Disease Interactions and Pathogen exchange between farmed and wild aquatic animal populations - a European network

A European review of disease interactions and pathogen exchange between farmed and wild aquatic animals

Non-technical summary

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Impressum

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Summary: This leaflet is a non-technical summary of the scientific review which is the main outcome of the EU-FP6 DIPNET research project. The scientific review document comprises 82 disease chapters with bibliographies. Fifty-two authors have contributed to the written report, and more than 100 persons in total have been involved in the work. In this summary aiming at stakeholders and non-expert public the information is being presented and discussed in four main sections, following an ecosystems approach, representing the situation in various parts of Europe: the North Atlantic, the continental European, the Mediterranean and the shellfish and crustacean scenario, respectively.	
Norsk sammendrag: Dette heftet, som er finansiert gjennom EU 6 rammeprogram for forskning og teknologisk utvikling, er en populærvitenskapelig oppsummering av den vitenskaplige rapporten fra prosjektet. Den vitenskaplige rapporten inneholder 82 kapitler med referanselister. 52 forfattere har bidratt til rapporten og mer enn 100 personer har vært involvert i arbeidet. I rapporten gjennomgås og diskuteres tilgjengelig faginformasjon om emnet i fire økosystembaserte hoveddeler som representerer situasjonen i ulike deler av Europa: det nordatlantiske, det kontinental-europeiske, og Middelhavs- scenariene, samt skjell- og krepsdyrscenariet.	
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The DIPNET Consortium: from left Paul J. Midtlyng (VESO), Laurence Miossec (Ifremer) Ignacio de Blas (Universidad de Zaragoza) Edmund Peeler (Cefas) Rob Raynard (FRS) and Åse Helen Garseth (VESO)*
** Mark Thrush (Cefas) was not present.*

A European review of disease interactions

Following two years of scientific work and discussions among European experts, a comprehensive assessment of disease interactions and pathogen exchange between farmed and wild aquatic animals has been presented to the EU Commission. The more than 400-page scientific review and bibliography is the main outcome of a FP6 RTD contract (SSP8-2004-006598) aiming to provide scientific background information and support to the further development of EU policies in the field of aquaculture, fisheries and environment. In total, the scientific review comprises 82 disease chapters with a very comprehensive bibliography of scientific articles pertaining to the subject. Fifty-two authors have contributed to the written report, and more than 100 persons in total have been involved in the work.

The available information is being presented and discussed in four main sections, following an ecosystems approach, each scenario representing the situation in various parts of Europe.

The North Atlantic scenario

Disease interactions between coastal net-pen aquaculture and migrating wild fish populations

In several North Atlantic coastal regions of Europe, large-scale net pen farming of salmonids has become of major economic and societal importance. These regions are the natural habitat for wild salmonid populations that migrate annually through the same coastal areas. There is also a growing commercial interest in net-pen farming of several indigenous marine species that have a natural migratory pattern of wild populations along the same coastal areas.

There is good evidence that many pathogens causing disease in coastal aquaculture have their origin in wild populations of the same or similar species. Thus, pathogen exchange from wild to farmed populations is fundamental to disease emergence in aquaculture. Once established, however, the large number of individuals and high biomass density of farmed populations may allow rapid propagation and spread of infection, leading to epidemics that can become self-perpetuated if not controlled within aquaculture, with a corresponding minor role of pathogen transfer from the wild towards the dominant epidemiological patterns.

Many of the diseases causing economic damage to current coastal aquaculture fall into this category, such as

- infectious salmon anaemia (ISA)
- pancreas disease (PD)
- infectious pancreatic necrosis (IPN)
- viral haemorrhagic septicaemia (VHS)
- furunculosis (*Aeromonas salmonicida* infection)
- classical vibriosis (*Listonella anguillarum* infection)
- salmon louse (*Lepeophtheirus salmonis*) infection

The role of disease interactions and pathogen exposure from wild fish sources for aquaculture is, however, strongly dependent on the actual status of disease control in farmed animals. The history of infectious salmon anaemia (a viral disease of Atlantic salmon) in Scotland may serve as an example for successful control within the farming sector, but where the potential presence of avirulent virus strains in wild populations may pose a hazard for re-emergence. Similar examples are being discussed for other diseases.

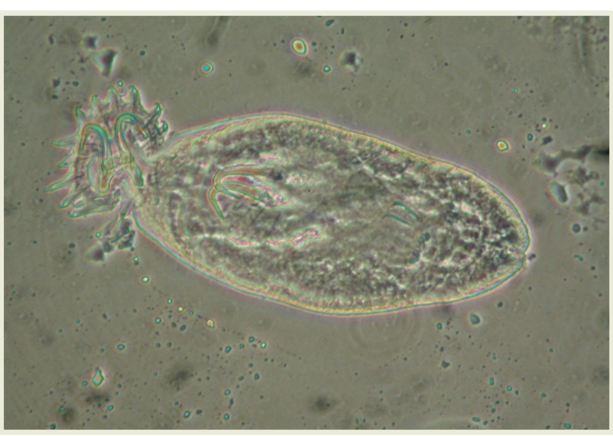
Net-pen aquaculture in Norway (Photo VESO)

High levels of pathogen discharge from farms may leave concern about increasing exposure of wild populations, potentially leading to disease in the natural stocks. Such mechanisms are believed by some scientists to account for the high levels of sea lice infection reported on wild salmonids where effective control measures in aquaculture are not implemented. However, the sea louse example also illustrates that the situation may be remedied and that disease interaction effects on wild fish can be reduced following the implementation of strategic measures to minimise infection load in the farmed fish sector.

For a number of finfish viruses, there is some evidence that infections in aquaculture spill over and infect wild susceptible host species. The limited data available suggest that where it occurs, transmission tends to be local and that epidemics among wild populations are not reported, suggesting that infections are not being sustained possibly because of low host density. It is further known that micro-organisms or parasites may evolve increased virulence in dense host populations. However, diseases such as infectious salmon anaemia (ISA) and infectious pancreatic necrosis (IPN), for which there is evidence of evolution in this way, do not seem to impact wild populations.

The conditions that promote epidemics and disease occurrence in aquaculture are rarely found in wild fish populations, a fact that tends to prevent the occurrence of clinical disease and negative population effects in the wild. Recongising diseased individuals in wild aquatic animal stocks is obviously far more difficult than in farms, and the lack of observations on effects on wild populations does not mean that such effects are absent. Nevertheless, epidemics of bacterial kidney disease (BKD) and furunculosis caused by bacterial infections of wild Atlantic salmon were reported in the UK in the first half of the 20th Century, preceding the farming of salmon.

The strongest example for negative disease interactive effects on wild finfish populations is the salmon ectoparasite which likely was translocated from the Baltic to the Atlantic region through stocking of infected parr or smolts. The infection has resulted in the decline of wild Atlantic salmon in affected watercourses. This example underpins the need to control movements of live fish for restocking and aquaculture in order to avoid the introduction of pathogens to naïve wild (or farmed) populations. Although some exchange of pathogens is inevitable, particularly in net-pen aquaculture, the application of biosecurity and disease control measures based on epidemiological principles can reduce disease risks to both farmed and wild populations.



Gyrodactylus salaris infection has resulted in decline of wild Atlantic salmon in the affected watercourses. (Photo: Torun Hokseggen, VESO.)

Angler with a wild salmon from the river Tana in Norway (Photo: Veso)

In this review, evidence for transmission of several pathogens was found but only one or two infections resulted in negative impacts on wild fish. Evidence for the opposite is amply available from aquaculture, but we must remember that transmission of pathogens and impacts of disease are relatively straightforward to study in aquaculture systems. The usefulness of studies that find little or no evidence for impacts or transmission depends largely on their scale and design. Bearing in mind that it is not possible to scientifically prove that something does not exist, there is a need for research and surveillance on wild fish populations, designed with sufficient power to confirm or reject a number of the conclusions drawn in the current review.

The continental European scenario

Disease interactions between freshwater resident wild fish populations and traditional (pond) aquaculture

The review of available scientific literature and data shows a clear negative economic effect caused by disease interactions on continental European aquaculture, via the role of free-living fish as long-term reservoirs of a number of pathogenic micro-organisms. In general, wild populations and escapees remain latently infected without overt disease, although occasional outbreaks may occur during periods of low water flow or when environmental conditions are particularly unfavourable.

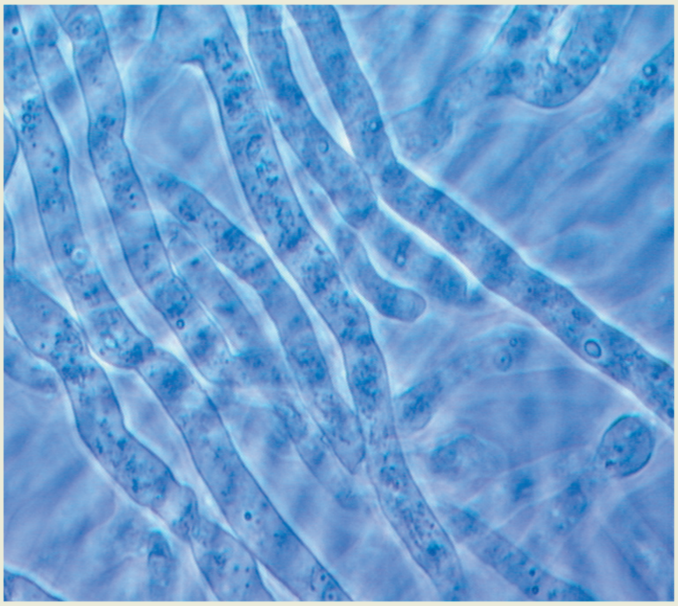
In the review document, evidence documenting the negative effects on aquaculture is discussed for a number of viral, bacterial and parasitic infections such as (among others):

- infectious haematopoietic necrosis (IHN)
- viral haemorrhagic septicaemia (VHS)
- spring viraemia of carp (SVC)
- furunculosis (*Aeromonas salmonidica* infection)
- bacterial kidney disease (BKD)
- *Flavobacterium psychrophilum* infection (Rainbow trout fry syndrome – RTFS)
- proliferative kidney disease (PKD)
- ichtyopthiriasis ("Ich")

The extent to which the current epizootics of these diseases in aquaculture are attributable to pathogen transmission from the wild is, however, variable. In particular where there is a lack of zoo-sanitary disease control measures, infections are easily perpetuated within the aquaculture sector itself, rendering the actual role of reservoirs in the wild of minor importance. Where disease eradication or control measures in aquaculture are in place, however, transfers and re-emergence from wild fish tend to play a greater role. Thus, there is a general need to generate more knowledge about the actual pathogen reservoirs among wild and feral (escaped) fish in European inland waters, and on relevant means to reduce their impact on current and future fish farming.

From the perspective of maintaining biodiversity and the viability and strength of wild aquatic animal populations, the spread of crayfish plague, an infection that has eradicated native crayfish species from large parts of Europe stands out as a dominant issue. This infection is being spread and maintained through the presence of introduced species of crayfish that carry the infection and shed infective spores without themselves becoming sick. The situation is currently prohibiting the re-establishment of populations of native species in affected waterways, but also hindering the development of an economically viable aquaculture production based on the native species, that are highly valued in European niche markets. The main problem prohibiting the management and improved control of this disease is the lack of diagnostic methods to confirm that crayfish being translocated for culture or stock enhancement are indeed un-infected.

The noble crayfish (Astacus astacus).
Photo: Trude Vrålstad, NVI



Hyphae of the oomycete Aphanomyces astaci causing crayfish plague. Photo: Trude Vrålstad, NVI

Experience from North America showing that farmed Atlantic salmon are highly susceptible to IHN suggests that this infection, if introduced, from the current endemic areas in the south, would pose a potential hazard not only to anadromous but also to landlocked Atlantic salmon strains, which are of high conservational value in several European countries. This hazard therefore warrants further research and assessment.

Although hitherto only scarcely supported by scientific data, there are indications that some parasitic infections such as proliferative kidney disease (PKD) and *Anguillicola crassus* are causing decline in European natural fish populations. The same goes for BKD in natural populations of wild grayling (*Thymallus thymallus*). When left uncontrolled in farming, there is a risk of vertical transfer via accidental use of BKD-infected escapees in enhancement hatcheries for wild brown trout and other freshwater species.

Whereas evidence has accumulated that koi herpesvirus (KHV) may cause disease and mortality in both farmed and wild common carp, there are still no data to evaluate the role of wild-farmed fish interactions in the epidemiology of this disease in either sector. This needs to be clarified in order to assess and develop appropriate control options for this disease in the future.

The review strongly advocates that the stocking of farmed fish into rivers and lakes poses particular disease hazards, as such animals are often translocated outside their original population habitat. It is therefore a priority to confirm that all fish being released for stocking purposes are free from certain infections and that high-prevalence reservoirs of infections that are normally rare in our natural fauna are not established by man due to the lack of adequate controls.

German carp pond
Photo. Dr. Grit Brauer

The Mediterranean scenario

Disease interactions between wild marine fish populations and Mediterranean sea cage aquaculture

In comparison to other geographic regions covered by the project there is a lack of scientific information and data relating to disease interactions and pathogen exchange between the wild fauna and Mediterranean aquaculture. Whereas wild and feral fish are often seen as reservoirs of causative agents, no significant epidemiological investigations examining this relationship have been conducted (even for the most important fish pathogens). In most cases, only sporadic isolations of various pathogens have been achieved from wild fish, but without association of these events with disease conditions in the farming environment. Hard evidence for transmission between wild and farmed fish exists only for streptococcosis (*Streptococcus iniae)* and fish tuberculosis *(Mycobacterium marinum)*, in the Red Sea.

All the diseases and their causative pathogens discussed by the review group have been found in both wild and farmed fish and many of them are causing major economic impact on Mediterranean aquaculture:

- marine vibriosis caused by *Listonella anguillarum*
- fish pasteurellosis
- nodavirus infections
- epitheliocystis.

With respect to nodavirus infections, the use of latently infected broodfish captured from the wild poses a specific hazard for disease interaction that may damage fish farming. In order to avoid interactions from the wild fauna and also control this disease within aquaculture itself, there is a strong need to improve diagnostic and testing systems. The scarcity of prevalence data on nodaviruses in Mediterranean wild species makes it difficult to fully understand the role of wild stocks in disease recurrence, or to assess whether there is a hazard to wild fish populations caused by virus discharge from aquaculture.

Seabass and seabream cages
Photo: Ivona Mladineo, IZOR

Feeding of bluefin tuna.
Photo: Ivona Mladineo, IZOR

The use of unprocessed wild fish as feeds in aquaculture, as practiced in the emerging tuna farming industry, is another obvious mechanism for wild-farmed fish interactions that calls for change in order to reduce risks.

Considering the ease of fish-to-fish transmission and the high pathogenic potential of myxozoan parasites in several sparid species, a potential hazard posed to mariculture by this parasite group is hypothesised. A possible transfer of *Kudoa iwatai* from wild fish to farmed sea bream and sea bass has been reported in Israel.

From the perspective of protecting wild stocks, the potential effects of isopod parasites warrant further attention. Although management measures can reduce the impact of these parasites in aquaculture, there is currently no effective treatment available to break their infective cycle. These parasites may affect a wide range of wild fish species and heavy infestations with parasitic larvae seeking permanent attachment are capable of killing small (i.e. 5-20 g) fish. The high abundance of a number of susceptible wild fish species in the vicinity of sea bream and sea bass net-pens raises questions on the potential local effects on the wild populations. The reverse aspect is also highly relevant, as these local populations may constitute reservoirs of these parasites to the farmed populations. The role of disease interactions in amplifying and geographical spread of these parasites in the sea is hypothesised, but has not been adequately studied as of yet.

The shellfish and crustacean scenario

Disease interactions between wild and farmed shellfish and crustaceans

European molluscs and crustaceans comprise highly valued food commodities that may originate from wild populations or from aquaculture. Harvest, culture and marketing of these organisms include practices that pose particular challenges for management and control of disease interactions and epidemiological spread:

Molluscs

Aquaculture of molluscs is typically located in estuaries and along coastlines where the natural living conditions for the relevant species are good. As a general rule, wild populations are either present before farming is established, or settle in close proximity via the natural reproduction of farmed animals. Consequently, cultured and wild molluscs tend to share the same ecological habitat and there is no real distinction between farming and harvest from natural populations regarding risk of disease emergence and spread.

The review of published information suggests that most diseases affecting cultured molluscs are also negatively affecting wild populations, and this is clearly different from the finfish situation. However, the direction (wild to farmed, or vice versa) and mechanism of disease exchange is often suspected but rarely well substantiated by scientific studies.

In wild mollusc populations the spread of infection is spatially limited to nearby areas and consequently, relatively slow. On some occasions, disease outbreaks in hatcheries and nurseries indicated the presence of pathogens in the wild, at low prevalences. However, the transfer of live shellfish during culture and marketing provides a powerful mechanism for rapid spread of any infection that is left uncontrolled. Prominent examples, including bonamiosis caused by *Bonamia ostreae* in flat oysters show that long-distance movement of juveniles plays a key role in disease spread among both wild and farmed molluscs. The drastic reduction of European flat oysters following marteiliosis and bonamiosis is a good example of disease impacts threatening fauna biodiversity. Protecting the habitats and health of wild mollusc stocks is therefore considered of major importance for both the protection of biodiversity and of future aquaculture.

The lack of knowledge about the life-cycle of many protozoan parasites of molluscs is currently hindering the assessment of risks and consequences for the emergence of exotic mollusc diseases in Europe. Another particular challenge to disease control in farmed and wild molluscs alike is the lack of cell lines for isolation of new viruses. As an example, the native oyster species *Crassostrea angulata* became extinct in French waters before the suspected causative agent(s) of the devastating haemocytic infectious viral disease and gill disease were identified.

Farmed oyster. Photo: Ifremer

Crustaceans

Crustaceans both from aquaculture and from the wild are often kept, transported and stored live before being marketed. This implies that numerous contact opportunities for disease interactions between various populations are being created, from which discharge waters and waste pose particular disease hazards to ecosystems containing susceptible hosts. There is also a large and widespread trade into Europe of frozen crustacean products from other parts of the world, that in theory might carry pathogens for which the susceptibility of native European crustaceans are unknown.

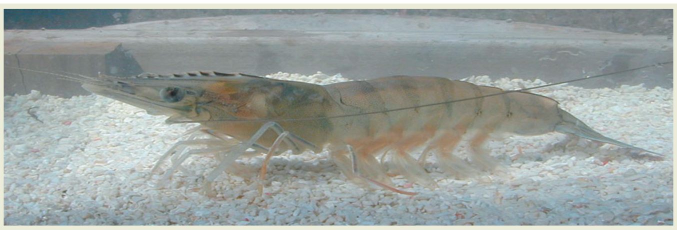
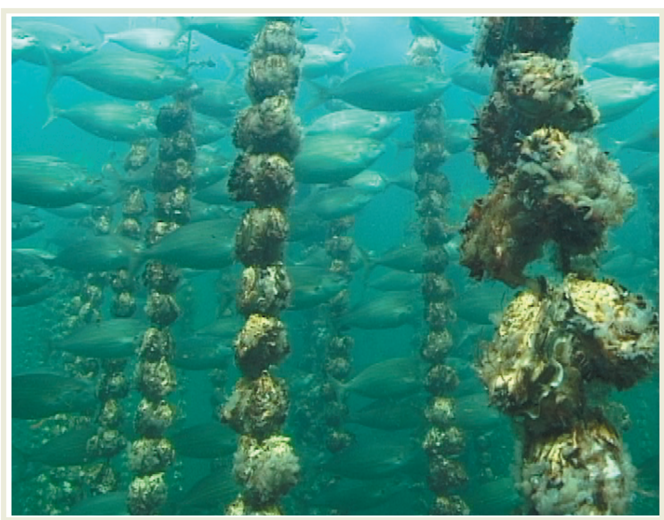


Photo: Ifremer

The aquaculture production of crustaceans in Europe is significantly less than that harvested by the capture fishery, and there is relatively little research into diseases of non-penaeid crustaceans world-wide. There is little information available on important pathogens of wild European crustaceans, even those undergoing commercial exploitation. Certain diseases, such as *Hematodinium* parasites, which can infect a wide range of crustacean host species, suggesting that uncontrolled live transport of infected animals to distant markets with potential re-immersion present a cause for concern. Furthermore, there are currently no disease controls for the importation of frozen shrimp from virus endemic regions in the Americas and Asia to European states. Scientific data suggest that crustacean viruses such as white spot syndrome virus (WSSV) are adaptable to a wide range of crustacean hosts, including those commercially exploited within the European area. The investigation of this issue should therefore be addressed as a matter of urgency.

Disease interactions between fish and shellfish

The review also covers the potential role of bivalves as vectors of fish pathogens. Bivalves take up viruses, bacteria and other particles during filtration, including pathogenic microorganisms. These microbes will be digested or expelled over time. Although few cross infection trials have been carried out, it seems that finfish pathogens in general are not pathogenic to bivalves, and vice versa. Furthermore, the persistence of passively acquired fish pathogenic agents in bivalves appears relatively short with no subsequent establishment of long-term reservoirs. The risks for pathogen transfers when moving bivalves from areas undergoing acute fish disease outbreaks should, however, be managed properly.



The potential role of bivalves as vectors of fish pathogens is covered in the review. Photo: Ifremer Sete

Further information and contacts
Newsletters, further information and publications from the project are available from the project website: [www. dipnet.info]

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