the death of histozoic nematodes
	+ Nematode treatments should be carried out with caution

# Elasmo II CH12: Elasmobranch Quarantine Review By Taxa

**Odontaspididae**

Infectious Disease

* Carcharias taurus (sand tiger shark) are generally a hardy species
* Animals collected in the western Atlantic are commonly infected with copepods, particularly around the distal fin edges and mouth (e.g., Anthosoma crissum, which can be associated with deep gingival erosions and tooth loss)
	+ Therapeutics may be considered, but the authors have seen clearance of three copepod species after 14 weeks of quarantine with no recurrence in three years, so the parasite life cycle may be broken in simple quarantine systems
	+ Juvenile porkfish, which have cleared quarantine, can be used as “cleaner fish” to remove copepods from C. taurus
* Heavy loads of Amyloodinium-like dinoflagellates on the gills were associated with acute mortalities in C. taurus during quarantine
	+ Treatment with chloroquine immersion resolved the infection
* Two possible viral diseases have been noted in C. taurus during quarantine: diffuse, crusting lesions on the skin that resolved over approximately one month, and black, raised, polyploid lesions that expanded and coalesced forming mucinous gray lesions that resolved over the course of a year
	+ Lesion recurrence was not seen
* Other infectious diseases appear to be rare during quarantine of C. taurus
* Inflammation of the ampullae of Lorenzini has been observed in C. taurus, but the etiology is unknown

Noninfectious Disease

* Scoliosis has been reported in several collections of C. taurus
	+ Predisposing factors may include pound net capture of small animals and insufficient space for normal glide distances in systems
		- It is critical that the size and shape of quarantine aquaria allow for normal swimming behavior
	+ Radiographs of the spine, cranial to the dorsal fin, should be considered, both to identify affected animals and to provide baseline images
* If caught by hook and line, C. taurus may show perforation or laceration of the esophagus, stomach, liver, or pericardium, and radiographs should be considered to check for hook foreign bodies
* Ultrasonography of the coelom is often limited in C. taurus due to air swallowing by the species
	+ It is important to monitor animals after handling, as it may be necessary to decompress or insufflate the stomach
* Gastric prolapse through the mouth or gill slit has been reported in C. taurus, but has not been seen in quarantine

**Carcharhinidae**

* Carcharhinus plumbeus (sandbar sharks) also called brown sharks, are generally hardy
* Blacktip reef sharks, Carcharhinus melanopterus, are considered sensitive to environmental stressors
	+ However, if transport is uneventful and further stressors are avoided, C. melanopterus typically do well in quarantine
* Negaprion brevirostris (lemon sharks) are generally a hardy species of shark

Infectious Disease

* Wild-caught C. plumbeus from the western Atlantic may be infected with copepods (e.g., Alebion spp. and Pandarus spp.)
* The eggs of the nematode Huffmanela carcharhini create characteristic black tracks in the skin of C. plumbeus
	+ Clinical signs have been noted in wild C. plumbeus and in an aquarium specimen six months after collection
	+ Lesions have been cleared successfully using levamisole
	+ Clinical signs are not limited to Carcharhinus spp
		- Huffmanella markgracei has recently been reported causing characteristic black tracks within the buccal cavity of a wild-caught Atlantic sharpnose shark
* C. melanopterus may be infected with Dermophthirius melanopteri or D. penneri monogeneans causing focal dermatitis
* Blacknose sharks, Carcharhinus acronotus, have shown a high prevalence of intravascular nematodiasis, associated with vascular occlusion, necrosis, and inflammation in the gills and brain
* N. brevirostris commonly harbor monogeneans, particularly Dermophthirius nigrellii and Neodermophthirius harkemai on the gills and skin
	+ Signs of Dermophthirius spp. include rubbing, erratic swimming, gray plaques and ulcers
	+ The most effective treatment for Dermophthirius spp. was trichlorfon immersion
	+ Signs of N. harkemai infection include rubbing, dark bands of hemorrhage around the mouth and increased mucus production particularly around the head
	+ The most effective treatment for N. harkemai was isolation and copper sulfate immersion, but when animals were returned to their exhibit the parasites and lesions recurred
* Wild-caught Triaenodon obesus (whitetip reef sharks) may carry the copepod Paralebion elongatus
	+ T. obesus have shown morbidity from gill nematodes while in quarantine, with a loss of all five sharks in the five months following treatment with pyrantel and febantel, due to a severe inflammatory response to the death of the nematodes

Noninfectious Disease

* Self-limiting prolapses of the cloaca and valvular intestine have been seen in quarantine in carcharhinids
	+ Prolapses of the cloaca and valvular intestine have been observed shortly after acquisition in wild-caught juvenile and adult C. melanopterus
		- Mortalities associated with conspecifics biting prolapsed tissue were observed 8 - 173 days following the arrival of the sharks
* C. plumbeus are particularly prone to rostral and pectoral fin trauma
* C. melanopterus are prone to skin erosions
	+ The size and shape of quarantine aquaria must be sufficient to accommodate the glide portion of their normal swimming behavior
* N. brevirostris tend to be more aggressive than other commonly displayed carcharhinid sharks
* T. obesus are pack hunters and conspecific aggression has been reported

**Triakidae**

* Leopard sharks, Triakis semifasciata, may be aquarium-bred and generally present few problems in quarantine
* The banded houndshark, Triakis scyllium, is closely related to T. semifasciata and is commonly displayed in China and Japan
* Dusky smooth-hound, Mustelus canis, also called smooth dogfish, have variable survival rates in quarantine
	+ Some individuals do well from the start, while others do not adapt well

Infectious Disease

* Common parasites in wild-caught T. semifasciata include Erpocotyle spp. monogeneans on the gills and copepods on the skin
* Morbidity and mortality have been reported from microsporidial parasites in captive T. semifasciata
* Chlamydiales have been associated with branchial hyperplasia in a T. semifasciata that died during quarantine
* Focal areas of depigmentation have been seen in T. semifasciata during quarantine, but the lesions resolved over time
	+ Papillomaviruses were identified in similar lesions
* An iridovirus that causes intravascular hemolysis (viral erythrocytic necrosis) has been identified in wild and captive M. canis, as well as T. semifasciata, and was associated with mortalities in younger animals
* A herpes virus that causes ulcerative dermatitis has been isolated from M. canis; the lesions resolved over time
* An adenovirus was associated with ulcerative dermatitis, epithelial and gill hyperplasia, and ultimately mortalities, in seven juvenile wild-caught M. canis during a three-month quarantine
* Intralesional ciliates and septicemia were also observed and appear to be common in M. canis
* A high prevalence of biliary myxosporeosis and pancreatic nematodes (Pancreatonema americanum) were identified in M. canis wild-caught in the northwestern Atlantic

Noninfectious Disease

* Conspecific aggression, particularly associated with breeding, may be noted in T. semifasciata during quarantine if maintained in groups
* “Spy- hopping” behavior has been observed in T. semifasciata in smaller quarantine systems
* M. canis are prone to traumatic lesions from tank wall abrasions

**Scyliorhinidae**

* The most commonly displayed species of scyliorhinid is the lesser spotted dogfish, Scyliorhinus canicular; other common species are the chain catshark, Scyliorhinus rotifer, nursehound, Scyliorhinus stellaris, cloudy catshark, Scyliorhinus torazame, and swell shark, Cephaloscyllium ventriosum
	+ S. canicula are often aquarium-bred and are generally hardy

Infectious Disease

* Invasive Scuticociliatida-like ciliates have been found on the skin, gills, brain and liver of C. ventriosum

Noninfectious Disease

* C. ventriosum may take several hours to deflate their stomachs after handling
	+ It is helpful to keep the sharks submerged at all times during physical exams so that water is swallowed rather than air

**Sphyrnidae**

* Bonnethead sharks, Sphyrna tiburo, especially juveniles, are often difficult to maintain

Infectious Disease

* S. tiburo are prone to Fusarium solani dermatopathy; sub-optimal environmental temperatures and trauma increased the risk
	+ Clinical signs include white pustules or ulcers along the lateral line system and cephalofoil
	+ The lesions are progressive, with local and sometimes systemic invasion
	+ The disease is typically fatal, but there is one report of resolution in an adult female using voriconazole and temperature modification
* Erpocotyle tiburonis monogeneans are common on the gills of S. tiburo
	+ In one report, proliferative gill lesions and higher parasite loads were observed, with mortalities seen within 28 - 156 days of arrival at the aquarium
* Huffmanella spp. nematodes have caused characteristic black tracks in the skin of infected S. tiburo

Noninfectious Disease

* S. tiburo are often inappetent post-transport and emaciation is a common postmortem finding
	+ Aggressive nutritional support is recommended for S. tiburo until they are eating reliably
* S. tiburo are sensitive to environmental stressors such as poor water quality, small changes in salinity or pH, and suboptimal housing
	+ Mortalities have been observed a few weeks into quarantine, with no previous clinical signs or apparent stressors and no gross or histologic lesions
	+ Similar mortalities have also been observed in scalloped hammerheads, Sphyrna lewini, a few weeks into quarantine
* S. tiburo are prone to cephalofoil and ocular trauma during shipping or quarantine, as well as bite wounds from tank mates, and should be quarantined in isolation or in small groups

**Heterodontidae**

* Horn sharks, Heterodontus francisci, are often aquarium-bred and are generally hardy

Infectious Disease

* Invasive Scuticociliatida-like ciliates have been associated with severe inflammation in the skin, gills, brain and liver of H. francisci, Japanese bullhead sharks (Heterodontus japonicus), and Port Jackson sharks (Heterodontus portusjacksoni)
	+ Clinical signs included lethargy, inappetence and acute mortality

Noninfectious Disease

* Breeding aggression may be noted from male heterodontids if maintained in groups during quarantine
* Refugia or “hides” are necessary for heterodontids, but tight spaces have been associated with entrapment and severe abrasions
* H. francisci have prominent spines on the dorsal fins, which are a potential hazard during handling

**Ginglymostomatidae**

* Nurse sharks, Ginglymostoma cirratum, are hardy and rarely have issues during quarantine

Infectious Disease

* Heavy loads of Amyloodinium-like dinoflagellates on the gills have been associated with acute mortalities in G. cirratum during quarantine
	+ Chloroquine immersion treatment resolved the signs

**Hemiscylliidae**

* Epaulette sharks (Hemiscyllium ocellatum), whitespotted bamboosharks (Chiloscyllium plagiosum), and brownbanded bamboosharks (Chiloscyllium punctatum), are hardy and rarely have issues in quarantine
	+ H. ocellatum and C. plagiosum are routinely bred in aquaria, while C. punctatum are less commonly bred

Infectious Disease

* H. ocellatum wild-caught on the Great Barrier Reef have shown a 100% prevalence of gnathiid isopod larvae on the skin, particularly around the cloaca and gills, but no morbidity was observed despite heavy loads

Noninfectious Disease

* H. ocellatum and C. punctatum have evolved to tolerate low dissolved oxygen concentrations and are relatively tolerant of freshwater dips

**Stegostomatidae**

* Stegostoma fasciatum (zebra sharks) are often aquarium bred and unproblematic in quarantine

Infectious Disease

* A wild-caught S. fasciatum, following an abbreviated quarantine, was considered the source of Lepeophtheirus acutus copepods identified in S. fasciatum, T. obesus, and a giant shovelnose ray (Glaucostegus typus)
	+ The parasites were typically on, or around, the eyes and mouth, and were associated with flashing and severe ulcerative keratitis
	+ Trichlorfon and dilflubenzuron immersion were effective treatments for the parasites
* Invasive Scuticociliatida-like ciliates were associated with necrotizing vasculitis and meningoencephalitis in juvenile S. fasciatum
	+ The ciliates were identified by PCR as Philasterides dicentrarchi (syn. Miamiensis avidus)

**Orectolobidae**

* Commonly displayed orectolobids include the spotted wobbegong (Orectolobus maculatus), Japanese wobbegong (Orectolobus japonicus), and ornate wobbegong (Orectolobus ornatus)
* Wild-caught female orectolobids are often gravid and ultrasound of the reproductive tract should be part of the quarantine exam
* Orectolobids can be difficult to manually restrain as they have a strong rolling response

Infectious Disease

* A review of elasmobranch histopathology showed that Orectolobus spp. had a particularly high prevalence of septicemia

Noninfectious Disease

* Orectolobids require refugia or “hides” and a complex substrate to reduce stress
* In addition, orectolobids can be difficult to transfer from a live to frozen food diet, and they tend to prey on other exhibit fishes

**Squalidae**

* Spiny or piked dogfish, *Squalus acanthias*, have shown variable success in quarantine

Infectious Disease

* *S. acanthias*, wild-caught in the northwestern Atlantic, showed a high prevalence of biliary myxosporeosis and pancreatic nematodes (*Pancreatonema americanum*) with histologic signs of chronic pancreatitis
	+ These sharks also showed a high prevalence of mononuclear inflammation of the ampullae of Lorenzini

Noninfectious Disease

* *S. acanthias* are prone to traumatic lesions from tank wall abrasions and quarantine systems should be designed to accommodate the swimming behavior of the species

**Rhinidae and Rhinobatidae**

* The bowmouth guitarfish, *Rhina ancylostoma*, is hardy, whereas other common species, such as the Atlantic guitarfish (*Rhinobatos lentiginosus*), common guitarfish (*Rhinobatos rhinobatos*), and shovelnose guitarfish (*Rhinobatos productus*), can be more problematic in quarantine

Infectious Disease

* Leeches (e.g., *Pontobdella* spp.) are often found on wild-caught rhinobatids and can be present on animals that come from other aquarium collections
	+ Observed parasite loads have been low and mechanical removal is often sufficient

Noninfectious Disease

* Inappetence is common in rhinobatids during quarantine and can sometimes be resolved by offering uncommon food items such as lobster or crab
* Traumatic lesions are common following collection and shipping of rhinobatids, particularly ulcerative lesions on the plates and eyes
	+ Quarantine systems for rhinobatids need to be large, with smooth walls and soft substrate

**Rajidae**

* Common Pacific species of rajids in aquaria include big skates (*Raja binoculata*), and longnose skates (*Raja rhina*)
* Common Atlantic species of rajids include clearnose skates (*Raja eglanteria*), thornback skates (*Raja clavata*), and little skates (*Leucoraja erinacea*)
* Some species breed well in aquaria

Noninfectious Disease

* Rajids are prone to skin lesions, particularly on the tail, claspers, or rostrum
	+ These lesions can result from unsuitable tank design or intraspecific aggression, and may be infected with filamentous bacteria (*Tenaci- baculum*-like), *Fusarium* spp., and Scuticociliatida- like parasites
	+ In the authors’ experience, lesions developed 5 - 8 weeks into quarantine
	+ The filamentous bacteria were successfully treated with trimethoprim and sulfadiazine immersion, but *Fusarium* spp. and Scuticociliatida-like parasites were invariably fatal once lesions developed
	+ A sand or fine gravel substrate in quarantine may help reduce stress in rajids.
* The small charge produced by the electric organs of *L. erinacea* and *R. clavata* can- not be felt by humans

**Dasyatidae**

* Commonly displayed species of dasyatid include southern stingrays (*Dasyatis americana*), roughtail stingrays (*Dasyatis centroura*), common stingrays (*Dasyatis pastinaca*), Atlantic stingrays (*Dasyatis sabina*), and pelagic stingrays (*Pteroplatytrygon violacea*)
	+ These species are hardy and *D. americana* and *D. sabina* are commonly bred in aquaria.
* Less common dasyatids include blue- spotted stingrays (*Neotrygon kuhlii*), ribbontail stingrays (*Taeniura lymma*), round ribbontail rays (*Taeniurops meyeni*), and honeycomb stingrays (*Himantura uarnak*)
	+ These species of dasyatid are typically more difficult to maintain in aquaria
* Dasyatid rays have one or more venomous spines on the dorsal tail
	+ These spines are typically trimmed, removed or covered prior to restraint
* Many dasyatids have a large disc width, making it difficult to turn them over during physical exams and leading to the possibility of overlooking cryptic parasites in the buccal cavity
	+ Endoscopy under chemical restraint may be considered for wild-caught dasyatids
	+ Many dasyatids secrete abundant mucus and frequent water changes, or a flow-through water system, may be required during physical exams
	+ The mucus is particularly thick in leopard whiprays, (*Himantura leoparda*)

Infectious Disease

* Dasyatids commonly carry *Monocotyle*, *Dendromonocotyle*, *Entobdella* spp., and *Neoentobdella* spp. monogeneans
* There is a report of heavy loads of *Neoentobdella taiwanensis* and *Dendromonocotyle pipinna* in *T. meyeni* wild-caught off New Caledonia, seen 24 days after arrival
	+ A freshwater dip removed ~2,000 of the monogeneans, although no follow-up information was provided
	+ *D. americana* and *D. sabina* appear relatively tolerant of freshwater dips
* *N. kuhlii* may present with leeches
* *D. pastinaca* in the Mediterranean have shown morbidity and mortality from microsporidial parasites
* In a review of elasmobranch histopathology *D. americana* and *N. kuhlii* showed a high prevalence for septicemia

Noninfectious Disease

* Non-infectious diseases of dasyatids include conspecific aggression, often related to breeding behavior or dominance
	+ It is useful to have facilities available to isolate animals if needed
* Ultra- sound of the female reproductive tract is indicated for dasyatids, as these species are often gravid and can present with pathology of the reproductive tract in quarantine
* *N. kuhlii* and *T. lymma* may come into an institution emaciated and are often inappetent in quarantine
	+ Mortalities within the first few weeks have been high without aggressive nutritional support
* Tail trauma is common in *P. violacea*, *T. lymma* and *H. uarnak*. Dasyatid rays may benefit from substrate, but if not available the tank floor must be smooth to avoid erosions developing on the ventral surface of the pectoral and pelvic girdles

**Myliobatidae**

*Eagle Rays*

* Spotted eagle rays (*Aetobatus narinari*), and ocellated eagle rays (*Aetobatus ocellatus*), are considered difficult species to maintain in aquaria
* These species commonly have heavy loads of gill monogeneans, particularly *Dendromonocotyle* spp., which can be extremely hard to eliminate, despite prolonged treatment rotations
	+ Treatment often needs to continue for as long as the animals are in the collection (e.g., regular praziquantel or freshwater dips)
	+ Freshwater dips (if matched to temperature and pH) are well tolerated by other- wise healthy eagle rays
* Chlamydiales have been associated with branchial epitheliocystis lesions in two *A. narinari*
	+ Clinical signs started on days 53 and 139 of quarantine, and included lethargy, increased respiratory rates and abnormal swimming patterns
	+ Treatment of one animal with chloramphenicol and oxytetracycline was ineffective, and both animals died
* *Eimeria southwelli* has been identified in the spiral valve of both asymptomatic and thin animals
* Myliobatids can be hard to convert to frozen-thawed food and often need aggressive nutritional support in quarantine
* Dental plate overgrowth can develop in quarantine if whole clams and other bivalves are not provided in the diet
* Erosive lesions can develop rapidly on the leading edge of the pectoral fins, as well as the ventral surface of the pectoral and pelvic girdles
* Myliobatid rays have one or more venomous spines on the tail

*Cownose Rays*

* *R. bonasus* (cownose rays) are hardy but often carry significant parasites
* *R. bonasus* are commonly infected with *Benedeniella posterocolpa* monogeneans, particularly on the ventral skin surface
	+ These parasites are hard to eliminate and can be present on animals that come from other aquaria
	+ Treatments may involve repeated praziquantel or organophosphate immersion, or long-term copper therapy
* *R. bonasus* may be infected with the leech *Branchellion torpedinis*, particularly within the buccal cavity
	+ *R. bonasus*, following an abbreviated quarantine, were considered the source of leeches that caused morbidity and mortality in demersal and pelagic elasmobranchs in a multi-taxa exhibit
	+ Clinical signs in naïve animals included anemia, hypoproteinemia, inappetence, lethargy, secondary infections and mortalities
* Endoscopy of the buccal cavity is recommended for this species, but some institutions will prophylactically treat with organophosphates
* *R. bonasus* wild-caught from the western Atlantic Ocean and Gulf of Mexico are known to carry *Eimeria southwelli* coccidia in the coelom and gastrointestinal tract
	+ While often commensal, the parasite can cause significant morbidity and mortality secondary to stress
	+ Coelomic aspirates or flushes show the highest sensitivity for *E. southwelli* diagnosis and screening of incoming animals is warranted
	+ Treatment of the parasite with sulfonamides, clindamycin, toltrazuril, or pona- zuril can reduce symptoms, but rarely clears the infection
		- Side effects of treatment have been reported, including cloacal prolapses and mortalities
* *R. bonasus* can be hard to handle under manual restraint and better success may be seen with chemical restraint or training for handling (e.g., feeding as they swim through a shallow stretcher)
* The thin tail may limit blood volume available from the ventral tail vein and the wing or radial veins are useful secondary sites for venipuncture

*Bullnose & Bat Eagle Rays*

* Bullnose eagle rays, *Myliobatis freminvillei*, and bat eagle rays, *Myliobatis californica*, are less hardy than *R. bonasus*
* *M. freminvillei* and *M. californica* are commonly infected with *Dendromonocotyle* monogeneans (e.g., *Dendromonocotyle californica* in *M. californica*) and freshwater baths appear to be effective and well-tolerated by *M. californica*
* Leeches may be found on wild-caught *M. californica*
* *E. southwelli* has been identified in *M. freminvillei* showing poor body condition and skin pallor
* *M. freminvillei* and *M. californica* are prone to tail trauma and to ventral erosions if no substrate is provided

**Urotrygonidae**

* *U. jamaicensis* (yellow stingrays) are generally hardy
* *Dendromonocotyle octodiscus* monogeneans are reported from *U. jamaicensis* in aquaria and in the wild
	+ *D. octodiscus* can cause morbidity and mortality, and has an unusually wide range of hosts, including dasyatids
* Inappetence is common early in quarantine of *U. jamaicensis* and aggressive nutritional support may be needed
* Females are often gravid and ultrasonography of the reproductive tract is warranted
* Urotrygonids have one or more venomous spines on the tail.

**Gymnuridae**

* The Japanese butterfly ray, *Gymnura japonica*, and the spiny butterfly ray, *Gymnura altavela*, can be difficult to maintain, particularly large *G. altavela*
* These species often require prolonged nutritional support before they start eating on their own
* Some gymnurids have one or more venomous spines on their tail

**Potamotrygonidae**

* The most commonly exhibited potamotrygonid is the South American freshwater stingray, *Potamotrygon motoro*
	+ Many potamotrygonids, such as the *P. motoro* and the white-blotched river stingray, *Potamotrygon leopoldi*, are aquarium-bred and unproblematic in quarantine
* Potamotrygonids can be prone to water mold infections on the skin and around the dental plates and treatment may include prolonged low-dose salt immersion
* Branchiuran *Argulus* spp. may be present on wild-caught potamotrygonids
	+ Physical removal is often sufficient as a treatment for *Argulus* spp
* Coccidia and nematodes are often identified in potamotrygonids, but have not been associated with morbidity or mortality
* Emaciation was a common post- mortem finding in potamotrygonids in a review of elasmobranch histopathology
* Potamotrygonids have one or more venomous spines on the tail and the venom is more potent than that of marine stingrays

**Chimaeridae**

* Spotted ratfish, *Hydrolagus colliei*, are relatively common in aquaria, but other chimaerids are not
* *H. colliei* are often infected with copepods (e.g., *Acanthochondria* spp. on the claspers), and leeches (e.g., *Branchellion* spp.)
	+ In the authors’ experience, mechanical removal has been a successful treatment for copepods and leeches
* Wild-caught *H. colliei* have a high prevalence of *Gyrocotyle* spp. flatworm in the gastrointestinal tract, but the parasites have not been associated with any pathology
* Lesions from physical trauma may be seen in chimaerids after capture or transport, and quarantine tank surfaces should be smooth as their integument is easily damaged
* Chimaerids do well in darkened quarantine systems with strict temperature control
* Chimaerids have a venomous dorsal spine and should be handled with care

# F7 Chapter 26: Quarantine of Fish and Aquatic Invertebrates

**Background**

* Quarantine reduces the risk of introducing infectious diseases into established collections
* For fish and aquatic invertebrates, key components include:
	+ Provision of excellent water quality and a suitable environment
	+ Isolation from collection animals
	+ Easy access to allow monitoring
	+ Diagnostics and treatments where necessary
* Regular visual exams on all individuals of a group are essential, but diagnostics (e.g., necropsies or hands-on examinations) on a subset of the group are often representative
* Prophylactic treatments may also be used, especially with animals that were wild-caught or came from large distributors, or when the target exhibits are large, with diverse species and complex life support systems
	+ It is common in these situations to treat for protozoal ectoparasites in teleosts and for monogeneans in teleosts and elasmobranchs.
	+ Many common freshwater fish are bred in captivity; the more unusual freshwater species and most marine species are wild- caught

**Common Problems**

* Some of the more common problems seen in quarantine are:
	+ Inappetence or poor body condition due to inappropriate collection, prolonged transport, or an unsuitable environment, diet, or social structure
	+ Trauma from transport, restraint, an unsuitable environment, or aggression
	+ Ammonia toxicity
		- Quarantine systems are at high risk because they are put through sudden increases in bioload, and some immersion treatments may affect the biologic filtration
	+ Viral diseases: some are common during quarantine (e.g., lymphocystis) vs. rare but serious (e.g., koi herpesvirus)
	+ Bacterial diseases: these may be primary but are often secondary to other diseases or stressors
	+ Fungal diseases (e.g., oomycete infections are common in freshwater fish secondary to trauma)
	+ Protozoal ectoparasites
		- Ichthyophthirius and Chilodonella spp. in freshwater
		- Cryptocaryon, Brooklynella, Amyloodinium, and Ichthyobodo spp. in salt water
			* May cause acute mortalities, with few preemptive signs
			* Several have life stages that are not susceptible to treatment and thus require repeated or long-term treatments (e.g., Cryptocaryon, Ichthyophthirius, Amyloodinium spp.)
	+ Monogenean ectoparasites:
		- Gyrodactylids are viviparous and may reproduce rapidly, causing acute mortalities
		- Other families such as the dactylogyrids and capsalids are oviparous and treatment often needs to continue through several life cycles
	+ Copepods, leeches, lice:
		- Although not detrimental unless loads are high, these must not be introduced into exhibits because they are particularly hard to eradicate once established

**General Planning**

* Ideal quarantine area is one isolated from the established collection, such as in a separate building or area, with dedicated staff
	+ If this is not possible, protocols should be in place to prevent cross-contamination (e.g., isolated systems, lids on tanks, separate equipment, hand washing facilities) and the area should have minimal through-traffic
* Fiberglass tanks with viewing windows are ideal for quarantinealthough some species require more specialized tanks (e.g., kreisel tanks for jellyfish)
* In general, smaller systems allow for easier monitoring and access and, in the event of a system-wide issue, fewer animals will be affected
	+ However, larger systems tend to have more stable environmental conditions
* For smaller systems, sponge filters are ideal
	+ Larger systems usually include sand filters and biotowers
* If systems are periodically unoccupied, protocols should exist to maintain biologic filtration, such as routine dosing with ammonium chloride
* Undergravel filters (and substrate in general) should be avoided, because parasites and intermediate hosts may collect in substrate
* Ultraviolet (UV) filtration may help reduce bacterial and viral load in the water.
	+ Ozone is generally not practical in quarantine systems because of the variable bioload
* Filters with activated carbon or zeolite clay should be available for adsorption of drugs following immersion treatment
* There should be redundancy in the life support equipment in case of failure.
* Disposal of wastewater, in-water medications, and filter media should follow relevant regulations
* The Association of Zoos and Aquariums (AZA)– recommended minimum quarantine duration is 30 days
	+ At the National Aquarium, quarantine for fish not treated for protozoal ectoparasites is a minimum of 90 days; some pathogens have presented up to 65 days into quarantine (e.g., Amyloodinium in temperate species)
* It may be hard to convert some wild-caught animals to a captive diet, and they may not have eaten recently
	+ Most facilities maintain some live foods to encourage food intake, such as brine shrimp, glass shrimp, rotifers, minnows, and mollies
		- These should be bred in-house or put through a quarantine period

**Considerations Prior To Acquisition/Arrival**

*Prior To Acquisition*

* Animals should be provisionally allocated to systems based on their environmental requirements, their compatibilities, and the target stocking density
* Water parameters should not be changed rapidly to accommodate incoming shipments because this damages the biologic filtration
* Invertebrates, teleosts, and elasmobranchs should not be quarantined in the same system because this limits treatment options
	+ Juveniles, or any animals considered potentially sensitive to treatments, should not be housed with large groups of other fish
	+ Stocking densities should be kept low to decrease competition and disease transmission
	+ Some systems should remain available in case groups need to be split.
* Prior to the animals’ arrival, the water quality should be checked to ensure that it is within the target range
	+ Décor that is suitable for the species should also be added
* Where animals are being acquired from another institution, a history and pre-shipment examinations should be obtained
	+ Pertinent questions include whether the animals were wild-caught or captive-bred, when they were acquired, any infectious disease concerns, and water quality, diet, and behavioral information

*Prior To Arrival*

* Most fish and aquatic invertebrates are shipped in clear bags with water and air or oxygen, packed in an insulated container
	+ Larger fish usually have their own transport container and may have continuous aeration and filtration
* Over time, transport water shows increased ammonia levels and decreased dissolved oxygen and pH, and will gradually adapt to the ambient temperature
	+ Unless shipping containers are badly fouled or drained, water from the target system should be gradually introduced over 20 to 60 minutes to allow the animals to adapt to the new parameters before they are moved to the new tank (acclimation)
		- They must be closely monitored; acclimation should be shortened if there are any signs of distress (e.g., increased gilling rates, neurologic signs)
		- Low light conditions and minimal noise may be beneficial during acclimation and the first 12 to 24 hours.
* It is important to record the shipping conditions, including delays in shipping, bag condition, stocking density, and fouling
	+ Temperature, dissolved oxygen, pH, and total ammonia of the transport water should be recorded
	+ This information helps determine stress levels during shipment, which may affect susceptibility to infectious diseases, and may be used to compare shipping methods

**Monitoring**

* Regular visual examinations must continue throughout quarantine—subtle changes in behavior and food intake are usually the first signs of impending issues
* Monitoring sheets may be used to track essential data, such as temperature, water quality, food intake, mortalities, treatments, and drug levels
* Water quality should be checked daily until stable and then at increased intervals
* Individuals may be identified based on external characteristics, fin clips, fin tags (e.g., Floy tags), or intramuscular transponders
* Dead fish should be removed and necropsied as soon as possible
	+ The priority is to assess food intake and look for infectious diseases that may be of concern to the quarantine or exhibit group
	+ At a minimum, each animal should receive physical examinations, skin scrapes, gill biopsies, an assessment of gastrointestinal (GI) contents, and GI squash preparations
	+ A full necropsy should be done, when possible, with tissue impression smears; tissue squash preparations; kidney, liver, or blood cultures; and histopathology
* Live fish showing clinical signs should be examined as soon as possible
	+ In groups with no clinical signs, examinations may be considered on a subset of the group (e.g., 2% to 5%) or on the whole group
	+ If premortem diagnostics are limited (e.g., small fish), some affected individuals from the group may be euthanized for diagnostics

**Specific Treatments For Fish**

* Unless there is a disease outbreak, most treatments should be delayed until the animals have had 7-10 days to recover from shipping and are eating well
* For immersion treatments, the volume should be calculated accurately, and all components of the life support system should be considered (e.g., removal of carbon and UV filtration prior to treatment, potential damage to biologic filtration)
* For novel species, the veterinary, aquaculture, and hobbyist literature should be reviewed
	+ Treating a subset first may be warranted
	+ Institutions should maintain a list of potential drug reactions, including information on doses, species, sizes, overall health, and concurrent stressors
	+ Treatments should be reassessed regularly, and thorough records are essential

*Freshwater and Saltwater Dips*

* Target: Ectoparasites
* Route, doses: Short-term immersion (up to 5 minutes) in water of the same pH and temperature as the source water, at 0 g/liter for saltwater fish and 27-30 g/liter salinity for freshwater fish
* Precautions: If done appropriately under close monitoring, these are usually tolerated by most larger fish, but some are sensitive (e.g., *Corydoras catfish*)

*Long-Term, Low-Dose Salinity*

* Target: Reduce osmotic stress in freshwater teleosts and reduce uptake of nitrites
	+ This is recommended for freshwater fish quarantine
* Route, doses: Long-term immersion at low salinity (e.g., 1-4 g/liter) for freshwater fish
* Precautions: This is generally well tolerated by most fish

*Copper*

* Target: Ectoparasitic ciliates and flagellates, with some effect on monogeneans
	+ This is recommended for most larger marine teleosts that were wild-caught or came from large distributors, and that will tolerate the treatment
* Route: Long-term immersion
	+ It is given as the ionized form (e.g., copper sulfate pentahydrate) or chelated form, which has a wider safety index (e.g., citrated copper sulfate or copper-amine complexes)
* Doses: Effective dose for Cryptocaryon is typically 0.18-0.20 mg/liter of ionized copper, maintained for 21 days
* Precautions:
	+ Considered toxic to most invertebrates, elasmobranchs, and plants; may be toxic to many teleosts species
	+ Be cautious with juveniles and novel species, and avoid rapid increases in ionized copper (e.g., secondary to a decrease in pH or bolus)
	+ Because copper is immunosuppressive, it should only be started once the fish are doing well
	+ Use only with alkalinity greater than 50 mg/liter; avoid in freshwater systems.
	+ Add the drug slowly (e.g., drip system), gradually increase it to the therapeutic level, and assay ionized copper levels daily
	+ Discontinue treatment if fish show behavioral changes or decreased food intake

*Chloroquine Diphosphate*

* Target: Ectoparasitic ciliates and flagellates (especially Cryptocaryon and Amyloodinium), with some effect on monogeneans and bacteria
* Route: Long-term immersion
* Doses: Often 10 mg/liter. Redosing schedules vary; use assays for accurate redosing
* Precautions:
	+ Be cautious with juveniles and novel species; may damage biologic filtration
	+ Tank should be darkened for treatment
	+ Personal protective equipment (PPE) is recommended

*Formalin (37% Formaldehyde)*

* Some formalin products are FDA-approved in finfish
* Malachite green, commonly combined with formalin, is under high regulatory priority and should be avoided
* Target: Ectoparasitic ciliates and flagellates (especially Ichthyophthirius), with dose-dependent effects on monogeneans, water molds, and bacteria
	+ It is recommended for most freshwater teleosts that were wild-caught or came from large distributors, and that will tolerate the treatment
* Route: Short-term or long-term immersion
* Doses: Low-dose administration is usually 10-25 mg/liter for up to 24 hours (25 mg/liter = 1 mL formalin in 10 U.S. gallons)
	+ High-dose therapy may be 100-150 mg/liter for 1 hour
	+ Treatments are often repeated (e.g., every other day for three doses)
* Precautions:
	+ Considered potentially toxic to most invertebrates, elasmobranchs, and plants and some scaleless teleosts (e.g., some catfish)
	+ Be cautious with juveniles and novel species
	+ Toxicity is increased with open skin lesions, and with low pH and high temperatures
	+ Formalin decreases dissolved oxygen so supplemental aeration must be provided
	+ High doses may damage biologic filtration and increase turbidity
	+ PPE is required

*Praziquantel*

* Target: Monogeneans, digenetic trematodes, and cestodes
	+ Immersion treatment with praziquantel is recommended for most fish to treat monogeneans
* Routes: Short-term or long-term immersion, intramuscular, or oral (e.g., in prey items or medicated gel food)
* Doses: Immersion treatment is usually 2-5 mg/ liter
	+ Duration varies from hours to days and treatment may be repeated
	+ Using a fine mesh filter or initially dissolving the drug in 95% ethyl alcohol (~1 mL/g praziquantel) helps dissolution
	+ Oral and intramuscular doses vary
* Precautions: Generally well tolerated at low to moderate doses.

*Organophosphates and Chitin Inhibitors*

* Target: Reserved for parasitic infections that cannot be treated by other methods (e.g., some leeches or copepods)
* Route: Short-term immersion using the organophosphate trichlorfon (Dylox) or the chiton inhibitor diflubenzuron (Dimilin)
* Doses: Vary; usually repeated in 7 to 10 days
* Precautions:
	+ Organophosphates are toxic to most invertebrates and potentially toxic to many species; be very cautious
	+ PPE is required
	+ Chitin inhibitors have a wider safety index for animals that lack chitin
	+ For both medications, disposal of medicated water must be considered

*Fenbendazole or Levamisole*

* Target: Gastrointestinal nematodes, with little effect on encysted stages
	+ Levamisole is a potential immune stimulant
* Routes: Intramuscular or immersion (levamisole), oral (fenbendazole and levamisole)
* Doses: Vary
* Precautions:
	+ Be cautious with fenbendazole in bottom-feeders, especially temperate species (e.g., rainbow and greenside darters, Etheostoma spp.)
	+ Levamisole immersion may damage biologic filtration.

*Antibiotics*

* Florfenicol is licensed in the United States for use in ornamental fish
	+ Specific oxytetracyclines and potentiated sulfonamides are licensed for use in catfish and salmonids
* Target: Bacteria
* Routes: Oral, immersion, intramuscular, or intracoelomic
	+ Ideally, these should be targeted to individuals but, for very small fish, immersion may be the only practical route
* Doses: Vary
* Precautions:
	+ These should be used only if there is a high index of suspicion for a bacterial infection
	+ Immersion antibacterials may damage biologic filtration
	+ Disposal of medicated water must be considered.

*Vaccines*

* FDA-licensed inactivated immersion vaccines currently exist for Vibrio anguillarum, Aeromonas salmonicida, Yersinia ruckeri, Flavobacterium columnare, and infectious salmon anemia virus
* Vibrio vaccines have been used by some institutions for syngnathids during quarantine

**Specific Treatments For Aquatic Invertebrates**

* There is little information available on the significance and treatment of infectious diseases in aquatic invertebrates
	+ However, some pathogens are known to cause high morbidity and mortalities (e.g., Perkinsus marinus in oysters), especially when environmental conditions are suboptimal, and invertebrates may be carriers for some fish pathogens
* Possible ectoparasite treatments are temperature or salinity changes and metronidazole or milbemycin immersion
	+ Antibiotics that have been used include tetracyclines, chloramphenicol, and enrofloxacin

**Clearing Quarantine**

* Visual or physical examinations, and a review of diagnostic procedures and treatments, should be completed prior to clearing animals from quarantine
* It is important to review quarantine protocols regularly
	+ This will include tracking morbidity and mortalities through quarantine (e.g., within the first 24 hours, first week, first month, or subsequently), and reviewing whether any pathogens seen on exhibit could have been avoided through quarantine

Scott et al. (2020) Evaluation of localized inflammatory reactions secondary to

intramuscular injections of enrofloxacin in striped bass (Morone saxatilis). Journal of

Zoo and Wildlife Medicine 51(1): 46–52.

Abstract: Enrofloxacin is a fluoroquinolone widely used in animals including fish. Intramuscular (IM) injection of enrofloxacin is a feasible and efficacious option for drug delivery. In many species IM injection has been associated with injection site reactions and increases in serum muscle enzymes. Injection site reactions have not been well characterized in fish. **Three groups of striped bass (Morone saxatilis) received an IM injection of enrofloxacin 2.27% in the right epaxial musculature 24, 48, or 96 hr prior to evaluation.** **Mean dose was 7.69 mg/ kg (6.14–9.69 mg/kg). The 24- and 48-hr groups received an injection of equal-volume 0.9% saline in the left epaxial musculature. A corresponding noninjected tissue sample was designated in the left epaxial musculature from each fish of the 96-hr group. Fish were euthanized and injection sites and noninjection control sites were evaluated grossly and histologically. Grades 1–4 were assigned to samples, with grade 1 corresponding to normal tissue and grades 2, 3, and 4 corresponding to mild, moderate, and severe inflammation and/or necrosis respectively.** Externally, all control and injection sites appeared visually unremarkable. On cut surface, epaxial muscle of the enrofloxacin-injected tissue appeared moderately to severely hemorrhagic compared to saline and noninjected tissue, which was normal or mildly hemorrhagic. Histologically, eight of eight noninjected tissues were grade 1. For saline-injected tissues, 14 of 16 tissues were grade 2 and 2 samples were grade 3 when 24- and 48-hr groups were combined. For enrofloxacin-injected tissues, 8 of the 8 24-hr samples were grade 3 and 16 of the 16 48- and 96-hr samples were grade 4. These data show that IM injection of enrofloxacin 2.27% is associated with severe hemorrhage, necrosis, and inflammation in striped bass, and may negatively affect animal welfare.

Background

* Enrofloxacin - extralabel use in ornamental and aquarium fish
	+ Safe therapeutic plasma concentrations oral and injectable 5-10 mg/kg
	+ IM PK more predictable than oral or immersion
	+ Highly alkaline (pH 11.5) suspected cause of tissue reactions in various species

Key Points

* Externally, dark within minutes of injection, resolved within 24 hr or mildly raised at 96hr
* Enro site on cut surface and histo: moderate inflammation at 24hr, severe at 48 and 96hr
* Enrofloxacin 2.27% IM at therapeutic doses causes severe hemorrhage, necrosis, and inflammation in striped bass, progressing in severity over 96hr with no tissue recovery.
* Saline injection also had mild to moderate tissue reaction

Conclusions

* IM enrofloxacin 2.27% causes severe injury at injection site in striped bass, difficult to appreciate externally, may negatively impact animal welfare and is not recommended

Ang et al. (2021) Use of topical treatments and effects of water temperature on

wound healing in common carp (Cyprinus carpio). Journal of Zoo and Wildlife

Medicine 52(1): 103–116.

Abstract: Skin lesions are frequently diagnosed in fish medicine. Although systemic fish treatments exist, little is known about the efficacy of topical drugs on fish skin lesions. This study aimed to investigate the efficacy of medical-grade honey and silver sulfadiazine on skin lesions using common carp (*Cyprinus carpio*) as a model. Additionally, the effect of temperature on the wound healing process was evaluated. Punch biopsies were generated on six fish per treatment group under anesthesia. Treatment groups received one of the following topical medications after wounding: Dr. Nordyke's Wound Honey, MicroLyte Ag Vet, or SilvaSorb Gel. Nontreated positive control groups were similarly wounded but did not receive topical treatment. Fish were housed at 10°C to 13°C or 18°C to 21°C for 29 days. Macroscopic evaluation and image collection of wounds were performed on days 0, 4, 8, 12, 21, and 29 after wounding to compare changes in wound areas and inflammation over time. On day 29, tissue samples were collected for histologic analysis. From day 12 after wounding onward, wounds in positive controls maintained at 18°C to 21°C were significantly smaller (days 12, 21, and 29: *P* < 0.0001) compared with positive controls kept at 10°C to 13°C. There was an overall improvement in macroscopic appearance in honey-treated groups compared with positive controls on day 12 after wounding at 18°C to 21°C (*P* = 0.001), whereas with the use of Microlyte and Silvasorb, wounds had increased inflammation grades (*P* < 0.0001 and *P* < 0.0001, respectively) with enlarged wound areas (*P* < 0.0001 and *P* < 0.001, respectively) in comparison with positive controls on day 12 after wounding at 18°C to 21°C. **This study suggests that topical use of medical-grade honey produces positive effects on wound healing in the carp model and higher water temperatures enhance the effects, whereas the use of silver sulfadiazine and lower water temperatures delays or worsens the wound healing process.**

Key Points

* Honey categorized into two groups based on the mode of antibacterial activity:
	+ Hydrogen peroxide dependent, non-hydrogen peroxide dependent.
	+ Manuka honey is a non-hydrogen peroxide dependent honey that possesses antibacterial and antioxidant properties derived from phytochemicals such as methylglyoxal (MGO).
	+ Honey also has anti-inflammatory properties to reduce edema and can be used as an autolytic debriding agent to speed up sloughing of devitalized tissue.
	+ High osmolarity of honey draws lymph which provides nutrients essential for regeneration of tissue in a wound.
* SSD has broad spectrum antibacterial effects that act against gram positive and negative bacteria and fungus.
* 4mm biopsy punches used to make eight wounds on each fish (4 each side) under anesthesia.
* All individuals received a danofloxacin injection and meloxicam injection.
* Images of wounds were standardized and wound area measured using Image J software to investigate differences in wound closure from day 0-29.
* Macroscopic evaluation based on grading scale addressing wound contraction, tissue reaction, signs of necrosis, or inflammation.
* Dr. Nordyke’s wound honey (gel including Manuka honey, aloe vera, panthenol), Microlyte ag (sterile, single use synthetic absorbent polyvinyl alcohol hydrogel sheet with silver), SSD (ionic silver and silver chloride).
* Contact of time of 3 min following application before releasing each individual into recovery tanks. Tx repeated every 96 hr for the first 2 wks on days 0, 4, 8 and 12.
* Wounds of positive control and honey groups maintained at 18-21C had significantly lower inflammation grades vs other groups kept at 10-13C across all time points.
* Lower inflammation grades for wounds at 18-21 C vs colder temps.
* Honey subjectively decreased hyperemia.
* No significant difference in macroscopic appearance of wounds between controls and honey groups at both temps, but there was a significant improvement in the appearance of wounds with overall reduction in inflammation grades with honey in the warmer temp groups.
* Microlyte and Silvasorb groups in warm temps presented worsened macroscopic appearance vs controls at all time points. Cold groups NSD. Microlyte appeared subjectively more hyperemic and swollen vs positive controls.

Takeaway: Higher ambient temp correlated with a reduction in inflammation and improved wound closure. Manuka honey significantly reduced inflammation at 18-21 C, may not significantly impact wound closure. Neither silver containing product showed any benefit and appeared to delay wound healing. Sedation recommended for adequate application and contact time of topical wound tx in fish.



Zec, S., Hadfield, C., & Hungerford, L. (2021). Retrospective review of copper sulfate immersion treatment in marine teleosts during quarantine at the national aquarium of baltimore from 2004 to 2016. *Journal of Zoo and Wildlife Medicine*, *52*(1), 97-102.

Abstract: Copper sulfate immersion is common for the prevention and treatment of *Cryptocaryon irritans* during quarantine of marine teleosts. **The National Aquarium in Baltimore has followed a consistent copper sulfate protocol for marine teleost quarantine since 2004. The protocol used copper sulfate pentahydrate as a slow drip to increase copper ions over 3–5 days to a level of 0.18–0.21 mg/L. This level was maintained for 21 days, and then copper ions were rapidly removed with activated carbon filtration and water changes. Quarantine records from 2004–2016 were used to examine mortality of marine teleosts during copper treatment and identify factors that might have influenced mortality.** The following records were excluded: brackish and freshwater teleosts (salinity <25 g/L); long-term treatment at subtherapeutic levels (<0.18 mg/L); intentional short courses (<14 days); and use outside of quarantine. Species, system volume, temperature, parasitic outbreaks, concurrent medications, and water quality concerns were evaluated. **During this period, 4,835 individual teleosts belonging to 347 different species were treated. From 2004 to 2016, mortality during copper treatment was 4.1% (199/4,835 individuals) and was higher when treatment was started during the first week of quarantine (7.7%, 68/884) rather than later (3.3%, 131/3,951 individuals). Of the mortalities, 24.1% (48/199) occurred during the initial subtherapeutic period, and 75.9% (151/199) occurred during the therapeutic period. No mortalities occurred in 75.5% (262/347) of species during copper treatment.** When using a similar methodology, copper sulfate is a safe immersion for quarantine of marine teleosts. **Mortalities during copper treatment can be reduced by increasing copper ion levels to therapeutic ranges more slowly (e.g., over 7 days) and starting copper treatment after the first week of quarantine.**

Introduction:

* *Cryptocaryon irritans* – Ciliate ectoparasite of marine teleosts.
	+ Causative agent ‘marine white spot disease’.
	+ High mortalities across wide range of teleost taxa.
	+ High risk to established collections.
* Copper sulfate immersion most common prevention and tx for *C. irritans*.
	+ Effective, inexpensive, considered of low regulatory priority by FDA.
	+ Activity vs ciliates, dinoflagellates, monogeneans, oomycetes, and algae.
	+ FW - Dosing based on alkalinity. Entire copper compound active.
	+ SW – Ionic form (Cu2+) active, influenced by alkalinity, pH, and salinity.
	+ Typically increased slowly over 3-5 days to a designated therapeutic level (i.e. 0.16-0.21 mg/L), maintained over 3 wks, then removed with carbon filter and water changes. Toxicity directly proportional to ionic concentrations. Varies by spp, dosing method, presence of other stressors.

M+M: National Aquarium marine teleost quarantine records 2004-2016. Evaluated mortalities.

* Slowly increased copper over 3-5 days to reach 0.18 mg/L using drip of copper sulfate pentahydrate (bluestone) dissolved in saline. 6-8 hr drip, calculation based on 25.5% active concentration. Administration over 3-5 days allows for induction of protective mechanisms (metallothioneins).
* Free copper measured with spectrophotometry once daily.
* Drip system adjusted as needed for 21 days.
* Copper removed with granulated activated carbon, water changes, or both.

Results:

* 226 quarantine groups; ~5,000 teleosts.
	+ Syngnathidae and juvenile tropical teleosts were routinely omitted from copper tx during quarantine due to concerns about sensitivity.
* Copper tx only discontinued for 10 individuals due to possible signs of toxicity (decreased appetite, hiding, color changes).
* Overall mortality 12.2%, with 4.5% before copper, 4.1% during tx, 4.1% after treatment.
* Mean % mortality of cold vs warm water fish did not differ significantly.
* Mortality significantly higher for groups that started treatment during the first week of quarantine.
* Concurrent medical tx during copper included prazi immersion, fenbendazole gel, metronidazole gel, other misc.
* Mortality during copper tx did not differ significantly between system volumes.
* Diagnosed *C. irritans* outbreaks during this time were rare (7 of 226) quarantine groups, all in warm-water systems.
* Changes made in 2010 decreased mortality – Limiting stocking density, stoppig animal additions 1 week after first addition to a system, and tailoring protocols by risk assessments for each group.
* Blue chromis mortalities were mostly attributed to mycobacteriosis which may have been exacerbated by copper treatment.

Takeaways:

* Copper sulfate immersion appears relatively safe for most marine teleosts.
* Start of copper tx should be delayed for at least 7 days after fish arrival.
* Increasing the subtherapeutic duration to 7 days (instead of 3-5) is recommended. Most of the mortalities were in the subtherapeutic period.
* The risk of mortality during copper treatment is far less than the risk of introducing *C. irritans* into a collection.



Jalenques, M., Vergneau-Grosset, C., Summa, N., Youcef, W. A., St-Cyr, J. F., & Lair, S. (2020). A cluster of cases of thyroid hyperplasia in aquarium-housed tropical marine teleosts following a change of salt mix brand. *Journal of Zoo and Wildlife Medicine*, *51*(3), 725-728.

Abstract: Follicular thyroid hyperplasia was diagnosed in nine out of 32 (28%) marine tropical teleosts housed in a public aquarium over a 9.5-mo period. These proliferative lesions were considered to be the cause of death in five of these fish. **Iodine concentration was undetectable in nonozonized water (<0.005 mg/L), suggesting that an environmental iodine deficiency was the cause of these hyperplastic thyroid lesions. The only significant modification in the husbandry was a change, 18 mo before the first case, of the commercial salt mix brand used to make artificial seawater. The iodine content in this replacement salt mix was five times lower than that of the salt mix used before.** This case series suggests that the iodine concentration in this new salt mix was insufficient to maintain thyroid homeostasis in reef teleosts under the husbandry provided in this institution.

Key Points:

* Limited access to iodine can result in development of thyroid hyperplasia (goiter).
* Majority of iodide uptake in teleosts from water rather than food.
* Iodate (IO3-), iodine (I2), iodide (I-) forms in SW – Only iodide absorbed by fish.
* Thyroid hyperplasia in fish has been assoc with iodine deficiency in water or diet, exposure to goitrogenic factors (high environmental nitrate), and water treatment with ozone.
* Sea salt mix changed from Instant Ocean to Crystal Sea Bioassay Marinemix salt.
* Starting 18 mo later, thyroid hyperplasia diagnosed in 28% of tropical marine fish on necropsy.
* Clinical signs only seen in two cases (one presented with classical goiter in ventral branchial arches, another had nonspecific clinical signs).
* Iodine water concentration measurements performed on water made with the two different salt mix brands. Tested with benchtop MultiTest Iodine/Iodide test kit. Crystal Sea salt iodine concentration almost five times lower.
* Each salt mix brand added to two identical tanks with cycled filters and devoid of fish.
	+ Iodine concentration decreased dramatically and was undetectable after 4 days with Crystal Sea salt.
	+ Supplemented the system with Reef Iodide (potassium iodide complex) to maintain concentration of 0.08 mg/L. After few months, no new cases of thyroid hyperplasia.

Takeaway: Cases of thyroid hyperplasia in a group of marine teleosts associated with recent switch to different aquarium salt mix deficient in iodide.

Noga Ch 6 Health Management

Intro

* Proactive health management strategies are playing a greater role in aquaculture
* Also involves minimizing environmental impacts of the culture operation and, when dealing with food fish, ensuring that the product is safe for human consumption

Biosecurity

* Vital to reducing the risk of acquiring a disease in a facility
* External barriers
	+ Prevent the spread of pathogens onto and off of a farm
	+ Using a specific-pathogen-free (SPF) water source when possible
	+ Never introducing fish from other farms or at least never introducing fish from farms having older or less healthy fish
	+ Restricting the movement of fish between farm sites of the same operator
	+ If new fish must be introduced, using SPF fish or at least those with a known history of health. The history of the fish will also dictate the quarantine procedures needed
	+ Strict sanitary measures for all persons (including farm workers and visitors) entering the farm
	+ Restricting access to the farm site (e.g., fencing the site, locking all doors, restricting visitors, etc.)
	+ A pest management control program
	+ A feed hygiene program
* Internal barriers
	+ Prevent spread of pathogens within a farm
	+ Partitioning the farm into isolation units
	+ Physically separating each nit and keeping all units isolated from each other
	+ Having specific sanitation and personnel hygiene protocols
	+ Having specific sanitation protocols for movement of fish or materials between units
* Pathogen inactivation strategies
	+ Disinfection
		- Must be practiced throughout the production cycle to eliminate pathogens on rearing nits, equipment, water, and even certain feeds such as live brine shrimp
	+ Antisepsis
		- Treatment of fish and eggs with antiseptics is an important component of disease management
		- Only effective against some skin or gill pathogens (ie prophylactic salt or formalin treatments)
	+ Fallowing
		- Removal of all fish from a culture site to case the elimination (natural death) of a pathogen from the site
		- Can be a very effective strategy as long as the microbe is an obligate fish pathogen
	+ Inhibiting fish to fish transmission
		- Geographic isolation of farms
		- Limiting human access to farms
		- Separation of age classes
		- Disease resistant strains
			* Breeding fish strains that are resistant to pathogens - little progress has been made in this area
			* Hybrids can also be superior in terms of resistance to stress and disease
		- Specific-pathogen-free stocks
			* The absence of a certain pathogen in a fish population
			* Development of SPF stocks has advanced the most in salmonids and zebrafish
* Quarantine
	+ Isolation of a new population of fish prior to their placement within the established population
	+ Also allows acclimation of the new stock to the environment in a controlled setting with close observation
	+ Water quality should be within a certain maximum range of the shipping water
	+ All materials used in quarantine should be restricted to that area
	+ Behavioral anorexia is common in quarantine
	+ Many practitioners recommend prophylactic drug treatments during quarantine to reduce any parasites (formalin, copper, slat/freshwater exposure)
	+ Antibiotic prophylaxis is rarely advisable
	+ Health exams are typically performed no sooner than 4-7 days after entering quarantine to allow acclimation before handling
	+ Time in quarantine varies, cold water fish often quarantine longer than tropical fish because it can take longer for disease to become apparent
	+ 30 days is standard but can be as low as 7 or as high as 90 days
	+ In an ideal world the new fish would never be introduced into the population, only their progeny, all showing the absence of pathogens
* Regulatory issues: reportable diseases and certification of stocks
	+ Be familiar with local and nationwide regulations and what diseases are reportable
	+ Health certificates may be needed for movement of fish within or into/out of a country
	+ Other texts elaborate on how to certify the disease free status of a stock

Health promotion and maintenance

* Vaccines
	+ Salmonid industry has lead the way in vaccination efforts, but many vaccines can be given to a number of species
	+ Hugely useful in disease risk management
	+ Special considerations:
		- A large number of vaccines can be expensive
		- Time of vaccination must be closely correlated with immune status (ie can’t be given when they’re too young or will be ineffective)
		- Environmental conditions such as temperature can be crucial for vaccine efficacy and immune response
		- Health status - the manipulations involved in vaccination are stressful and can provide an opportunity for latent or opportunistic pathogens
	+ 3 routes used to vaccinate fish
		- Waterborne--useful for large colonies, but not cost effective for large fish, protection for 3-12 months which is often not long enough for the production cycle of some fish
		- Injection - often used in more valuable fish. Impractical in fish smaller than 5 grams
		- Oral - used least commonly as they are not hugely protective and also not cost effective for larger fish
	+ Only healthy fish should be vaccinated, should not be vaccinated within 21 days of slaughter or release
	+ If there is no commercially made vaccine, autogenous vaccines can be effective, though regulations vary within the US about their use
* Nonspecific immunostimulants
	+ Nonspecific immunity seems to be especially important in fish
	+ A number of drugs and microbial products (e.g., levamisole, lipopolysaccharide, peptidoglycan, killed bacteria) can experimentally “turn on” nonspecific immunity and thus act as an immunostimulant.
	+ Commercial products are used either alone to “boost” fish immunity or in combination with vaccines
* Probiotics/competitive exclusion
	+ Experimental studies have shown that administering some live bacterial strains to fish can protect against pathogenic bacteria, but data are lacking from controlled field trials
* Biological Control
	+ The use of an organism to specifically prey upon, parasitize, or otherwise reduce the levels of an undesirable organism (usually a pest)
	+ Important that it only kills or preys upon the pest and doesn’t harm non-target organisms
	+ Best known example are cleaner wrasses, which remove ectoparasites and other material from other fish
* Health monitoring
	+ Day to day operations
		- Aquaculture operations should have a predetermined routine monitoring schedule that includes water quality testing, inspecting fish for signs of disease, and randomly sampling moribund and/or asymptomatic fish for routine diagnostics
		- Helpful to have a sentinel animal program by placing a group of fish in a location where they will be exposed to most or all of the effluent water from the culture systems
	+ Animal identification
		- Individual identification becoming more mandatory
		- Microchip is one of the most useful options
		- PIT tags also sed
* Animal welfare
	+ Still controversial whether fish feel pain or not
	+ Welfare based around the 5 freedoms
	+ Conditions should be tailored to a particular species, life stage, and environmental setting
	+ To facilitate day to day evaluation of fish welfare, several simple indicators have been proposed: color, ventilation rate, swimming pattern, food intake, growth rate, BCS, presence of morphological abnormalities, injury, disease, reproductive performance

Food Safety

* Antibiotic resistant pathogens
	+ None reported from fish to humans yet, but something to be aware of
* Chemical contaminants
	+ Drug residues
		- Large variation in drug use between companies
		- The discovery or illegal resides can have serious ramifications
		- Imperative that clinicians adhere to legal local guidelines for drug se and withdrawal time
	+ Environmental toxins
		- Recent concerns about toxins such as PCBs in food fish, but this claim has been contested--still important to be aware of

Environmental Safety

* Mortality management
	+ Fish euthanized at the clinic should be disposed of sing standard biohazard guidelines for infectious waste
	+ On farms there are 3 major concerns
		- Carcasses and associated pathogens might be released from holding systems into public waters
		- Decomposition of dead fish can cause effluent water quality to decline
		- Odors might be a nuisance to nearby homes
	+ A few dead fish are not a major environmental concern, but after a large kill fish should be promptly removed and placed in a permitted landfill or incinerated/composted/etc
* Drugs in the environment
	+ Especially a concern in semi-open and open systems where drugs are not easily contained
	+ Some drugs like oxytet can persist for a long time
	+ Persistent antibiotics may inhibit microbial activity in the sediment, reducing the rate of aerobic organic matter decomposition
	+ Can also induce selection for antibiotic resistant bacteria
	+ Drugs can also kill or injure non target aquatic species
* Exotic pathogens and exotic hosts
	+ All efforts should be made to keep pathogens from being introduced into a new region
	+ Exotic fish species should also be brought in with caution, as they can act as a reservoir for an exotic pathogen and amplify an epidemic

AAZV guidelines for Zoo and Aquarium Veterinary Medical Programs and Veterinary Hospitals

Intro

* AAZV has developed guidelines for veterinary medical programs and hospitals
* These guidelines are adjunct to the USDA regulations for licensed animal exhibitors
* The AZA also references these guidelines in the evaluation of accredited institutions

Veterinary care

* Vet care must available 24/7
* Necropsies should be performed whenever a collection animal dies

Staff and personnel

* The veterinarian must be familiar with the staff and the animal collection
* They are responsible for development and supervision of long-term prev med programs
* Can be full or part time
* Any zoo or aquarium in which a part-time veterinarian provides veterinary coverage must have one staff person who serves as the veterinary program coordinator and supervises this program under the direction of the veterinarian.
	+ This can be a keeper, curator, or hospital manager
	+ Ideally should be an RVT or animal health technician
* Adequate support staff are also required

Veterinary program

* Medical and surgical care must be provided to all animals in the collection at current standard of care practice
* Vet staff must have diagnostic laboratory support available
* Consultation with a pathologist should be available to the clinician
* Appropriate surgical, anesthetic and monitoring equipment must be available
* All medications should be accompanied by a prescription
* Necropsy should be performed on animals that die in the institution AND on wild or feral animals found dead on the grounds
* Appropriate medical records, prev med program, disease surveillance, and quarantine procedures should be established and followed

Management

* Nutrition, preshipment exams, husbandry, pest control, euthanasia should all be overseen by th vet

Veterinary facilities

* All zoos and aquariums should have an on-site veterinary facility
* Designated areas for exam and treatment, sterile surgery, necropsy, animal holding, laboratory, radiology, pharmacy, capture and restraint equipment, anesthesia equipment