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Proceedings & Abstracts

AQUATIC MEDICINE

INVITED SPEAKERS PROCEEDINGS
OPPORTUNITIES IN AQUATIC VETERINARY MEDICINE

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As the globalization era progresses, societies and world economies have been transformed dramatically, mainly through increased international trade. Concomitant with the emergence of the globalization era, mass mortalities have been observed over a wide range of farmed and wild aquatic animals, including fish, mollusks, crustaceans, harbor seals, manatees, turtles, frogs, coral organisms, and sea urchin. In addition to these mortalities, many aquatic animals are at the brink of extinction, and many more cannot reproduce, thereby causing their fisheries to collapse. Needless to say, dramatic increases in demand for the live aquatic animal trade, explosive expansion in aquaculture and ornamental fish trade, increased urbanization and industrialization, invasion by non-indigenous species, catastrophic climatic events, and continuous influxes of toxic chemicals into water bodies top the list of links. This situation has created a need for veterinarians, who are specialized in aquatic animal medicine, to provide the expertise and leadership needed to prevent the emergence and spread of aquatic animal pathogens.

Similarly, the expansion of international trade in aquatic animals and products along with the history of past pathogen introduction have increased the need for the development of more stringent legislations to control pathogen introductions. Most of the current legislations were issued in response to outbreaks associated with aquatic animal introductions, primarily fish and shellfish. For example, the 1937 Diseases of Fish Act of Great Britain was introduced in response to several outbreaks of furunculosis disease, caused by Aeromonas salmonicida, in wild salmon and other fish species in the rivers of England, Wales, and Scotland, attributed to the importation of infected live rainbow trout from Germany. The continuous growth in aquatic animal trade, however, stimulated the development of a number of regional, national, and international disease control policies. Unfortunately, such efforts have been impeded by the weakness of the aquatic animal health infrastructure in most nations. There are a limited number of laboratories that can accurately diagnose aquatic animal diseases, and there is a huge shortage in aquatic animal health professionals.

Currently, the aquatic veterinary profession has expanded in multiple directions and became indispensable for fisheries conservation, aquaculture productivity and profitability, natural resource management, ornamental fish and invertebrate hobby and industry, public aquaria and for developing and implementing health plans to reduce the transmission of aquatic animal pathogens and mitigate their effects. The rigorous veterinary curricula have prepared veterinarians very well to understand the basis of pathogenesis, epidemiology, and pharmacokinetics, yet, except for a very few exceptions, veterinary students are never trained
to practice aquatic animal medicine. While this knowledge gap could be overcome by
continuing education and professional development, there exist many additional challenges
that will be summarized below.

The aquatic environment differs substantially from the terrestrial environment, even though
many broad types of disease-causing organisms occur both on land and in the water. Some
emerging disease problems in aquatic environments are associated with pathogens moving
from terrestrial to aquatic systems such as toxoplasmosis in sea otters and aspergillosis in sea
fans. Other major differences between aquatic and terrestrial environments include the
taxonomic diversity, with its associated anatomical features and physiological functions, is
far more evident in aquatic rather than terrestrial animals. This diversity definitely influences
disease transmission modes and many other aspects of the disease process. Aquatic
populations are reproductively typically more open than terrestrial ones, with the potential for
long-distance dispersal of larvae. As a result, the rates with which epidemics spread in the
aquatic environment are more rapid than those observed for terrestrial pathogens. For
example, herpes virus ravaged pilchard populations in the Southern Ocean and the
morbillivirus epidemic spread rapidly among marine mammals. The rapid spread of the
pilchard epidemic in Australia was not merely a result of directional transport in currents, as
it spread against the prevailing currents. Moreover, in the case of non-motile, colonial aquatic
animals, such as sponges and coral organisms, rates of infection transmission of pathogens
are higher than in other motile aquatic or terrestrial animals due to the ease of pathogen
transmission among adjacent susceptible hosts.

Modes of disease transmission are different between aquatic and terrestrial organisms. For
example, vertical transmission, which is important for many terrestrial diseases, has been
proven in only a few aquatic diseases such as the bacterial kidney disease of salmonids. In the
same context, transmission through a vector, which is common in mammalian diseases,
appears to be rare in aquatic animals’ diseases, in spite of well-documented examples of
blood parasites of fish which use leeches and gnathiid isopods as vectors, fireworms which
spread infection of Vibrio sp. among corals, and invertebrate intermediate hosts for fish
worms.

Proper understanding of aquatic animal diseases is compounded with a number of constraints.
For example, baseline health data for the presence of pathogens and diseases of aquatic
animals is lacking and disease databases are either non-existent or relatively primitive. This
lack of knowledge impedes accurate disease risk analysis, increases the difficulty of
differentiating between exotic and endemic infections, and hinders the selection of disease
management options. In the same context, information on host ranges (i.e., all species
susceptible to infection) is vastly lacking for most pathogens of aquatic animals. There is an
urgent need to develop more sensitive diagnostic tools to detect subclinical carriers, at least
for pathogens that have a significant economic impact on production and trade.

The current situation, however, mandates that veterinary organizations, at all levels, join
forces to balance unimpeded trade with low risk of pathogen introduction. The consensus is
that this goal can be achieved through the following principles:
• developing, harmonizing, and enforcing appropriate and effective national, regional, and interregional policies and regulatory frameworks on introduction and movement of live aquatic animals and products to reduce the risks of introduction, establishment, and spread of aquatic animal pathogens;

• developing and implementing effective national disease reporting systems, databases, and other mechanisms for collecting and analyzing aquatic animal disease information;

• improving technology through research to develop, standardize, and validate accurate and sensitive diagnostic methods, safe therapeutics, and effective disease control methodologies; and promoting a holistic system approach to aquatic animal health management, emphasizing preventative measures and maintaining a healthy ecosystem.

• Concurrent efforts are needed to narrow knowledge gaps, to find innovative ways to implement health control measures, and to be prepared in case an emerging disease erupts. These efforts include the establishment of comprehensive databases on pathogens and diseases and related issues essential for the understanding of national disease status, for use in risk assessment studies, and to serve as a decision support system for introductions and national quarantine policies, guidelines, and strategies.

• Finally, the events that lead to the emergence of a disease are often complex, with the cause often being obscure and only indirectly related to the new agent. Therefore, global efforts should be focused on preparing a contingency research plan that can immediately be followed should an emerging infection erupt, in order to expedite the identification of effective control measures.
USE OF THE OIE PVS TOOL FOR THE EVALUATION OF NATIONAL AQUATIC ANIMAL HEALTH AND VETERINARY SERVICES

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The OIE has had the responsibility for setting aquatic animal health standards for more than 50 years. Aquaculture production represents an essential asset to the income of many developing countries. Strengthening Aquatic Animal Health Services (AAHS) governance and, consequently aquatic animal health programs, is the best way to ensure a dynamic and sustainable aquaculture sector in the future.

The OIE PVS Pathway is a global programme for the sustainable improvement of a country's Veterinary Services' or AAHS’s compliance with OIE international standards and is the key contribution to OIE’s capacity building activities.

Initially the OIE Tool for the Evaluation of Performance of Veterinary Services (OIE PVS Tool) was developed and applied to the evaluation of Veterinary Services regarding terrestrial animal issues with the objective of strengthening governance and securing investment in key infrastructure elements, such as diagnostic laboratories, legislation and technical capacity of professionals. Its application to the evaluation of AAHS commenced in 2009 when the OIE undertook a pilot mission in Vietnam. Following this and several subsequent missions, it was clear that the OIE should consider the development of a stand-alone tool for the evaluation of an AAHS. In 2013 the first edition of the OIE Tool for the Evaluation of Performance of Aquatic Animal Health Services (OIE PVS Tool: Aquatic), based on the OIE PVS Tool, will be published.

Details of the OIE PVS Tool: Aquatic, why it is important and how it can be applied to improving aquatic animal health will be described in this presentation.
HOW TO GET YOUR ‘FLIPPER’ IN, TO BECOME A FISH VET

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Who are the clients of a fish vet? The nature of the profession is such that one day, you may be working with a much loved, single pet goldfish and on another, you may be working with the mindset of population health as you help problem solve the fish farmer’s issues. There are very few fish veterinarians and as such, when you provide a veterinary service to the aquatic animal health sector, the diversity of clients become very large. As a general rule, the categories you may be dealing with include ornamental fish, food fish, aquaponics, education sectors (e.g. universities, animal ethics committees, technical institutes) and the internet (e.g. forums, social media). For each sector, I’d like you to consider how the general ideas apply to you, whether you are a veterinarian getting into aquaculture or ornamentals.

So, how do you get your foot or flipper in the door to become a fish vet? First, you will need to gain some basic knowledge and understanding of the aquatic world, and apply the fundamentals learnt in veterinary school to medicine anatomy, pathology, epidemiology, biosecurity and so on. This can be gained by working alongside a veterinarian, attending conferences and workshops, self-study and practicing it. You do not need to know everything to get started. You can learn along the way. The basics you need to know include: recognising the clinical signs of sick fish, ensuring water quality (nitrogen cycle, ammonia, nitrite, nitrate, pH, KH, GH, salinity, dissolved oxygen, water temperature), conduct standard diagnostic sampling and testing (gill biopsy, skin mucus scrape, microscopy skills) and have some basic equipment (e.g. water testing kit, nets, a microscope, medicines, reference books).

The best way to gain a firsthand understanding of everything mentioned is to set up your own aquarium. Keeping fish will also hold you in good stead because you can personally relate to your clients, and tell them what you keep when they ask.

Once you are set up, you can begin to work with fish clients. You are the central person in a given situation. Here, we have your typical veterinarian-client relationship where you provide services and goods. With the water testing kit and microscopic equipment, you can perform diagnostics and solve more than 80% of cases that are presented since the vast majority of cases is to do with water quality issues and ectoparasitic conditions.

For the more complex cases, you have access to the veterinary laboratories and you can collect and prepare diagnostic samples just as you would for your other animal pathology work. Some laboratories may offer services such as necropsy, histopathology, bacteriology, virology and even biochemistry and haematology. You would be the intermediary and be able to interpret the laboratory results as they relate to the clinical history, for your client.

Once you have your diagnosis, you will be able to provide the treatment. For the commonly available medicines, you may be able to refer the client back to the fish store to obtain over-
the-counter the medicines required. By doing so, you are creating a relationship with the fish store, showing them that you are no threat to their business, but are offering a complementary service. It also means that you do not have to stock such readily available medicines which the fish shop may be able to supply to the customers at a more economical price. By establishing a good relationship with the fish shop, you will create trust, respect and recognition that you are using real diagnostic tools to arrive at your conclusions and treatment options, rather than making a guess. In turn, the local fish store will refer clients to you, or the fish stores themselves may call on your services directly.

The medications commonly stocked by ornamental fish stores include formalin, malachite green (note, this is banned for use in food fish), acriflavine, methylene blue, copper sulphate, potassium permanganate, triple sulfa, tetracycline (the antibiotics range may vary depending on local veterinary pharmaceutical laws).

With any hobby groups, there are always going to be hobby magazines. What better way to contribute to the advancement of fish health, and advertise your services at the same time, than to write for a captive audience. Many such magazines welcome veterinary input as it gives a refreshingly different angle/insight that biologists, breeders and hobbyists may be unaware of. Magazines may provide an honorarium for articles, or afford you advertising space in the magazines. It is very worthwhile to seek such opportunities to contribute and to represent veterinarians in aquatic animal health, and to a wide audience.

But as a veterinarian, it is not always practical to have clients that are too far from base. How do you attract clients who are in your area? Again, with many hobby groups, they often have clubs or societies. The common groupings of fish clubs include koi, goldfish, cichlid, discus and native fishes. It is a good idea to seek out these groups, and again, they would welcome veterinarians to become involved. You will find that many fish keepers have never had the luck of finding a vet who would take on fish cases. In such clubs, the learning would be a ‘two-way street’. You will learn of the common conditions as they occur seasonally, the backyard style treatments that are used and about all the latest in products and gadgets. As the veterinarian, you can give presentations and teach them about evidence-based medicine and treatment. Although, the biggest draw card from the point of view of the hobbyists is that you, as the veterinarian, have access to prescription-only medicines.

So far, I have outlined the traditional, inexpensive ways of advertising your services. Other ways to advertise include other print media such as newspapers, flyers, letter drops, billboards, radio and TV, but these attract high fees. What else can you do? In this new age of technology, the adage of, “It’s not WHAT you know, but WHO you know”, is now being replaced by, “It’s not WHO you know, but WHO KNOWS YOU.” We now have the power of the internet. Why is the internet powerful? It is because it has the possibility of reaching a massive audience without the monetary expense. There are many internet sites that offer free listings for your business. Search ‘free listings’ in the internet and you may be able to find numerous sites that will allow you to list for free in your own country. The one global source of free fish veterinary listing is www.aquavetmed.info/ so make sure you list your business on there.
In the last 3 years, there has been a spike in social media activity. The most popular include blogs (web log), Facebook, LinkedIn, Twitter and YouTube. Each one of these targets/captures different sets of audiences. And so when you publish on them you will have to bear that in mind. My main reason getting involved is to educate /impart knowledge about fishes and to dispel myths by sharing with the audience, any interesting and practical and useful information that I have gained Blogs are for those interested in reading, gaining information that is more in-depth. Facebook is more visual and are for those who are attracted to looking at pictures. LinkedIn is a professional’s form of Facebook. Twitter are for headlines. Youtube appeal to those who like watching short videos. The purists would tell you that you will need to create completely different message types for the different audiences, however, if you are short for time, you can link everything together such that when you publish on your blog (I use Wordpress), it automatically publicises to Facebook, Twitter and LinkedIn without having to create additional work for yourself. You might wonder what you can write and what if you run out of ideas. But I would have to say that there is a lot to write about in the aquatic veterinary field. You can gain ideas from anything you read (newspapers, texts, journal articles, internet sites), from your consults, conferences/workshops, etc. I must say that trivia are very popular and I receive daily hits for search questions relating to whether goldfish have a 3 second memory, whether they grow to the size of their tank and whether they have a stomach. Give it a try and you might find that new ideas and topics keep arising.

To increase your ‘following’, you can follow others in the related field. Then they, or their followers may follow you. Make sure you advertise that you are on social media, showing links on your business cards, websites and other advertising campaigns. Don’t be afraid of self-promotion because as mentioned before, it is not WHO you know, but WHO KNOWS YOU!

Good luck!
Certainly within the major ornamental fish markets of the UK, Germany, USA and Australia, ornamental fish in terms of animal numbers, probably account for roughly 10:1 of all animals kept as pets. As an example, in the UK there are around 140 million fish kept in approximately 4 million homes\(^1\) with around 14 million fish imported each year. Ornamental fish medicine can be considered a sub-set of aquatic veterinary medicine which is currently the fastest growing area of veterinary medicine\(^2\). Working with retailers and importers places the aquatic veterinarian in a pivotal position within the supply chain to influence the health and welfare of ornamental fish from supplier (farm or wild capture) to the hobbyist. Ornamental fish practice, on the whole, fits well within a small animal veterinary practice whilst offering services to retailers and importers is more akin to farm animal practice with its emphasis on visiting the client and dealing with disease control and prevention.

There are over 2000 species kept as ornamental fish and the veterinarian is likely to see more species at importers and retailers than working solely with hobbyists where the species seen are likely to be no more than around 50. This large number of species means that it is unlikely the veterinarian will be familiar with all species seen which will have significant variation in anatomy, environmental and nutritional requirements. However, this variation and diversity can be readily grouped into relatively few combinations of the categories listed in Table 1.

<table>
<thead>
<tr>
<th>Water Type</th>
<th>Water Temperature</th>
<th>Body Shape</th>
<th>Nutritional Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater (Soft)</td>
<td>Coldwater</td>
<td>Fusiform (e.g. Carp)</td>
<td>Herbivores</td>
</tr>
<tr>
<td>Freshwater (Hard)</td>
<td>Warm Water</td>
<td>Laterally Compressed (e.g. Discus)</td>
<td>Carnivores</td>
</tr>
<tr>
<td>Brackish Water (Estuarine)</td>
<td>Tropical</td>
<td>Dorsoventrally Compressed (e.g. Rays)</td>
<td>Omnivores</td>
</tr>
<tr>
<td>Salt water (marine)</td>
<td></td>
<td>Filliform (e.g. Eels)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1**

Using these categories it is possible to work out the basic requirements of most species and this can be further refined, for example, by looking at mouth position (indicating whether surface or bottom feeders etc.) and caudal fin shape which is indicative of swimming habits\(^3\). It should also be remembered that the intent of the ornamental trade is to sell live fish, so fish...
are likely to be robust and amenable to living in an aquarium otherwise they will not survive the rigors of the supply chain. Additionally the retailer/importer will have knowledge of the fish’s specific requirements along with whether the fish is communal or solitary. In terms of disease susceptibility, this is often defined by water temperature (cold water, warm water and tropical) coupled with whether the species is freshwater or marine. Thus despite the diversity it is possible for the veterinarian to make reasonable assumptions from what might be called first principles.

Specifically when dealing with ornamental importers and retailers the veterinarian should be aware of the following:

1. Most premises will use centralised filtration systems thus large populations of fish may well be held within the same system. Centralised filtration offers several benefits of which the two most obvious are decreased cost of instillation and the ability to cope with variations in stocking density due to the greater volume of water. The most significant disadvantages are the ease with which pathogens can spread within the system and issues that might arise from requirements to treat diverse species. Clearly biosecurity needs to be of the highest order.

2. Due to the requirements of biosecurity, importer premises should have sufficient spare capacity or systems to provide adequate isolation if required.

3. The commercial aspects of the business require that the vet consider the economics of any suggested regime or treatment. However, this does provide scope for the provision of routine visits as “prevention is better than cure”.

4. When dealing with importers (or potentially retailers acting as consolidators) the attending vet needs to be aware of international and national legislation such as CITES\(^4\), the Convention on Biodiversity\(^5\), IATA regulations\(^6\), EU 2006/88\(^7\) and any current national legislation.

5. Staff should be trained to ensure they are able to interpret routine water quality measurements, reception procedures for fish and basic diagnostics such as skin scrapes. They need to be trained in making adequate records and be able to undertake the advice given by the vet who is often at a distance and should ensure adequate communications to provide advice as required. This may occasionally be at night depending on flight arrival times. Clearly the vet must trust the ability of the member of staff carrying out these procedures and training is the key to this.

6. If correct pre-transportation procedures have been enacted (and it is often worth working directly with suppliers to ensure this) then the risk of introducing infection is limited. However, given the range of suppliers often used, and human error, it is essential that a diagnosis can be obtained quickly given the potential losses. Thus systems need to be in place to provide rapid diagnostics.
7. One of the main reasons for refusing entry into a country is the supplier failing to follow applicable import regulations. An obvious example being medicines regulations vary between countries. This may have public health implications but perhaps more importantly may result in the euthanasia of the whole shipment on welfare grounds.

8. Be aware that regardless of procedures in place that providing timely advice at a distance may be required in an emergency.

Further information

1. Ornamental Aquatic Trades Association. [www.ornamentalfish.org](http://www.ornamentalfish.org)
2. World Aquatic Veterinary Medical Association. [www.wavma.org](http://www.wavma.org)
In the New York metropolitan area, the demand for advanced veterinary care for ornamental and pet fish has existed for many years and has been growing slowly. The speed of growth has not been faster due to the general lack of knowledge by the pet fish owning segment of the public as to the availability of veterinary services. The advent of modern web-based information is accelerating the pace of this demand. Small animal/exotic veterinary practices are now being consulted more frequently about pet fish care. The addition of these services is feasible and can be integrated profitably. In a survey and presentation done in 2003 by this author, it was determined that a) the capitalization of the pet fish practice with no hospital facility most resembles the business model of the relief (per diem) veterinarian b) compared to the relief veterinarian, the salary is superior and comparable to the small animal/exotic specialist c) for the practice owner or principal, it was hard to offset the lost productivity as a pet fish vet compared to the regular in-office services, and d) the small animal/exotic employed vet, working part time at the facility, part time as a pet fish vet, was very profitable. In a follow-up survey, 5 ornamental/pet fish veterinarians practicing at least 10 years in this specialty were asked to respond to questions concerning the business aspects of their practice. Based on the type of practice within the specialty, these aspects varied considerably. For the existing small animal/exotic practice, the introduction of this specialty requires very minimal new equipment purchases and most standard practice tools, drugs and lab services are utilized. The primary difference, based on the very high (>90%) call volume for koi consultations, is the need to practice onsite rather than via office visit. This often translates to more travel time than actual consultation, with the need to adequately capitalize this time. Fee structures vary considerably, but all surveyed practitioners calculate this travel time into their fees.

The intangible benefits of ornamental/pet fish practice for the small animal exotic practitioner are the opportunity to leave the office and enjoy practicing outdoors, especially during the warmer months. Additionally, many clinical cases offer challenging diagnostic and treatment dilemmas to stimulate the professional mind.
Many factors must be analyzed when doing a complete veterinary diagnostic workup for a pond problem. In areas where two distinct seasons are characterized by a warm metabolically active and cold metabolically inactive period, the diagnostic workup should account for these variable factors. Despite a relatively low utilization rate and high water concentration of oxygen in winter, difficulties maintaining ventilation of pond water during freezing periods can lead to hypoxic conditions. Furthermore, several mechanisms, such as pond deicers, heating systems, air bubblers and high circulation rates with spillways, which have been promoted to mitigate winter hypoxia, can themselves lead to medical problems. A thorough understanding of the inter-relationship between air and water temperature, water circulation and gas exchange is critical in evaluating cold season health problems. In addition, two distinct pond design formulas are currently in usage in the USA, that being the deep pond with circulation featuring bottom drainage and the shallow dished pond with surface circulation only. As each of these differ metabolically, an understanding of these design features is important. Gas exchange for ventilation may be accomplished by using air diffusers and stones, waterfalls and spillways, surface skimmers, fountains, venturis, pond deicers and slow bottom to surface water flow rates. As koi have adapted to overwintering at the bottom of lakes and ponds at a water temperature of 39°F (4°C), colder water can lead to medical problems such as koi winter “layover” syndrome. Water temperatures as low as 28°F (-2°C) have been recorded by this author. Water temperature can be modified, intentionally or not, by the use of a warm air bubbler, greenhouse, solar cover, heaters and pond deicers. A simple waterfall bypass has been used successfully to reduce pond water temperature fluctuation during periods of varying air temperatures. Circulation is accomplished actively via external or submersible pumps, fountains, air lift devices and passively with pond deicers. The rate, called the turnover time and the frequency should be analyzed. Problems encountered are often caused by too high a circulation rate or the use of multiple devices. Water chemistry is less often incriminated as the source of cold weather problems. However, due to the lack of intentional water exchanges during cold weather, depletion of carbonate buffers will lead to pH instability in those areas where water is naturally soft. Other conditions seen during cold weather are entrapment in shallow areas, saprolegniasis or water mold, a fungal pathogen that grows well in cold water and ichthyobodo, which can reproduce rapidly in cooler water than is often seen with most parasitic infestations.
Fishes show a range of clinical signs when diseased. What are these, and what do they mean? There are clinical signs that are pathognomonic for certain diseases, however, many are non-specific and a step-by-step approach to working up a case is necessary.

Firstly, it is very important to familiarise yourself with what is normal in terms of appearance and behaviour for the species you are dealing with. Typically, healthy fish should have a good appetite, have clean, clear, vibrant body colouration, hold their fins erect and have bright red gills. They should be active and not display abnormal behaviour, swimming patterns or have loss of buoyancy control. However, there are always exceptions to these rules as the types of different fish species number in the thousands. There are some fishes such as the wrasses that lie on the bottom or on their side, there are upside down catfish that swim upside down and there are fish (goldfish) with deformities which are all ‘normal’.

In the following paragraphs, I will describe pathological presentations and how they may be interpreted in terms of pathobiology and aetiology. At the end of this document is a table of common aetiologies as they relate to the general syndromes that are discussed (see Table 1).

Skin conditions can vary from erosions on the mouth or fins (usually due to Flavobacterial infection) or along their lateral line system (e.g. hole-in-the-head disease). Ulcers are common and they can originate from the outside (e.g. Aeromonas), or be ulcers that originate from the inside (Mycobacterial). Ulcers may present as discrete lesions anywhere on the body including the fins, flank and operculum. They can be circumscribed and show advancing border. They may be pale to red, depending on the depth of the ulcer. The pale ulcers are more superficial and indicate oedema and the red may be due to hyperaemia. A dull red appearance is evidence of deeper ulceration with exposed muscle. Such deep ulcers may be due to fungi (e.g. Aphanomyces invadans), protozoa (e.g. Tetrahymena), or simply from a predator attack. It is more common that the skin ulcers are due to secondary bacterial infection, with the primary pathogens being either skin flukes or lice. Thus it is very important to investigate for the primary cause. Sometimes, melanisation occurs in response to injury which is commonly seen in goldfish.

Fish may have proliferative skin lesions that may be raised and smooth (e.g. carp pox and neoplastic conditions) or be fine and granular (e.g. lymphocystis). They may present with fine white spots (e.g. white spot disease) or appear as a haze (e.g. velvet disease) or larger
spots (e.g. digenetic trematodes). Excessive slime production may be an indication of ectoparasitism or poor water quality issues (e.g. low pH). A change in body colouration, whether it be pale or dark is non-specific. Fish may have tuft-like white growths which can be due to fungi (Saprolegnia) or bacteria (Flavobacteria). Hyperaemia of finnage or body is a common sign of stress and/or bacterial infection.

Often, fish with skin lesions may present with flashing (scratching against substrate or tank walls), have clamped fins and separate from the group. If they are infested with particularly irritant parasites (e.g. Argulus), the fish may jump in an attempt to dislodge the parasites. Generally, those with severe disease may become lethargic and very often display respiratory signs of disease too. The reason for this is because the gills are also in intimate contact with the water and the external environment. Thus, many pathogenic organisms that colonise the skin will also affect the gills.

It is always a good idea to check that the gill colouration is a healthy bright red. Pale gills indicate anaemia, whereas dark gills indicate methaemoglobin formation. Gills with excessive mucus indicate ectoparasitism or dissolved toxin. Whenever gills are damaged, they have a limited range of response and they include formation of synechiae (secondary lamellae ‘stick’ to each other), epithelial hyperplasia, secondary lamellar fusion and if given sufficient time, mucus cell hyperplasia. All these will decrease the efficiency of gill function and fish will display respiratory signs of disease. Fish may congregate at water inlets and ‘pipe’ or ‘gasp’ at the water surface. The opercular beat rate may initially be increased as the fish try to respire through inefficient gills, but as fish become moribund, the opercular rate will decrease.

Under the heading of ‘distended abdomen’ we have proliferative conditions (ovarian neoplasia is common in koi) or cystic conditions (polycystic kidney disease common in goldfish), ‘bloat’ and ‘dropsy’. Bloat is typical for certain cichlid fish known as ‘Malawi bloat’ which is caused by Hexamita (an intestinal flagellated protozoa). But enteric infections with bacteria such as Pseudomonas can also present in a similar fashion. The common term of ‘dropsy’ is used when there is also protrusion of the scales to create a ‘pine cone’ appearance due to subcutaneous oedema. This is obvious in fish with larger scales, but is difficult to appreciate in species such as the angelfish with fine scales. Dropsy is often accompanied by ‘pop-eye’ (exophthalmia). These are commonly a result of primary or secondary bacterial infections causing inflammation and vascular damage, especially to the rich vascular beds in the kidney and choroid rete behind the eye. The insult to the kidney interferes with fluid balance, causing the ‘dropsy’ appearance and inflammation behind the eye causes the ‘pop-eye’ appearance. There is one breed of goldfish where exophthalmia is selected and these are known as telescope moors.

Fish in advanced disease can present with buoyancy disorders. They may either become negatively buoyant and sink to the tank floor, or become positively buoyant, floating to the surface. This is a very common condition in goldfish breeds and in my experience, it is more common in rotund breeds such as the ryukin, pearl scale and orandas. These fish tend to also have twin tails. There is suggestion that fish should not be overfed and that
they should be given adequate fibre in their diet. Systemic bacterial infections are also common causes of buoyancy disorders. Less common causes include coccidial and fungal infections of the swim bladder.

Fish that are wasting present with concave abdomen. The differential diagnoses for poor body condition in fishes include, but are not confined to the following: chronic malnutrition, or infections by bacteria (e.g. mycobacteriosis), protozoal organisms (e.g. Hexamita, Spironucleus, Cryptobia, Sporozoa, Ichthyobodo) and metazoa (e.g. Gyrodactylus, Dactylogyrus and a number of cestode species).

Fish with enteropathy will have long faecal strings, that may contain bubbles and float, or they may be empty faecal strings (in most freshwater fishes, normal faecal casts should resemble black string). If they are overfed, their faecal strings take on the same colouration of the fish food fed to them. Those with enteritis will display congested vents. This can be overlooked when assessing health of pond fish. Thus it is very important to capture some fish to examine their vents.

Causes for sudden death are difficult to diagnose because fish tissues autolyse rapidly. Based on epidemiological principles, sudden death is likely due to environmental causes. Collating a good history and water quality analyses are important.

Inappetance is a non-specific sign of illness. It can also occur when water temperature deviates from their tolerance range. The most common is during winter when owners are unaware that they need heating for their Siamese fighting fish, or their heater has stopped working. You will see remains of uneaten food in the tank or filter.

So we have discussed the clinical signs displayed by fish during ill-health. But some other things we should also consider include their environment. Fish that are sick tend to produce more mucus and you may notice a fishy smell coming from the tank and perhaps there may be excess stable foam accumulating at the water surface.
<table>
<thead>
<tr>
<th>General cause</th>
<th>Skin Conditions</th>
<th>Respiratory</th>
<th>Distended abdomen</th>
<th>Buoyancy</th>
<th>Wasting</th>
<th>Sudden death</th>
<th>Inappetance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacterial</strong></td>
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<tr>
<td></td>
<td>Flavobacteria</td>
<td>Aeromonas spp.</td>
<td>Aeromonas spp.</td>
<td>Mycobacteria</td>
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<tr>
<td></td>
<td>Pseudomonas spp.</td>
<td>Mycobacteria</td>
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<tr>
<td></td>
<td>Citrobacter spp.</td>
<td>Nocardia</td>
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<tr>
<td><strong>Fungal</strong></td>
<td>Saprolegnia</td>
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<td></td>
<td>Aphanomyces</td>
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<tr>
<td><strong>Algae/protozoa</strong></td>
<td>Ichthyophthirius</td>
<td>Ichthyophthirius</td>
<td>Hexamita</td>
<td>Spironucleus</td>
<td>Toxic algae</td>
<td>Algal bloom</td>
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<td></td>
<td>Ichthyophthirius</td>
<td>Ichthyophthirius</td>
<td>Hexamita</td>
<td>Spironucleus</td>
<td>Toxic algae</td>
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<td>Ichthyophthirius</td>
<td>Ichthyophthirius</td>
<td>Hexamita</td>
<td>Spironucleus</td>
<td>Toxic algae</td>
<td>Algal bloom</td>
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<tr>
<td></td>
<td>Trichodina</td>
<td>Trichodina</td>
<td>Chilodonella</td>
<td>Hexamita</td>
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<td></td>
<td>Oodinium</td>
<td>Oodinium</td>
<td>Amoeba</td>
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<td></td>
<td>Tetrahymena</td>
<td>Amoeba</td>
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<tr>
<td><strong>Metazoa</strong></td>
<td>Gyrodactylus</td>
<td>Gyrodactylus</td>
<td>Dactylogyrus</td>
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<td></td>
<td>Dactylogyrus</td>
<td>Dactylogyrus</td>
<td>Lernaea</td>
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<td></td>
<td>Argulus</td>
<td>Argulus</td>
<td>Predator</td>
<td></td>
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<tr>
<td><strong>Viral</strong></td>
<td>Iridovirus</td>
<td>Herpesvirus</td>
<td>Herpesvirus</td>
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<tr>
<td><strong>Toxic/Environmental</strong></td>
<td>Low pH</td>
<td>Nitrite toxicosis</td>
<td>Hypoxia</td>
<td>Hypoxia</td>
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<td>Hypoxia</td>
<td>Hypothermia</td>
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<td>Hypoxia</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Hypoxia</td>
<td>Hypothermia</td>
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<tr>
<td><strong>Nutritional</strong></td>
<td>Burn (heater)</td>
<td>Hyperthermia</td>
<td>Neoplasia</td>
<td>Intestinal blockage</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Ingested large</td>
<td>Neoplasia</td>
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<td>meal</td>
<td>Neoplasia</td>
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<td></td>
<td></td>
<td></td>
<td>Neoplasia</td>
<td></td>
<td></td>
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<tr>
<td><strong>Genetics</strong></td>
<td>Upside catfish</td>
<td></td>
<td>Down</td>
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</table>
The field of veterinary medicine is diverse, furthermore, the field of aquatic veterinary medicine is just as diverse. However, as veterinarians, we have more than enough knowledge and skills to work with fish.

Disease is complex and is rarely a simple association between fish and pathogen. Successful fish health management begins with prevention of disease rather than treatment – the key areas being water quality, nutrition, sanitation and fish health.

Fish show a limited range of clinical signs of illness. And these are usually not specific enough to make a diagnosis by clinical examination alone. With the tools available at hand, many veterinarians can provide the service for clients with fishes.

With water quality analysis and microscopic examination of wet and cytological preparations, the veterinarian can diagnose more than 80% of common conditions they will be presented with. For more complex cases, samples can be sent to the veterinary laboratory for testing. The information contained in this document will help you understand the aquatic environment and provide you with a starting point.

In the lecture presentation, I will take a different approach to discussing common fish diseases. Just as certain species and breeds of animals are predisposed to certain disease conditions, this also holds true for many fish species. I will outline the common diseases based on the infectious agent as an alternative way of learning about the conditions. Remember that for most freshwater diseases, there are often, marine equivalents. I have used freshwater fish examples since freshwater fish owners are the more likely to call on the veterinarian as they tend to have a special affinity with heir fish.

**COMMON ENVIRONMENTAL ISSUES**

**Water Quality Problems**

**Temperature**

Fish are particularly sensitive to temperature changes and different species have specific temperature ranges within which they can live normally. In excessively high temperatures hyperthermia and hypoxia can result and hypothermia and immunosuppression can occur at lower temperatures. When acclimatising fish, water temperature changes should occur as gradual as 1°C per hour until the desired temperature is reached and this is particularly important when increasing temperature.
**pH**

The pH (potential hydrogen) of water is the measure of the concentration of hydrogen ions. pH values between 7.0 and 14.0 is alkaline/basic and pH units between 0.0 and 7.0 is acidic. Numerous biological processes depend on pH; playing important roles in the blood system, especially for oxygen diffusion. pH can indirectly affect fish through its effect on other chemical parameters as well. For example, low pH can result in the solubilisation of potentially toxic metals from the sediments, while at high pH, the toxic form of ammonia becomes more pronounced. The stability of pH is determined by the KH (carbonate hardness).

**Ammonia**

Ammonia (NH₃) is produced by fish respiration and by the decomposition of waste products (excessive organic matter and excessive feeding). Ammonia can be present as highly soluble toxic unionised ammonia (also known as free ammonia nitrogen, abbreviated to FAN) and as the less dangerous ammonium ion (NH₄⁺); the sum of both is known as TAN (total ammonia nitrogen).

The toxicity of ammonia may be influenced by pH, temperature and salinity. Of these, the pH of water is the most important factor that determines the ratio of NH₃& NH₄⁺. When the pH is high, more of the ammonia is in its toxic form. Toxic ammonia will increase exponentially with increasing pH levels and temperature (see Table 1).

*Table 1. Toxicity of ammonia at different pH in freshwater. Table sourced from the Hagen water test kit.*

<table>
<thead>
<tr>
<th>pH</th>
<th>NH₄⁺ (ppm)</th>
<th>0.25</th>
<th>0.50</th>
<th>1.00</th>
<th>2.00</th>
<th>4.00</th>
<th>6.00</th>
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</thead>
<tbody>
<tr>
<td>7.0</td>
<td></td>
<td></td>
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<tr>
<td>7.5</td>
<td></td>
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</tr>
<tr>
<td>8.0</td>
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</tr>
<tr>
<td>8.2</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>8.4</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>8.6</td>
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<tr>
<td>8.8</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>9.0</td>
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</table>

**Clinical signs of ammonia toxicosis include** (but are not limited to) increased mucus production, red or bleeding gills, darkening of body colouration, 'gaspering' for air at the surface and increased respiration rate.

**Nitrite**

Nitrite (NO₂⁻) is generated through the oxidation of ammonia by nitrifying bacteria. Elevated levels often occur during the early stages of setting up new aquariums as they undergo the nitrogen 'cycling' process. A sudden spike in the nitrite usually means there is an imbalance
in the system. This could stem from something as simple as washing the biological filter media too thoroughly (Nitrobacter are not as adherent as Nitrosomonas and may be washed off).

Nitrite toxicosis results in methaemoglobin formation, inhibiting oxygen transport by the erythrocytes. Both nitrite and nitrous acid are toxic to fish, but nitrous acid is the worse of the two. The relationship between total nitrite and unionised forms such as nitrous acid (HNO2) is inversely pH dependent. Thus nitrite is more toxic in acidic water. It is also more toxic in soft water and at higher temperatures with marine fish and juveniles being most sensitive.

Nitrite levels and their consequences:
0-0.2mg/L is ideal
>0.5mg/L is harmful
>1.6mg/L is lethal

Nitrate

Elevated nitrate (NO3-) levels create considerable stress to fish and retards their growth rate, reduces disease resistance, delays wound healing, causes redness in the fins or body and, dilated blood vessels (especially visible in the white fins). Nitrate is the final byproduct of organic and inorganic decay. In the natural environment, nitrate is removed through organic usage (by plants), however, in the closed system, nitrate will accumulate if not removed. Thus, high levels indicate pollution from prolonged waste build-up and partial water change is necessary.

Nitrate limits for:
Freshwater: 110mg/L (optimal 40mg/L as a balance for planted tanks)
Marine fish: 40mg/L
Marine invertebrates: 15-20mg/L

Oxygen

Oxygen is vital for a healthy aquarium. The maximum oxygen carrying capacity of water is affected by the temperature (low levels in warmer waters) and specific gravity (SG). Healthy systems should be >70% saturated, but as a general guide, fish need >5mg/L of dissolved oxygen.

Table 2: Solubility of oxygen in water at different temperatures and SGs at 760mmHg

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.000</td>
</tr>
<tr>
<td>5</td>
<td>12.8</td>
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<td>10</td>
<td>11.3</td>
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<tr>
<td>15</td>
<td>10.2</td>
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<td>20</td>
<td>9.2</td>
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<tr>
<td>25</td>
<td>8.4</td>
</tr>
<tr>
<td>30</td>
<td>7.6</td>
</tr>
</tbody>
</table>
Additional oxygenation may be required when there is high stocking density, fish are large, low water movement, high feeding rate, high metabolic rate, high water temperature, algal blooms, bacterial blooms and during certain chemical treatments (e.g. formalin). Oxygen saturation of >100% have been implicated in Gas Bubble disease and dissolved oxygen of <3ppm has been associated with fish kills.

Larger fish are less tolerant of low dissolved oxygen and are usually the ones that die first. Fish that die from low water oxygenation, carbon dioxide toxicity or with gill disease will show gaping mouths. Also, it is important to maintain a DO of >3mg/L, otherwise, there is the risk of nitrate converting back to nitrite, poisoning the fish.

**Carbon Dioxide**

CO2 is essential for healthy plant growth and is usually present dissolved in the aquarium from the air, from the decomposition of organic matter and respiration wastes of organisms. Some aquarists may utilise CO2 injectors to promote plant growth. Elimination is by diffusion into the atmosphere and photosynthesis.

For optimal fish health, it is recommended to keep levels of CO2 to less than 6ppm, but on the other hand, for optimal plant growth CO2 should be maintained at levels between 10-25ppm. It must be remembered that levels greater than 15ppm are harmful and have been implicated in some fish kills. But in most freshwater aquaria, fish can tolerate up to 60ppm. Thus, the aquarist needs to understand the delicate balance that exists and choose to understock the tank with fish, or choose species (e.g. anabantid) that are tolerant of such water conditions.

**Chlorine/Chloramine**

Chlorine (Cl2) is toxic and causes gill necrosis and is more toxic at lower pH. It is usually present in tap water at 0.5-2mg/L. Toxicity can occur if owners perform >2% water change without using chlorine/chloramine neutraliser.

Chlorine levels & their consequences
>0.01mg/L \( \rightarrow \) stress
>0.02mg/L \( \rightarrow \) adverse effects seen
>0.04-0.1mg/L \( \rightarrow \) death
*NB: there are large species variations in terms of tolerance.

**COMMON INFECTIOUS DISEASES**

**Virus**

**Lymphocystis (iridovirus)**

Infected fish may present with clusters of tiny round nodules on damaged areas, particularly the fins or mouth. The most common group of fish affected are gouramis. Fish are infected via contact or ingestion of infected material or virus.
**Carp Pox (herpesvirus)**

These are usually low profile, raised skin lesions, usually of the same colouration as the skin in the vicinity. It can occur on the body or fins of koi or goldfish. In some cases, the protruding lesions can incur traumatic damage and the open sores can become secondarily infected. The lesions tend to appear in winter and may regress spontaneously over summer. Like most other herpesvirus infections (e.g. human cold sore), the virus can remain latent in ganglia to re-emerge when the host becomes stressed.

**Iridovirus**

Can cause sudden death in fish, particularly gouramis, cichlids and livebearers. Diagnosis is by histology (inclusion bodies in vascular endothelium and haematopoietic tissue) or PCR.

**Bacteria**

**Flavobacteria (F. columnare)**

Grossly, lesions appear as a fluffy white growths on the mouth, skin or fins. Long, slender, Gram negative rods that may be bunched in haystacks. They produce proteolytic enzymes and cause much damage to fish tissues particularly the skin and gills. Poor water quality and trauma predisposes fish to infection.

**Aeromonas spp. (A. hydrophila)**

Short, Gram negative rods. Is ubiquitous in the environment and there is debate whether fish contract disease secondarily or if they are indeed, primary pathogens. Poor water quality and trauma predisposes fish to infection.

**Mycobacteria (M. marinum, M. cheloniae, M. fortuitum)**

Relatively large. acid-fast bacilli. On wet preparations or Diff Quick smears, they appear as non-staining rods. It causes a chronic, granulomatous disease in fish. Ingestion of infected material is the most common method of transmission.

**Fungi**

**Saprolegnia**

Grossly, lesions appear as a fluffy white growths on the skin or fins. skin scrapes produced large masses of parallel sided mycelium. Some terminate in elongate sporangia delimited by septation. Water mould (oomycete) commonly infect immunocompromised fishes and this commonly occurs during cooler water conditions.
Protozoa

Ciliates

 Mostly free-living, many are commensals and some are parasitic. Possess cilia or ciliary appendages and 2 types of nuclei. When they move, they do so in a smooth pattern (like a hover-craft).

Ichthyophthirius

The common disease name is “White Spot Disease”, where 0.5mm diameter white spots can be seen all over the fishes’ body and gills. This is perhaps, the only fish disease with pathognomonic clinical signs.

Chilodonella

Chilodonella is a protozoan parasite that has cilia arranged in rows across its body and a characteristic cytopharangeal basket made of stiffened cilia surrounding the cytostome. The organism moves with a characteristic gliding and flipping motion. This particular parasite tends to only take advantage of fish that are in poor condition (e.g. stress, disease debility, overcrowding, pre-existent injuries, starvation etc.) and only rarely attacks healthy, vigorous fish. It is a big problem in over-wintering fish in temperate and sub-tropical climates which are in poor body condition and usually flares up as the temperature begins to rise with onset of spring.

Trichodina

This is a common pond inhabitant and is only pathogenic in high numbers. It is also a useful indicator of the level of pond/tank hygiene.

Flagellates

Are protozoa with flagella and usually single nucleus. They swim in an erratic manner, often flipping and tumbling.

Hexamita

It is one cause in a multi-factorial disease known as “Hole-In-The-Head Disease. As the name suggests, affected fish develop ulcers, beginning around the head and body where the lateral line pits normally lie. Hole-In-The-Head Disease can occur for a variety of reasons including poor water quality, inappropriate or unsuitable diet, intestinal parasitism (Spironucleus/Hexamita), suppressed immune systems or concurrent infections.

Ichthyobodo (formerly Costia)

These are flagellated protozoa that are obligate parasites of the skin and gills of freshwater fish. The organism may be free-swimming both on and around the host or attached to the host, where it feeds on the epithelial cells of the skin and gills. The free-swimming form is
kidney-shaped with two flagella and the attached form is pear or teardrop shaped and usually found in sheltered areas of the skin and gills (e.g. beneath the operculum or fins).  

**Oodinium**

This is actually a dinoflagellate algae, but I have included it under this category for simplicity because its mode of locomotion. The common disease is termed “Velvet Disease”. These organisms are parasites of the skin and gills of many species of fish, particularly goldfish, killifish, anabantoids and marine coral fish and can cause serious disease outbreaks. They produce many dinospores which must actively seek a host. The entire lifecycle takes less than 10 days. Affected fish have a yellow-grey coating to the skin and fins, which may take on the form of gold specks (due to their chlorophyll). In advanced cases the skin may peel away in strips, leaving large ulcers underneath. The fish may scrape against the rocks as a result of irritation to the skin.

**Metazoa**

**Trematodes**

**Gyrodactylus**

Viviparous, monogenetic trematodes with large haptors. Primarily found on the skin and fins of fishes. Perennial issue in goldfish and other pond fish.

**Dactylogyrus**

Oviparous, monogenetic trematodes that possess “eye-spots”. Primary site of infection is the gills of the host. In heavy infestations, they can be found on the body. Highly pathogenic in discus fish.

**Nematodes**

**Camallanus**

Large, red worms found protruding from the anus of fish. Commonly seen in livebearing fish.

**Crustacea**

**Argulus (fish lice)**

These are up to 5mm diameter, colourless parasite. Latches by suckers to skin and fins of fish. Highly irritant. Create portals of entry for secondary bacterial infection.

For specifics about treatments, consult the following texts:

THE NEED FOR RISK ASSESSMENT TO MINIMIZE THE IMPACT OF EMERGING INFECTIONS IN PROPAGATED FISH

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SF Snieszko Endowed Scholar and Professor of Aquatic Animal Medicine
College of Veterinary Medicine, Michigan State University
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With the continuous rise in the number of emerging and resurging infections in farmed and wild fish populations, natural resource managers, fishery biologists, fish farmers, and conservationists are increasingly concerned on risks diseases may pose to aquaculture profitability and fishery sustainability. In particular, it is alarming that farmed fishes and aquaculture practices may pose a health risk to free-ranging populations. This compounded by the fact that the consequences and extent of infections in wild fish populations are often difficult to measure, control, and understand. Diagnostic assays and sampling strategies developed to assess the health of fish in aquaculture may not be applicable for assessments of wild fish populations. As a result, there is an increasing need to rely upon risk analysis approaches as we develop an effective health plan at the facility, regional, national, and international levels.

An example on the proper use of risk analysis approach to limit or minimize the impact of emerging infections in propagated and wild fish populations is the viral hemorrhagic septicemia. A novel sublineage of the Viral hemorrhagic septicemia virus (designated VHSV-IVb) emerged in the Laurentian Great Lakes region of North America. In addition to the numerous large-scale mortality events of wild fish, the emergence of VHSV has resulted in a major regulatory response to protect both farm raised and wild fish populations. However, characterizing and mitigating risk factors for the continued transmission of VHSV was a difficult task. A semi-quantitative risk assessment model was utilized to focus VHSV management efforts in the Great Lakes basin. The risk of VHSV introduction into major watersheds in the basin was directly correlated to their proximity to VHSV positive water body in the basin. Although the current regulations are uniform across the Great Lakes watershed, the risk varied for specific locations within the watersheds. For example, the introduction of game fish for stock enhancement (a common fisheries management practice) is a significant factor to determine the risk of VHSV introduction into public water bodies as well as the movement of baitfish. In this analysis, aquaculture facilities with strict biosecurity programs and frequent health inspections received the lowest risk scores and were largely considered as protective or at low risk for VHSV introduction. These results suggest the current management strategy, based on political boundaries only, should be re-evaluated. The creation of a risk-based management strategy based upon identification of higher risk
watersheds and/or specific water bodies is recommended, thus allowing managers to efficiently target surveillance and response activities in infected and free zones.
Transportation is seen as one of the biggest welfare issue when it comes to fish. Much of the scientific literature reports mortalities of up to 80 or 90% in ornamental fish and up to 25% in aquaculture but this is not seen on a daily basis by those involved in aquatic veterinary medicine. Whilst 20 years ago the reported figures might have been correct, today mortalities across ornamental species match or are below those of day old chicks (i.e. <0.5%) having often been transported over larger distances, whilst in aquaculture and fisheries there is still room for improvement. Much of this improvement is down to producers learning how to transport fish since there is little point in transporting water (unless in a plastic bottle) around the world.

In working with producers, importers and transporters of fish several aspects become clear. Fish need to be prepared prior to transport, human error is the largest cause of mortalities, arrival procedures need to consider the interaction of pH, ammonia, water temperature as well as dissolved oxygen, and invariably a period of recuperation is required post movement prior to further management interventions. Whilst transportation is seen as an important issue there are more pressing welfare issues such as stocking density, nutrition and angling pressure on commercial fisheries.

Transportation is all about preparation and reception practices if one presumes that the method of transportation is appropriate. Selecting an appropriate method of transportation is dependent on distance, time, volume and ease of access. Whether there is a requirement for temperature control depends on species transported, time and distance coupled with the thermal insulation of the transporting container. There is a requirement to minimise noise, vibration and sudden movement but some vibration or movement is required to prevent the formation of a static layer of CO\textsubscript{2} at the air/oxygen/water interface. A static layer of CO\textsubscript{2} will cause suffocation of the fish even if other parameters are adequate.

The required preparation will vary between species and distance travelled but there are some generic principles that can be applied in all cases:

1. Fish should be rested and inspected for disease prior to transportation and any treatments prescribed with a further period of rest if this is the case. Therefore there is a requirement for holding facilities at the packers.

2. Food should be withheld for a minimum of 24 hours to ensure emptying of the gut. This minimises ammonia production during transport.
3. Water temperature should be decreased to $10^\circ C$ for coldwater species and $20^\circ C$ for tropical species if required. This is important to reduce ammonia toxicity see Table 1.

4. Air can be used for short journeys (<1 hour) or longer if air can be exchanged. Otherwise oxygen should be used.

5. Fresh water should be used for packing (i.e. not water that has previously contained fish.

6. The container should be made of a suitable container to transport fish (e.g. some plastics are toxic).

Reception practices depend on volume and number of fish:

1. The fish may be emptied straight in to the pond or lake either manually or through a vacuum pump. Where possible, it is better to first consider water temperature and pH (i.e. are they similar).

2. Best practice would indicate that the fish should be held in quarantine prior to mixing with current stock (good biosecurity). If held in a quarantine facility then transport water should not be added to the quarantine facility but disposed of hygienically.

3. Facility water should be slowly trickled in to the transport water over a period of time to gradually adjust temperature and pH. This is critical if there was a build-up of ammonia as sudden changes in temperature and pH can cause ammonia toxicity.

4. Somewhat counter-intuitively adding oxygen can also be damaging. The rise in pH as CO$_2$ is removed will cause an ammonia spike.

5. Dependent on species, mortalities associated with transportation stress will occur within three weeks but up to three months.

Table 1

<table>
<thead>
<tr>
<th>pH/Temp $^\circ C$</th>
<th>6</th>
<th>6.5</th>
<th>7</th>
<th>7.5</th>
<th>8</th>
<th>8.5</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>250</td>
<td>77</td>
<td>24</td>
<td>7.7</td>
<td>2.4</td>
<td>0.78</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>154</td>
<td>50</td>
<td>16</td>
<td>5</td>
<td>1.6</td>
<td>0.52</td>
<td>0.07</td>
</tr>
<tr>
<td>10</td>
<td>105</td>
<td>34</td>
<td>11</td>
<td>3.4</td>
<td>1.1</td>
<td>0.36</td>
<td>0.05</td>
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<tr>
<td>15</td>
<td>74</td>
<td>23</td>
<td>7.5</td>
<td>2.3</td>
<td>0.75</td>
<td>0.25</td>
<td>0.04</td>
</tr>
<tr>
<td>20</td>
<td>50</td>
<td>16</td>
<td>5</td>
<td>1.6</td>
<td>0.52</td>
<td>0.18</td>
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<tr>
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<td>11</td>
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<td>0.37</td>
<td>0.13</td>
<td>0.03</td>
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<tr>
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<td>8</td>
<td>2.5</td>
<td>0.8</td>
<td>0.27</td>
<td>0.1</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Levels of total ammonia (mg/l or ppm) that maintain free ammonia at or below 0.02mg/l (ppm) at a range of pH and temperatures

Of greater welfare concern in commercial fisheries is often a lack of biosecurity procedures and/or a quarantine facility. Thus disease is easily introduced and is well illustrated by the spread of exotic pathogens. Whilst the industry is aware of this issue, certainly within the UK, there has been little improvement over the past decade. Indeed the need to satisfy the
desire of the average angler to either catch large numbers or weight of fish has probably seen a decrease in welfare in the last decade:

1. Increased stocking density, reported to have increased by up to seven times.
2. Increased hook damage through angling pressure.
3. Fisheries reliance on angling bait (boillies) to provide nutrition for stock.
4. This reliance means fish often starve over-winter as anglers are few.
5. Stocking densities remove the natural foods.
6. Starvation encourages fish to take bait or hooks increasing damage to mouth.
7. Boillies rarely provide good nutrition. The current fashion of using salt for boillies, may affect water quality and fish health through the quantities used particularly at popular venues.

There is little research or public concern over welfare in fisheries probably due to “out of sight, out of mind”. However those veterinarians working in the area are becoming increasingly concerned not only as a welfare disaster waiting to happen but in some fisheries it already has.
EUROPEAN AND NON-EUROPEAN SEAFOOD SAFETY PROGRAMMES

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This presentation shall focus on national and international seafood safety programmes which are currently being implemented in animal aquaculture-based food production within Europe and abroad, with an emphasis on the existing differences between the national legislations and practices involving seafood safety, and on their current economic impact over the domestic and export markets, as well as on the global aquaculture.

1. Seafood, a worldwide food commodity

Aquaculture defines the cultivation of fish, shellfish and seaweeds, within both sea and freshwater environments. This activity takes place all over the EU and the European Economic Area Member States. Due to the developments in science and technology, within the last six decades, aquaculture has become a major contributing sector to food supply worldwide. In Europe, it is currently providing 2.6 million tons of product annually, valued at 7 billion Euro. According to the Strategic Research and Innovation Agenda of the European Aquaculture Technology and Innovation Platform, by 2030, the European aquaculture might be able to provide annually 4.5 million tons of seafood, worthing 14 billion euro. This target is attainable through a constant growth of the industry, of 3.1% per year. Among other benefits, this growth would bring along more than 150,000 direct jobs, and would consolidate the role and importance of aquaculture in society.

The market of seafood products is a globalised market. Although in the past European fisheries and aquaculture production used to cover 60% of the consumption requirements of the Europeans, 65% of seafood consumed today in Europe is imported from other continents. However, this declining trend in the long-term growth rate of aquaculture production is global. Massive stock losses caused by uncontrollable disease outbreaks, improper management of aquatic animal stocks and a lack of consumer confidence in marketed fish and seafood products, are among the factors claimed to have caused the aquaculture sector to decrease. While fish supply has stagnated over the last years, the demand for fish and fish products continues to rise; since 1973, consumption has more than doubled. One of the core functions of aquaculture is to provide the consumer best quality, diversified and safe seafood.

2. Fish and seafood-borne disease outbreaks and illnesses

Seafood-borne diseases and illnesses affect consumers and create regulatory issues for both the importing and exporting states/regions. In order to prevent such instances, like any other food product, seafood must be safe. Safe seafood refers to the risk level associated with
illnessess or deaths caused by the consumption of a seafood product which is contaminated with biological, physical or/and chemical offensive agents.

There are a number of national and international agencies, i.e. the OIE, the EU Rapid Alert System for food, the Centers for Disease Control Food-borne Disease Outbreak Surveillance Programme of the Food and Drug Administration (U.S.) etc., actively involved with the collection and recording of reliable sets of data on seafood-borne illnesses and disease outbreaks. Among the most frequent causative factors of fish and seafood-borne disease outbreaks, there have been mentioned\textsuperscript{3,4}: paralytic shellfish poisoning, *Vibrio cholerae*, *V. parahaemolyticus*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Clostridium bifermentans*, toxic strains of *Escherichia coli*, Shigella spp, Salmonella spp and *Bacillus cereus*, as well as chemical substances and naturally occurring poisons like scombrotoxin (histamine). Among the physical hazards, fish bones and in-canned products, metal or glass pieces seems to occur most frequently.

Responsibility for safe and healthy food should be on each stage of the food chain, i.e. production, processing, trade and consumption. By the adoption of sound practices along the food chain based on the principles of good aquaculture practices and in-plant control of food processing based on hazard analysis and critical control point analysis (HACCP), hazards can be prevented from entering the system, ensuring healthy food for the consumer.

3. Current programmes relevant to aquaculture products (excluding aquatic plants)

Seafood safety is one of the implicit characteristics that consumers have to rely on the seafood producers to be provided with, through product certification. With reliable certification systems in place, buyers are assured of the product safety, as this involves inspection and surveillance-based activities across the production chain, so that the safety of end products to be attained. To ensure food safety function beyond national borders, reliable certification systems are necessary. A range of related standards and public regulatory frameworks have been introduced by the private sector and non-governmental organisations (NGOs), to certify safety of fish, seafood and related products which are traded on international markets. Assurance that a product conforms to specified international requirements is provided through certification by the producing company, the industry or trade association and by accredited external certification independent bodies (ISO Guide 2, 2004)\textsuperscript{3}. Currently, the stakeholders involved with establishing and application of standards, technical regulations and certification schemes, are government institutions, retailers and processors, associations of producers, retail firms and independent NGOs, e.g. World Organisation for Animal Health, Codex Alimentarius, Global Aquaculture Alliance and Aquaculture Certification Council, Federation of European Aquaculture Producers, International Organisation for Standardization, etc.

There are actually major issues associated with the development of standards and certification in aquaculture. The impact of standards is claimed not to be uniform across the markets or type of products. Likewise, by adopting private standards and requiring their suppliers to be certified, retailers can protect their reputation and their business, but the overall impact of these standards in aquaculture and the way they affect certain stakeholders remains a matter
of concern. However, overall, ensuring the safety of aquaculture products remains one of the
golden rules in supporting the aquaculture growth, as it would improve public perception and
would wipe out consumer concerns with respect to what they actually buy from the market.

Acknowledgments: A. David Scarfe, PhD, DVM, MRSSAf, Assistant Director, Scientific
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Fish and fish products represent a very important source of nutrients: proteins rich in essential amino acids, lipids containing polyunsaturated fatty acids in majority, all the minerals and necessary vitamins for the human metabolic processes. Through the high degree of digestibility and the superior biological value, the aquatic products present and increasing point of interest on the food market and in the diets of humans worldwide. The more and more accelerated rhythm of development for aquaculture and fish processing industry requires a reliable knowledge and the implementation of adequate systems for raw materials and finished products safety assurance, as well as for aquatic products safety.

Fish and fishery products are rarely involved in food-borne outbreaks in comparison to other food products of animal origin, having at the same time a high microbiological load in several species such as *Vibrio* spp., and different parasites (*Diphyllobothrium* or *Anisakis*), as well as different specific toxins (ichthyotoxins).

The evaluation and quality assurance and safety systems should focus firstly on raw materials (the aquatic environment where fishing takes place), the periodical evaluation of the plankton, the evaluation of aquatic species at inferior trophic levels, and the random evaluation of aquatic species from superior trophic levels. By comparison to other animal food products, where processing affects the biological and trophic quality (protein denaturation, the saturation of several polyunsaturated fatty acids, the metabolic blockage of several minerals, the advanced destruction of several important vitamins, especially vitamin C and B complex), the aquatic products do not undergo any thermal or irradiation treatments so profoundly. Through their preservation, it is thus possible that the availability of different nutritive substances within the diet to be maintained. The hygienic quality and the innocuity of aquatic products is, though, the most important part, with different aspects, from chemical environmental pollution to the more accentuated development of the biological factors (especially bacterial and parasitic agents) that can be transmitted to consumers.

**Sanitary requirements considering the good hygiene practices and good management practices for fish and fish products**

**Unloading operations:** i. equipment easy to clean and disinfect; ii. equipment maintained in good and clean status; iii. the products contamination is avoided during operations; iv. operations are quickly performed; v. operations will not cause any damages to the products; vi. the products are placed immediately in a protected environment; vii. the products are maintained at an adequate temperature, close to ice melting values.
In order to prevent the contamination of fishery products and to ensure that they are manipulated in a manner that does not affect their quality and safety, they must be protected against contamination and deposited in adequate conditions of preservation. References: Regulation EC 853/2004, Annex III, section VIII, chapter II (1).

**Sanitary requirements for the fish and fish products retail, auction fish and fish products**

**Specific requirements:** i. The retained fishing products are kept in adequate and safe areas (locked); ii. The spaces used for the products storage that are declared as improper for consumption are separated from spaces having a different use; iii. If necessary, there has to exist an adequate space, properly equipped; iv. The spaces should not be used for other purposes during the storage or exhibition of fishery products; v. It is not allowed the access of vehicles that eject vent gases; vi. The personnel with access to the unit must not let animals enter the area; vii. The spaces should be equipped for good lightning in order to facilitate official control. The spaces and the equipment should be built so as to avoid contamination.

References: Regulation EC 853/2004, annex III, section VIII, chapter II (2).

The requirements concerning terrestrial units for fish and fishery products are also applicable through Regulation EC 178/2002 (requirements and general principles), Regulation EC 1774/2002 (Requirements concerning animal by-products not destined to human consumption), Regulation 852/2004, annex II (general requirements for hygiene in primary production).

References: Regulation EC 853/2004, annex III, section VIII, chapter III-VIII (specific requirements of hygiene considering fishing products) III- requirements for products and parasites; IV – requirements for processed fishing products; V – sanitary standards for fishing products (organoleptic properties, histamine, total volatile nitrogen, toxic fish species); VI – packing of fishing products; VII – fishing products storage; VIII – fishing products transportation.

**The compliance of sanitary conditions in aquaculture units of exploitation** - The control for compliance of sanitary and veterinary registration and authorization according to the requirements of the Order of The National Sanitary-Veterinary and Food Safety Authority no. 16/2010 for the approval of the Sanitary-Veterinary Guideline for the sanitary-veterinary registration/authorization of units/centers of collection/exploitation of origin and of transportation equipments from the health and animal welfare domain, for the units involved with the storage and neutralization of by-products not destined for human consumption and for the processed products. This regulates the following aspects: 1. The activity of the facility: the breeding system, water source, fish and other animal species used for aquaculture, the type of feed/food, the source of the food, the source for the veterinary drugs, the incubator/the source of biological material, the responsibility for the products retail, the production capacity and the production/year; 2. The surroundings, placement and buildings;

**Sanitary-veterinary conditions – fresh products, premises for fish processing, fish collection centers**

This section provides rules for the activity within the unit (number of employees, type of raw materials, source of raw materials (capture fisheries/fish farms), etc) as well as elements to check for (surroundings and buildings, requirements in areas where food products are manipulated – all facilities, aim and control of specific criteria of the process, sanitary standards applied on fish products, HACCP plan evaluation etc.).

The implementation of management systems that endorse the quality control and the safety of aquatic products destined to human consumption should take into account at least the four mentioned points mentioned and presented before, this way assuring adequate raw materials (irrespective of the origin and the exploitation method – direct fishing or aquaculture), transport – storage – adequate processing (that would not affect the trophic and biological quality and that would comply with the provisions for hygienic quality), in the end obtaining and selling products that would not constitute themselves hazardous for the consumer.
Biosecurity can be defined as Biological Risk Management or the control, prevention and possible eradication of infectious or contagious diseases. Whilst few would disagree that biosecurity is a necessity to minimise disease incursions and/or loss of production, in terms of implementation and compliance there is still much room for improvement. It is frequently neglected even when appropriate procedures are in place unless there has been a recent disease incursion or production loss. Biosecurity is often at its highest after a disease event occurs which is somewhat pointless. The aim should be to put biosecurity practices in place prior to a disease outbreak so as to minimise spread and losses. So how do you ensure a client implements biosecurity and then carries it out?

The first step is to demonstrate that biosecurity is essential. The following three equations are useful in providing evidence of this. However since equations are often frightening and confusing it is best to provide this evidence in a graphical form where possible. Studies have shown that conveying information visually is up to six times more effective.

The probability (P) of purchasing at least one infected animal from a population is given by the formula:  
$$P(\geq 1 \text{ infected}) = 1-(1-p)^n$$

Where $p$ is disease prevalence and $n$ is the number of animals purchased.

![Graph showing the probability of purchasing an infected animal](image)

Graphing the results, given the likely number of animals purchased clearly demonstrates a high probability of purchasing an infected animal.
The probability that a supplier at level \( n \) in the supply chain will be free of infection is given by the formula: \( P_n = (P_{n-1} + X(1 - P_{n-1}))^S \)

Where \( X \) is the effectiveness of screening (e.g. testing or quarantine) and \( S \) is the number of suppliers used from the level below.

Estimating the probability of at least one (disease) event in an interval (of time):

\[ P(x \geq 1) = 1 - \exp\left(-\frac{t}{\beta}\right) \]  

(this formula uses the \( \exp() \) function in Microsoft Excel) where \( t \) is the interval of time and \( \beta \) is the mean interval between events.

Setting up an Excel spreadsheet using this formula and using a program such as Palisade’s @Risk looks even more daunting.

When we run @Risk and output the results to a graph, this becomes much more meaningful. We can clearly see that the likelihood of a disease outbreak within the next six months is less
than 20% which is roughly what we might expect. However, there is a very small possibility that we could have four outbreaks. If this was to occur this would obviously be catastrophic.

Whilst the above formulae and graphics can assist in demonstrating why the client requires a biosecurity plan the second step is to ensure compliance. Compliance can be achieved by demonstrating the economic benefit (input< output), training to ensure staff know and understand a procedure, education so staff understand disease processes, causes and consequences, and responsibility – the greater the stake, the better compliance is. If this information is tailored to local conditions and provided by a trusted source (i.e. the clients veterinarian) then compliance is better assured.

The rest of the presentation looks at how to maximise information whilst minimising disease testing, some basic economic principles such as opportunity costs, rational choices and discounting and how to present the information using partial budgeting, decision trees and Cash Benefit Analysis.
The explosive expansion in global aquaculture and the emergence of deadly diseases of aquatic organisms have created a need to train veterinarians in the field of aquatic animal medicine. For this reason, the Aquatic Animal Health Laboratory in the College of Veterinary Medicine at Michigan State University, together with the Multistate Conservation Grant Program, initiated web-based training modules for aquatic veterinary medicine entitled *Formulating a Vision for Fish Health Management in Fishery Conservation: Bridging Knowledge Gaps*. The aim of this training is to provide veterinarians with the essential information on diseases of aquatic animals, and the biology of their causative agents, modes of transmission, reservoirs, or vectors. These emerging and endemic fish disease issues have presented growing challenges to managers of fisheries and conservation programs. Through exercises based on real cases, veterinarians practice how to develop control strategies that prevent the spread of these infections and minimize their impacts on fishery conservation programs.

The online course is designed with a multi-tiered approach covering concepts and educational material to benefit both beginner and advanced participants. It is the experience of the instructional team that trainees in fish health acquire information better when they are allowed guided access to instructional material, and since learning is an active process, interactive instructional materials prove effective for understanding complicated concepts and terms (Ernst and Colthorpe 2007). To keep pace in a profession where new knowledge is ever expanding, a combination of traditional lecturing methods, computer-based material, videography, teleconferencing, and teleconsultation was interwoven harmoniously to provide trainees with the information they need in a manner that they can follow, assimilate, memorize, and apply to their own situations. In other health-related fields, these methods have proven to be cost-effective, reliable ways of delivering important information (Verhoeven et al. 2007), and with the advancements in computer and internet technology, the costs of interactive web-based learning are now low enough that larger audiences can be reached effectively with the latest knowledge in aquatic medicine, allowing for better trained aquatic health specialists and technicians.

Prior to beginning the online course, criteria for selecting suitable participants was established to include persons working in aquaculture or fishery conservation programs at the technician level or above, such as biologists, managers or veterinarians. The initial participants were selected from the US states and territories, with the approval of the natural
resources agencies that are members of the Multistate Conservation Grant Program. Along with this approval, each participant also met the technical requirements of having a capable computer and internet connection to access the course website and view the online video lectures and participate in the interactive discussions and quizzes.

The website is database driven with each page being dynamically generated with each visit, allowing for new and updated content to be continuously added. All video content is presented using Microsoft’s Silverlight technology, providing the newest video compression methods and delivery. Upon meeting the requirements and being accepted into the training course, participants are directed to the website for registration (Fig. 1) and to take the evaluation test. After registration, participants were granted access to the timed evaluation test, which is taken on the website. With the completion of the test, participants are then granted access to the lectures of Tier I where they can work at their own pace. Within each tier, participants can download lecture handouts, view the video lectures, and take part in forum discussions after each lecture, sharing valuable information with each other.

![Figure 1 Website registration](image)

Tier I is presented as three modules with periodic quizzes provided to assist the participants in self-evaluation of their individual progress (Fig. 2). Module I provides information on topics such as fish & shellfish anatomy and physiology, fish feeding and diet formulation, fish immune system and invertebrate host defense mechanisms, environmental factors of importance to fish health, water quality, principles of fish diseases and causation, introduction to biology of major pathogens, and pollution. The topics in Module II build on the knowledge gained during Module I, covering diseases of fish, mollusks, and crustaceans, principles of disease diagnosis, and clinical and laboratory examination of fish and shellfish diseases. When participants reach Module III of Tier I, they are presented with topics covering biosecurity, disinfection, prophylaxis, and disease control.
Figure 1. Links to individual lectures within Tier I

Tier I provides a solid base on which participants will build during the more advanced topics of Tier II, such as developing a health plan and the role of state agencies and the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Agency (APHIS) in safeguarding fish and shellfish stocks against endemic and emerging diseases and pathogens. Other topics in Tier II include diseases as a threat for fishery conservation and assessing the risk of disease and the impact on fishery conservation. Specific examples of case studies and the administration of fish and shellfish medicine are also covered in Tier II. The lectures in Tier II include Q&A sessions with a panel of leading fish health professionals, experts, and representatives of regulatory agencies, along with the instructors.

Tier III is a web-based community designed for biologists, managers, fish health professionals, and others who have successfully completed Tiers I & II. The developed website contains the close examination of case studies with use of a step by step Emerging Infection Response and a Fish Disease Key for diagnostic identification. Through the interactive website, participants collaborate with national and international experts in fish health and disease management in adopting a fish health plan to address the specific disease issues of concern and those they are encountering at their own facilities. This program will result in the creation of a network of employees in each region with a strong background in fish disease, who are in contact with experts, and are familiar with developing health plans, risk assessment, responding to emerging disease issues, and most importantly, know how to inquire about a disease problem. This quality of technicians and biologists does not currently exist in most of the 50 states.
With the completion of each tier, participants are given a final test and receive a certificate of completion and with a passing grade and a certificate of course credit. Satisfactory completion of a tier opens up access to the following tier for the participant.

After completion of the online training course, all continually updated course lectures and materials will continue to be available to the participants as a reference. The interactive community remains available, keeping participants updated and involved through collaboration with others in the field, resulting in a better understanding of aquatic diseases and pathogens, providing a stronger knowledge base for the development of health plans, and enabling better treatment, earlier detection, and limiting the spread of aquatic disease and pathogens.

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