Ecosystem Health and Sustainable Agriculture

Ecology and Animal Health

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Introduction

Fish has an enormous value as the most frequent source of animal protein for the major part of the humans, especially in countries during rapid development in Asia and Africa. All fish species are a part of the local ecology and as such has a biological and environmental importance.

Fishing also gives a great pleasure to sport fishermen around the world and at the same time contributes to the local economy. In spite of this fish receive very little attention in consideration to diseases and health protection especially in regard to feral populations. These populations are often very vulnerable and to promote sustainability it is of outmost importance to take active actions and promote international regulations for restrictions of fisheries. Fish is a difficult group to handle regarding welfare, diseases and health protection. The reasons for this are several but the most important are:

- Fish lives in water – and water is an excellent medium to transfer pathogens from one area to another, which contributes to a fast and uncontrolled transmission of infectious diseases.
- It is often difficult to recognise clinical signs of disease in fish since they live in water. Fish also lack mimic, voice or recognizable body language, which gives a late discovery of the disease and restrain a fast starting up of the treatment.
- Vertically transferred diseases have been described in all vertebrate classes, which mean that the offspring from infected females are born with the pathogen in their bodies. The fecundity in fish is high compared to other classes of vertebrates, leading to that a single infected female may deliver several thousands of infected of eggs.
- Feral fish lives in the vicinity to farmed fish. Consequently, it is unavoidable that the two groups share infectious agents with each other. Farmed fish are often kept during extreme conditions with high population densities, and a not completely optimized environment. This is a situation which promote options for pathogens to infect farmed fish which thereby can constitute a reservoir for further spreading of diseases.
- Fish are as other animals biological packages, which means that they share habitat with other organisms (Figure. 8.1).
- A feral fish population is in practice impossible to treat for diseases without very significant negative impact on the environment.
Infectious Diseases

Viral Diseases

Infectious Pancreatic Necrosis (IPN)
IPN is one of the most important virus diseases in aquaculture. IPN is caused by a birnavirus. The clinical symptoms may vary depending on the species infected and the serotype of the virus. IPN is primarily of great concern in juvenile rainbow trout (*Oncorhynchus mykiss*). Infected individuals show abnormal behaviour and abnormalities such as a swollen abdomen, exophthalmia (protruding eyes) and dark pigmentation of the skin. Pathological findings include inflammation and necrosis of the pancreas and intestines with bleedings (Figure 8.2).

Viral Hemorrhagic Septicaemia (VHS)
VHS is caused by a rhabdovirus. The virus can be carried by both fresh water and marine fish species. VHS causes problems mainly in rainbow trout aquaculture but also affect feral fish and can cause mass mortality in herring (*Clupea harengus*). The virus is considered a serious threat to the fish populations in the Great lakes, USA/Canada, due to the high mortalities and that it strikes so many different species. The clinical symptoms of VHS varies considerably. Pathological findings include haemorrhages in muscles (Figure 8.3).

Infectious Haematopoietic Necrosis (IHN)
IHN is caused by a rhabdovirus and is a highly infectious disease affecting cultured salmonids. Disease usually occurs at water temperatures between 4°C and 18 °C. Young fish up to 1 year are most susceptible to overt infection often with high mortalities. The virus occurs and cause disease in fish populations in several countries within EU. Transmission can be both vertical and horizontal.

Spring Viremia of Carp (SVC)
SVC is caused by a rhabdovirus. It originates from carp in Asia but has been spread (partly by goldfish) to Europe, and constitute a problem for farmers of carp in the central Europe but also for fresh water cyprinids in infected areas.

Lymphocystis
Lymphocystis, caused by an iridovirus is a widespread disease revealed in more than 140 marine and freshwater
fish species. The disease is characterized by occurrence of tumour-like clusters of relatively hard nodules up to 2 mm in diameter of white, cream, gray or brownish colour localized mainly on the body surface of affected fish including fins (Figure 8.4). Occasionally, lymphocystis nodules also can occur on gills and internal organs. In marine areas the various flatfish species has been reported as mainly affected by disease. In the Baltic Sea lymphocystis has been revealed in dab (*Limanda limanda*), flounder (*Platichthys flesus*) and plaice (*Pleuronectis platessa*).

**Bacterial Diseases**

**Bacterial Kidney Disease (BKD)**

The disease is caused by the intracellular bacterium, *Renibacterium salmoninarum*, a gram-positive, non-sporulating, non-variable, coccoid rods. The bacterium is transferable to all salmonids, including whitefish (*Coregonidae*) and has also been demonstrated in non-salmonids such as stickleback (*Gasterosteiformes*). Arctic char (*Salvelinus alpinus*) and salmon (*Salmo salar*) seems to be more sensitive to the disease than other salmonids. Rainbow trout (*Oncorhynchus mykiss*) seems to be more resistant to the disease, often with no visible symptoms. The disease occurs in most European countries as well as in Canada and the USA. The disease is both horizontally and vertically transmissible. The horizontal transmission is probably the most important factor in the eradication program for the disease. As the disease can exist in a very low prevalence in adult fish and be transferred to a few offsprings it can be very difficult to detect the disease in the fish farms. BKD causes granulomatous changes with nodular changes in the kidney but also liver, spleen and heart can be affected (Figures 8.5 and 8.6).

**Furunculosis**

The disease is caused by the gram-negative bacteria, *Aeromonas salmonicida* subsp. *Salmonicida* and occurs both in both fresh- and seawater. The disease has been widely distributed geographically and occurs throughout Europe. The bacterium causes disease in all salmonids, but has also been isolated from other species. The rainbow trout is less susceptible to the disease and can therefore act as sub-clinical carriers, which may also be the case with a number of non-salmonid fish species. It is only transmitted horizontally and a vaccine with good effect is available.
Acute outbreaks can be treated with antibiotics. Clinical manifestations depend on age and species affected.

**Enteric Redmouth Disease (ERM)**
ERM is caused by *Yersinia ruckeri*, a gram-negative bacterium, which exists in several serotypes and can cause disease in several fish species, including non-salmonids. The disease is only horizontally transmitted. The bacterium is a major health problem for rainbow trout in European aquaculture and gives rise to significant economic losses in terms of increased mortality and discarded products. A well-functioning vaccine is available and acute disease can be treated with antibiotics.

**Flavobacteriosis**
*Flavobacterium* spp are gram-negative, filamentous, yellow-pigmented bacteria. Some of the most important pathogens causing great economical losses in aquaculture all over the world are *Flavobacterium psychrophilum* and *Flavobacterium columnare*. Establishment of infections caused by *F. columnare* and *F. psychrophilum* are highly dependent on environmental factors such as water temperature, water quality, stocking densities and handling of the fish (Wakabayashi, 1991; Holt et al., 1993).

*Flavobacterium psychrophilum* causes rainbow trout syndrome (RTFS) and bacterial cold water disease (BCWD). The bacterium is psychrophilic and causes disease at water temperatures below 15°C. Problems are mainly seen in salmonids but probably all freshwater species in cold water are susceptible. The severity and signs of disease depends on the age or size of the fish. Young life stages are the most seriously affected with a systemic disease, sometimes with external lesions. At later life-stages ulcerations of the skin are the most common sign of disease. Ulcerations often occur on the peduncle but other locations of the body i.e. anterior to the dorsal fin, at the anus or on the lower jaw are also common. The bacterium is horizontally transmitted but the definite routes of infection are not yet fully elucidated. *F. psychrophilum* has also been isolated from both male and female sexual products indicating a vertical transmission from brood fish to the offspring (Ekman et al., 1999). However, if a true vertical transmission actually is present is debated. Fish suffering from *F. psychrophilum* infection are often treated with antibiotics. Bath-treatments with anti-bacterial chemicals are sometimes used to treat mild outbreaks of disease with primarily external lesions. No commercial vaccine is available. (Figure 8.7)

*Flavobacterium columnare* causes columnaris disease characterized by skin lesions, fin erosions and gill necrosis (Figure 8.8). Both wild and farmed freshwater fish are susceptible to the bacterium. Columnaris disease is a problem in salmonid aquaculture worldwide and also causes great economics losses in the channel catfish industry in the US (Pulkkinen et al., 2010). Disease usually occurs at high water temperature, above 20°C. The bacterium is horizontally transmitted. Diseased fish can be treated with antibiotics or bath-treatments with anti-bacterial chemicals. A commercial modified live columnaris immersion vaccine is licensed for use in catfish in the US.

**Vibrios**
These gram-negative bacteria are curved rods motile by flagellae. Several species of Vibrio can cause disease in
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fish both in marine and brackish waters. *Vibrio anguillarum*, today renamed to *Listonella anguillarum* is the cause of vibriosis affecting both farmed and feral species including eel (*Anguilla anguilla*), salmonids, turbot (*Scophthalmus maximus*) and cod (*Gadus morhua*). Disease occurs especially when the fish are stressed due to high water temperatures, poor water quality or high stocking densities etc. *Alivibrio salmonicida* (formerly *Vibrio salmonicida*) is the aetiologic agent of cold water vibriosis (Hitra disease) and causes problems mainly in farmed Atlantic salmon in Norway. Vaccines are available to both vibriosis and cold water vibriosis.

**Parasites**

Parasites are important components of any ecosystem, which not only play key roles in fish population dynamics and community structure, but also can provide important information on environmental stress, food web structure and function and biodiversity. Numerous studies demonstrated effects of anthropogenic-induced environmental perturbations on parasitic organisms at both the population and community levels. In general, responses of hosts and communities depend very much on the type and intensity of the stressor, the parasite life cycle and duration of exposure.

Examples of common protozoan parasites are *Trichophyra* spp. (Figure 8.9), *Ichtyobodo* spp. (Figure 8.10) and *Trichodina* spp. (Figure 8.11). These *ektoparasites* are often found in large number on gills and skin and may cause high mortality.

*Anisakis simplex* (Nematoda) is a zoonotic parasite which can infect humans. *A. simplex* infect a large number of fish species, i.e. Baltic herring and cod. The mean annual prevalence trend for infection of Baltic herring with larvae of *A. simplex* in the Russian EEZ of the Baltic Sea (26 ICES sub-division) are decreasing between 1997-2008 (Figure. 8.12)

*Anquillicola* spp (Nematoda) is found in the swimbladder of eel. The parasite has spread from eel farms in southern Europe to the Baltic sea where is first was found 1987.
Cryptocotyle spp. (Trematoda) infect species such as in dab, flounder and cod.

Lepeophtheirus pectoralis (Crustacea) – in dab and Lernaeocera branchialis (Crustacea) – in cod (Lang and Rodjuk, 2006).

In connection with aquaculture the role of parasites is fairly known, but when it comes to wild fish and new species for farming the knowledge is limited. It is known that ornamental fish, now frequently imported from Asia and EU for garden ponds, can carry exotic parasites, for example Atractylotocestus huronensis, Bothriocephalus acheilognathi and Monobothrium wageneri, which can cause disease problems in native species. Some parasites will be favoured due to the climatological change – for example the agent that causes whirling disease in salmonids Myxobolus cerebralis. Also a myxozoan parasite of salmonid fishes, Tetracapsuloides bryosalmonae, which causes proliferative kidney disease (PKD), one of the most serious parasitic diseases of salmonid populations in Europe and North America. T. bryosalmonae is favoured by high water temperature.

Miscellaneous Diseases

Skin Ulcer Disease
Skin ulceration is commonly seen in numerous marine and freshwater wild fishes as well as in farmed fish. The skin ulcers can be from small to large and of irregular shape, and usually appear as shallow lesions. They are often spherical with red necrotic centers surrounded by a thickened rim of epidermis and white peripheries. Sometimes lesions can penetrate deeply into the muscle and reach several cm in diameter (Bucke et al., 1983, Wiklund, 1994). The etiology of skin ulcer disease has not been thoroughly examined. In scientific literature the ulcer lesions are connected with various infectious agents (viruses, bacteria and parasites), dinoflagellate toxins, immunological, nutritional and metabolic perturbations in fish (Sinderman, 1979, 1996). This disease is associated with water salinity, temperature variations, skin injuries and pollution (Wiklund, 1994). Therefore the etiology of ulcer disease is suggested to be complex and multifactorial (Vethaak, 1992). In the Baltic Sea, skin ulcers (Figure 8.13) have been described in herring, sprat, cod, eelpout, four-bearded rockling, smelt, turbot, flounder and plaice.

Fin Rot Erosion
Fin rot is a disease, which is mostly observed in aquaculture, but can also occur in natural populations. This disease is characterized by a progressive necrosis of the anal and dorsal fins, and less frequently, caudal fins. The first signs of the disease are milky white areas appearing on the fish fins, particularly around the edges. The fins begin to fray and get ragged, becoming shorter in some time. Usually the edges look white, and may give rise to a fuzzy growth due to the secondary infection. Slowly the lesion becomes red and inflamed, bloody patches appear and fin is eaten away. Fin rot starts at the edge of the fins,
and destroys more and more tissue until it reaches the fin base. If it reaches the fin base, the fish will never be able to regenerate the lost tissue. At this stage, the disease may attack the fish body. **Secondary infections are common at** the advanced stage of fin rot, bringing new symptoms to the afflicted fish such as white cotton-wool-like tufts or streaked red patches. **Fin rot can be the result of a bacterial** or fungal infection. Sometimes, both types of infection are seen together. Fin rot disease is commonly associated with bad water conditions, injuries, poor diet, or as a secondary infection in a fish which is already stressed by other disease. In the Baltic Sea, fin rot erosions have been described in many species such as dab, flounder and cod.

**Skeletal Deformities**

Skeletal deformities have been found in a numerous fish species. The following types of deformities occasionally occur in fish populations: “pug-head” (Figure 8.14), scoliosis, lordosis, kyphosis, (Figure 8.15), dwarfish, deformations of jaw and gill-cover shortening etc. The background to these types of malformations is often unknown but potential causes are for example pollutants, nutritional. In general, skeletal deformities constitute a “grey area” of understanding and in those cases a genetic aetiology is often proposed. In the Baltic Sea the skeletal deformities have been reported in many species such as herring, pike, perch, sprat, fourhorn sculpin, cod and flounder.

**Skin Tumours**

Skin tumours of fish are easily recognizable lesions, some of which have been known for centuries (Figures 8.16 and 8.17) Tumours are widely reported in different fish species including the Baltic ones. The term “a tumour” is defined as an abnormal mass of tissue which can grow independently and uncoordinated from normal tissue. A benign tumor do not spread to other organs or infiltrate adjacent structures and is often within its own capsule. A malign tumor has the ability to spread to different organs and infiltrates surrounding tissues. Skin tumours are classified on the histological basis according to the origin of the proliferating cells and their degree of malignancy. Among the naturally occurring fish tumours, benign epidermal hyperplasias and papillomas are the most frequently observed. The causes of fish tumours formation...
vary. In more than half of all causes examined by electron microscopy and virological methods, virus or virus-like particles were found in tumour tissues. So far, oncogenicity has been clearly demonstrated only for herpes viruses isolated from benign tumours. Several studies suggest that toxic chemicals present in sediments and tumours observed in certain fish species may be related (Kinne, 1984; Möller and Anders, 1986; Maccubbin and Ersing, 1991; Anders and Yoshimizu, 1994). Nowadays the aetiology of fish tumours is proposed to be multifactorial. Skin tumors have been reported in dab, eel and smelt in the Baltic Sea (Lang, 2002).

Liver Tumors
The hepatic tumours are recognized to be in close connection to marine pollution. Therefore, they are common in bottom feeders, including 13 flounder species. An increased prevalence of liver tumours and preneoplastic lesions in marine flatfish species is considered as an indicator of biological effects of carcinogenic environmental contaminants (e.g. chlorinated biphenyls, polycyclic aromatic hydrocarbons). Nodular lesions are situated on the surface of liver and look lighter or darker in colour than the surrounding liver tissue with well-defined margins. The benign hepatomas occur more frequently in fish. Hepatic tumours in Baltic Sea have been reported in flounder and dab.

Kidney
Nephrocalcinosis is a condition when high levels of carbon dioxide results in deposition of calcium carbonate within the kidney tubules. Nephrocalcinosis which results in extensive kidney damage is irreversible (Figure 8.18)

Reproductive Disorders
Disruption of the endocrine system has been shown to occur in wild fish populations across the globe and affect fish during the last 25 years (Jobling and Tyler, 2003). Effects range from subtle changes in the physiology and sexual behaviour of fish to permanently altered sexual differentiation, impairment of gonad development and altered fertility. The intersex condition is defined as simultaneous presence of female gametes within the testis tissue which contained predominantly normal male gametes at late stages of spermatogenesis. Specimens with

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*Figure 8.16. Skin tumour in a pike. Photo: Bengt Ekberg/SVA.*

*Figure 8.17. Pike (Esax lucius) with a tumour in the abdomen. Photo: Bengt Ekberg/SVA.*

*Figure 8.18. Renal calcification (nephrocalcinosis) in the rear part of the kidney in rainbow trout (Oncorhynchus mykiss). The disorder is caused by an excess of carbon dioxide in the water. Photo: Bengt Ekberg/SVA.*
a severe form of intersexuality exhibited large strands of oocytes in the testicular lobules (Matthiessen, 2003). These reproductive disorders may be induced by wide variety of adverse environmental conditions, including sub-optimal temperatures, restricted food supply, low pH, environmental pollutants, and parasites. Furthermore, it is possible that all these factors can act simultaneously. The gonad alterations like intersex and atresia seem to be suitable biomarkers to detect the effect of reprotoxic stressors in the water environment. In the Baltic Sea reproductive disorders are found in eelpout, stickleback and perch (Gercken and Sordyl, 2002).

**Intersex**
Fish living in the vicinity of for instance sewage treatment works and industrial point sources may be exposed to substances resembling endogenous hormones, i.e., Endocrine Disrupting Chemicals (EDCs), such as alkyl phenols, phthalates and synthetic estrogens. In the 1980s anglers in the UK reported intersex roach in sewage effluent lagoons. Elevated incidence of intersex in roach and many other fish species has been shown to be widespread all over Europe. Several field studies throughout the world have confirmed that fish exposed to EDCs are displaying intersex (Figures 8.19, 8.20), altered spermatogenesis and decreased reproduction success. Even though field observations have contributed to disclose the risk of exposure for instance in the vicinity of industries and sewage treatment works, there are still very large gaps of information regarding the effects of EDCs on reproductive fitness and population dynamics.

**The M74 Syndrome**
The most serious threat towards the Baltic salmon has been abnormal yolk-sac fry mortality. This diseases is designated M74 and was first observed in the early 1970s. The incidence of M74 have varied and the situation was extremely serious during the 1990s when extremely high mortality was recorded (Figure. 8.21). A number of different explanations to M74 have been considered, i.e., pollutants including persistent organic compounds, pathogens, abiotic conditions such as water temperature, changed feed, nutritional compounds such as astaxantin and other vitamins. During the middle 1990s, US scientist reported that a syndrome affecting salmonids in the Great
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lakes with similar pathogenesis as M74 was caused by thiamine deficiency. This information initiated research to evaluate the role of thiamine in M74, and it was shown that thiamine deficiency was involved in both EMS and M74. The background to low thiamine levels in salmon suffering from M74 is still unknown.

Conclusions

Fish in the Baltic Sea are affected by a number of health problems including infectious diseases such as Flavobacteriosis, Vibriosis, Furunculosis, IPN, PKD and BKD. A number of species are affected by reproduction disorder and the most significant, M74, has been a serious threat towards Baltic salmon populations.
References


Chapter 8

References


Further Reading:


Chapter 9


