Disease interaction between wild and farmed fish - is it important for import risk analysis?

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The establishment of exotic pathogens introduced via live aquatic animal imports for aquaculture is often dependent on disease interaction between wild host species and the infected imported animals. Interaction is facilitated by the deliberate (e.g. for recreational fishing) or accidental (e.g. escapees) introduction of imported animals into a wild environment. The open design of most aquaculture systems also permits the exchange of pathogens between farmed and wild aquatic animal populations without direct contact. Thus, species introduced for aquaculture may be contained, their pathogens and parasites will be disseminated via water currents exposing endemic species in the vicinity.

Anguillicoloides crassus (a nematoade infection of the swimbladder of European eels) succeeded in establishing in wild native species whilst their non-native hosts did not. *A. crassus* was introduced through the import of Asian eels (*Anguilla japonicus*) a non-native species (NNS), for slaughter. Interaction is crucial not only to exposure and establishment but also consequences. Without interaction introduced pathogens may succeed in establishing only within aquaculture facilities, with considerably diminished consequences, compared with spread to wild populations. Many important disease outbreaks of wild aquatic animal populations in recent years can be attributed to the spread of pathogens, introduced with NNS, to new naïve hosts.

The lack of immunity in the new hosts is exemplified by the emergence of the macroparasite *Gyrodactylus salaris* in wild Norwegian salmon, *A. crassus* in European eels and *Myxobolus cerebralis* (spread via rainbow trout for aquaculture) in native American trout. Examples in other aquatic animals include *Bonamia ostreae*, a protistan parasite introduced from N. America which has severely depleted native European oysters and abalone ganglion neuritis which spread of from farmed animals to devastate native abalone populations in parts of Victoria, Australia. The fungus *Batrachochytrium dendrobatidis* (cause of chytridiomycosis) is consistently carried by the North American bullfrogs (*Lithobates catesbeianus*) which are farmed for food and for the pet trade. International trade in bullfrogs is likely to have played a role in the international spread of the fungus, with devastating consequences for many wild amphibian species. The introduction of NNS drives disease emergence, thus the *ex-ante* assessment will not identify the hazard. New approaches to IRA must be considered and generic risk measures more widely practised (e.g. quarantine).

Minimising disease interaction is an essential element of any biosecurity programme (e.g. through effluent disinfection) to reduce the likelihood of exposure, establishment and the consequences. The planning of new aquaculture facilities needs take into account disease interaction between wild and farmed populations.

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Overview

- Where does interaction fit in a risk framework?
- How does disease interaction take place?
- How can disease interaction result in establishment of introduced pathogens?
- How does interaction influence the consequence assessment?
- The movement of non-native species and disease emergence
- The limits of import risk analysis, biosecurity and risk mitigation

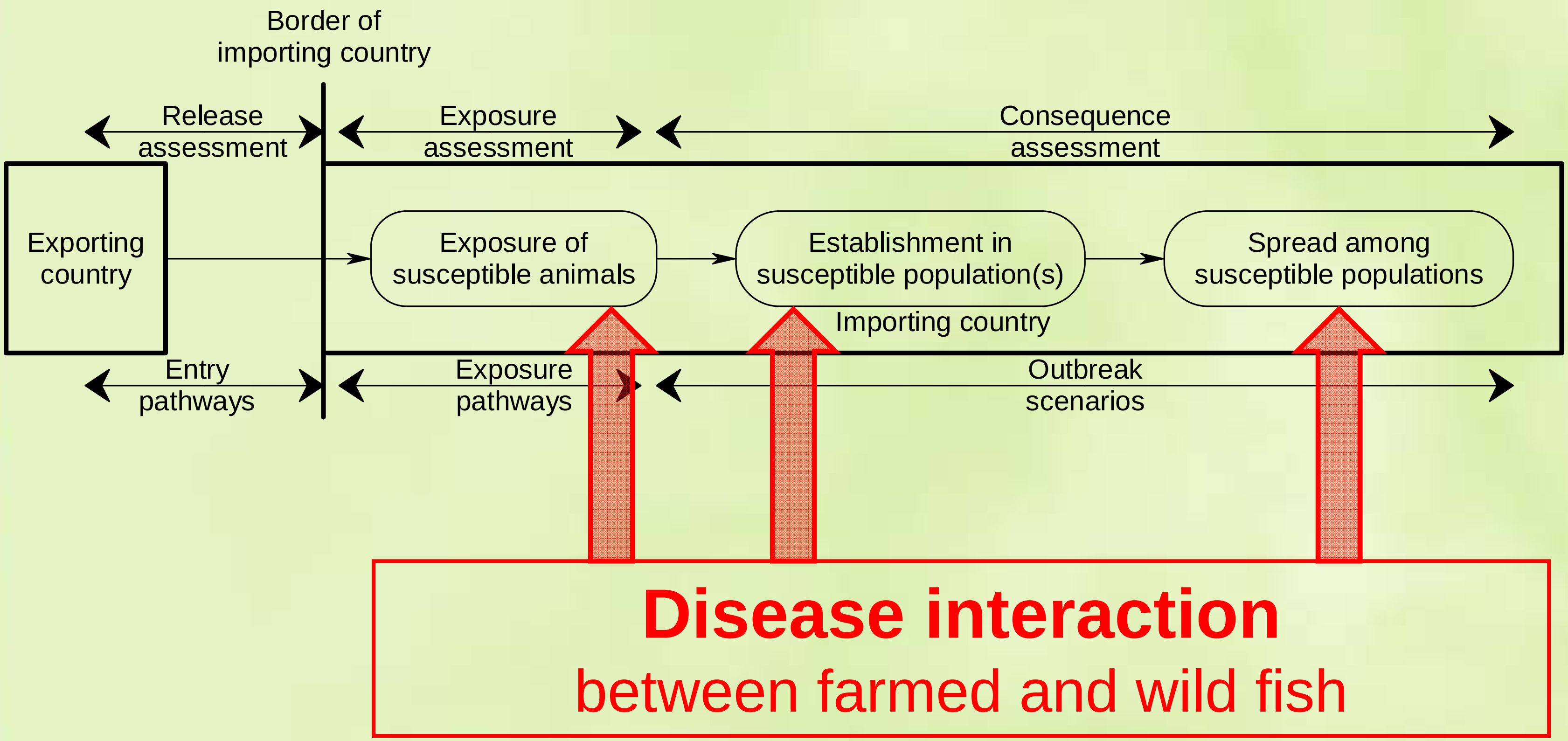
Introduction

- Very large volumes of live aquatic animals are moved internationally
  - Aquaculture
  - Food (crustaceans and molluscs)
  - Pet trade
  - Laboratory animals
- The development of aquaculture has depended on the introduction of non native species (NSS)
  - Pacific oysters
  - Rainbow trout



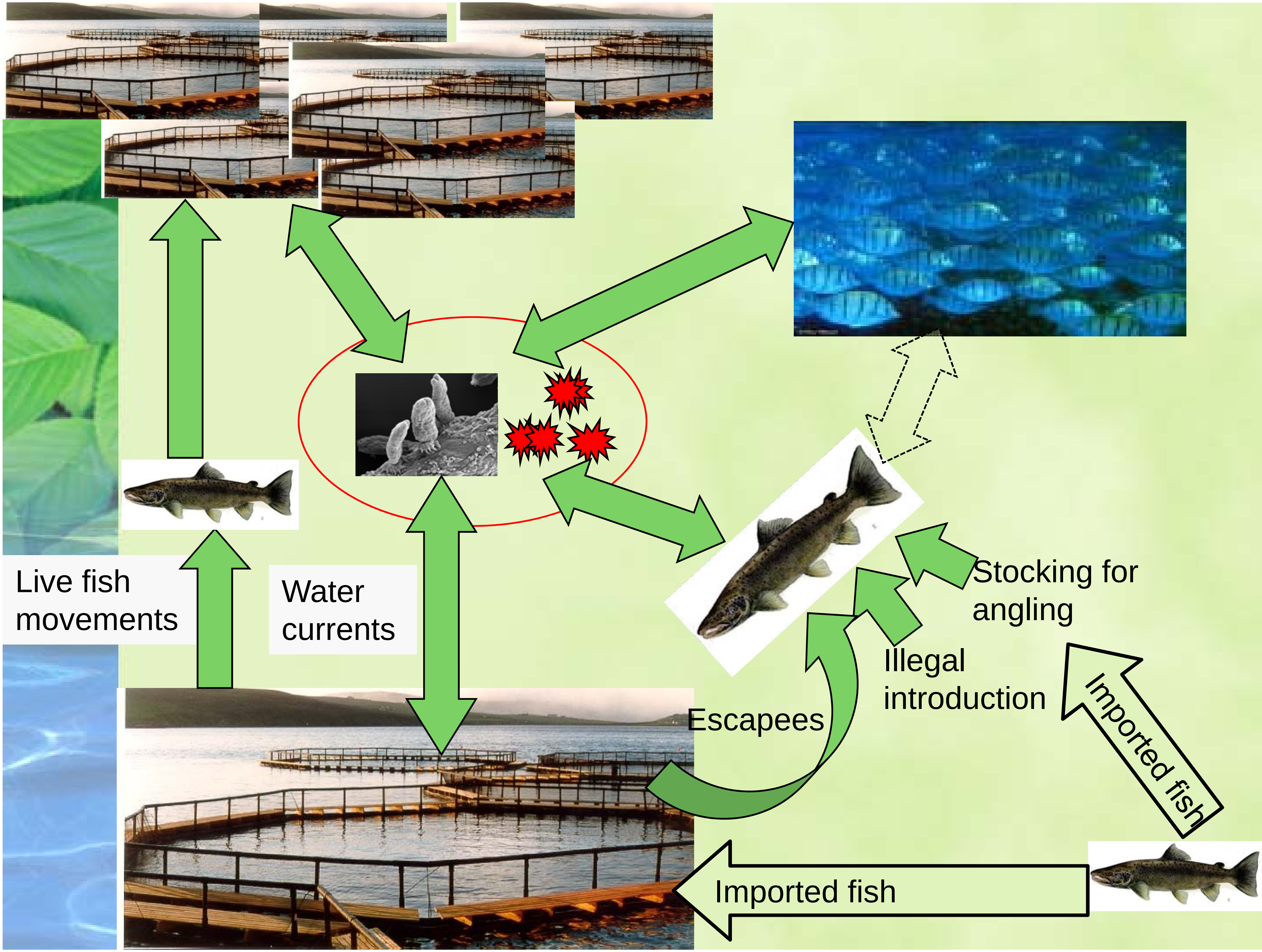





Border of
importing country
Release
assessment
Exposure
assessment
Consequence
assessment
Exporting
country
Exposure of
susceptible animals
Establishment in
susceptible population(s)
Spread among
susceptible populations
Importing country
Entry
pathways
Exposure
pathways
Outbreak
scenarios
Disease interaction
between farmed and wild fish

Types of disease interaction interaction

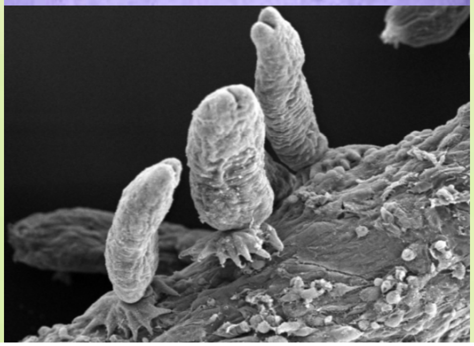
- Direct
  - – Escapees from aquaculture facilities
  - – Deliberate introduction into the wild of imported fish
    - stocking
    - accidental
- Indirect
  - – Pathogen exchange through the water column, spread through movement of currents


Live fish movements
Water currents
Stocking for angling
Illegal introduction
Escapees
Imported fish
Imported fish

Exposure & Establishment

- Disease interaction is often critical to the successful exposure and establishment of an introduced pathogen in the importing country

  - *Anguillicoides crassus* escaped from aquaculture facilities and established in native European eels
  - *Gyrodactylus salaris* spread from farms and from stocked fish to wild fish



Consequences

- Interaction result in spread of disease from farmed to wild populations
- Only limited consequences if pathogen remains within aquaculture facilities
- Introduced disease negatively affects the level of wild populations
  - Knock ecological impact
  - Loss of angling resource
  - Loss of non-use (existence) value

Following long distance movement of aquatic animals **disease interaction** between farmed and wild populations

May result in:

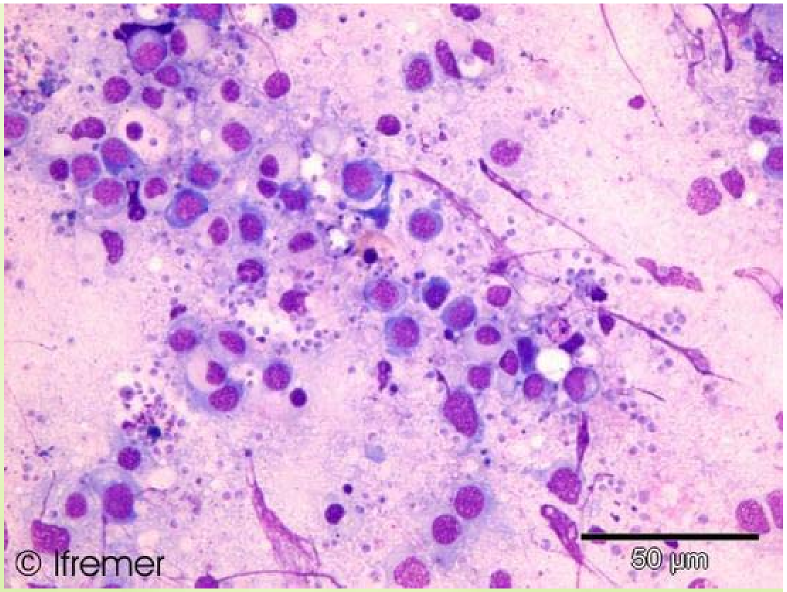
- the establishment of known pathogens in wild populations in new areas
- Emergence of new diseases or known diseases in new hosts through host-switching

Non native species introduction drives disease emergence

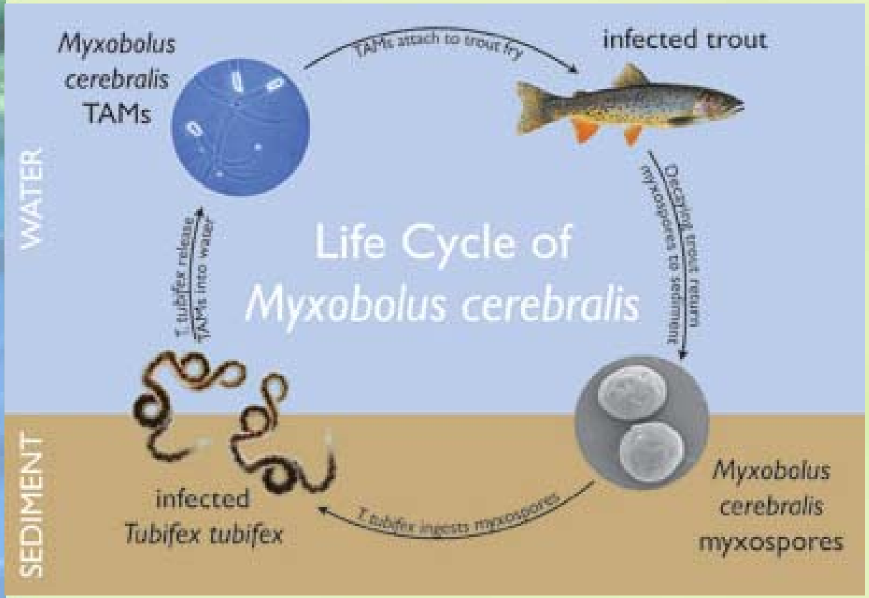
- The introduction of non-native species (NNS) outside of their original range brings together putative pathogens (commensal on the original host) with new hosts
- Host switching drives disease emergence
  - New disease
  - New host for a known pathogen
- Commensal organisms in original host may be highly pathogenic in new (naïve) hosts

Resulting in severe consequences

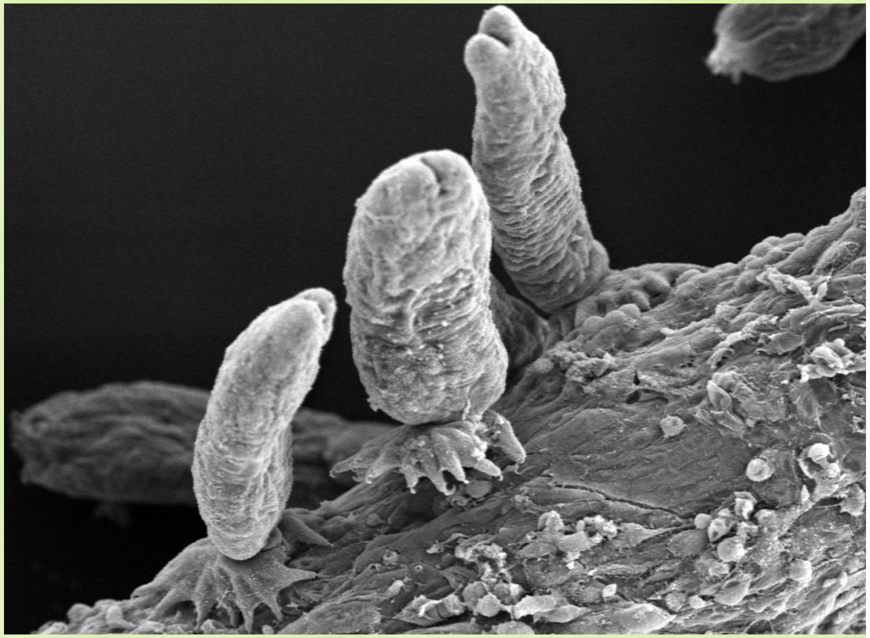
Anguillicoides crassus



Bonamia ostreae



Myxobolus cerebralis

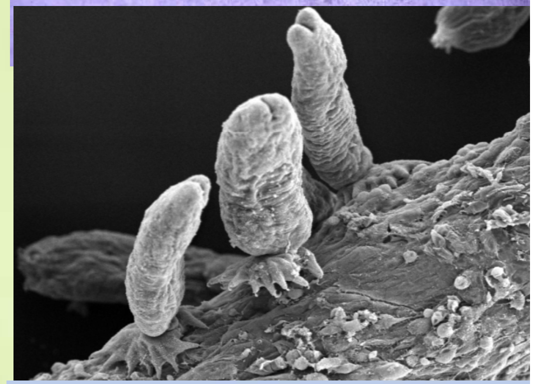


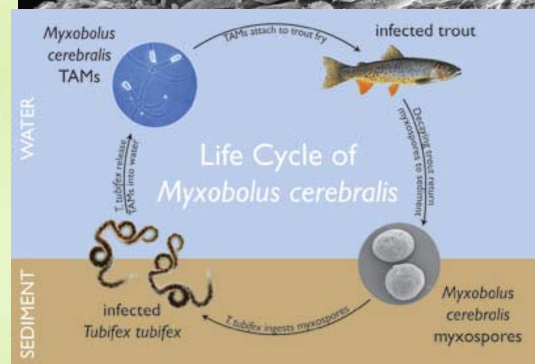
Gyrodactylus salaris

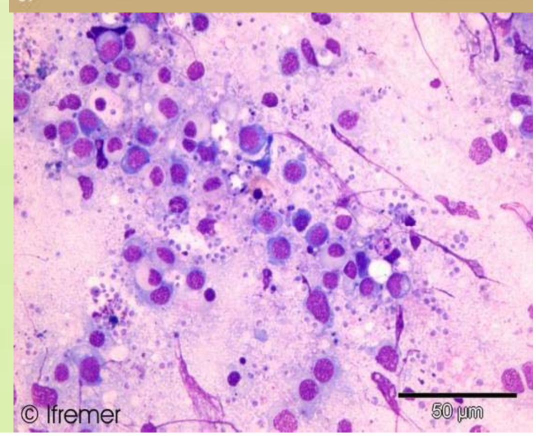
Examples

- *A. crassus* was introduced with Japanese eels imported live for fattening, spread to European eels causing disease and mortality

- *G. salaris* was introduced to Norway with Baltic strains of Atlantic salmon from Sweden, leading to large losses in naïve wild Norwegian salmon populations



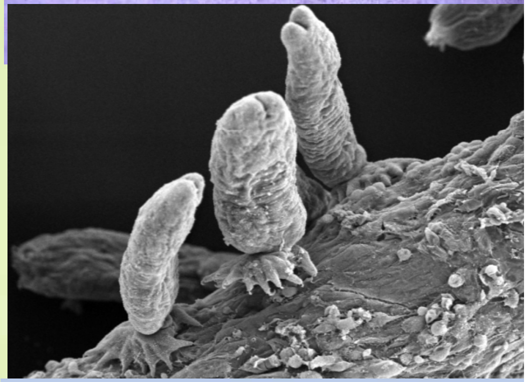


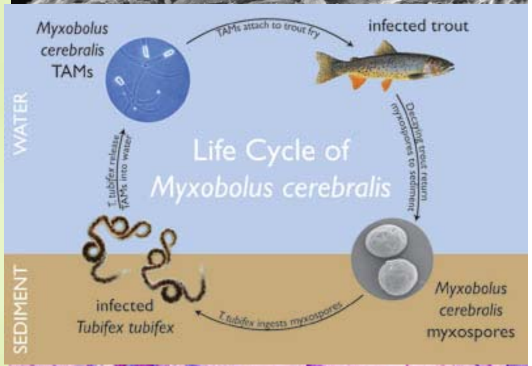


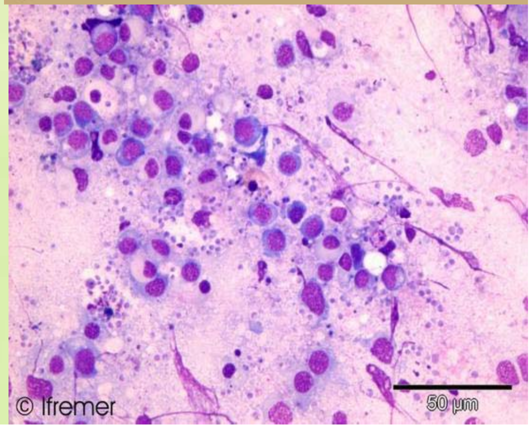
Examples

- *B. oestreae* was introduced to Europe from N. America (with live oyster imports) and has devastated European flat oysters

- *M. cerebralis* has been spread worldwide with the movement of rainbow trout and has caused serious losses in wild trout species in N. America



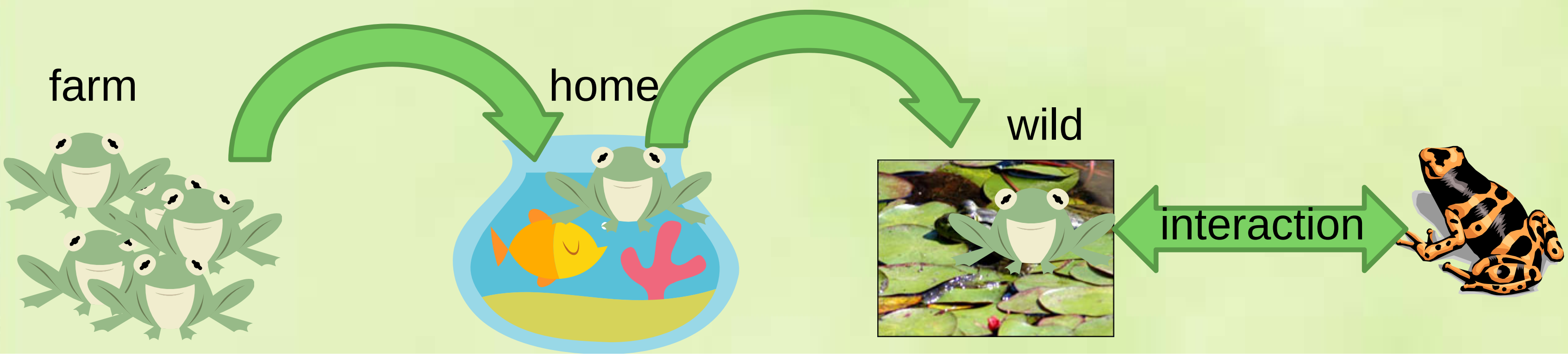




- Abalone imported from Tasmania to be farmed in Victoria introduced abalone ganglion neuritis
- The disease spread from farms to wild populations leading to population declines over 150km of coastline
- Impacts on wild-harvest sector is significant

Chytridiomycosis

- North American bullfrogs (*Lithobates catesbeianus*) are farmed for food and the pet trade
- They consistently carry the chytrid fungus (*Batrachochytrium dendrobatidis)*
- Chytridiomycosis is implicated in severe declines of many amphibian species in the tropics
- The fungus was detected in the UK in 2004 in an introduced population of North American bullfrogs in Kent and is known to be established in at least five other European countries .



Host reservoirs favours establishment and increases impact

- Introduction of a pathogen with its natural host is much more likely to result in establishment compared with introduction of the pathogen without its host
- Presence of a reservoir
  - Allows time for evolution of strains that can host switch
  - Removes drivers for evolution of avirulence

The limits of import risk analysis

- The introduction of NNS drives disease emergence
- The starting point for IRA is the identification of pathogen hazards
  - Unidentified hazards are not accounted for
  - e.g. *G. salaris, A. crassus, A. astaci* were only recognised as ‘hazards’ following a NNS introduction
- Develop alternatives to pathogen-centric IRA

Risk mitigation & biosecurity

- Quarantine
- Limits sources and range of ornamental species traded
- Trade in fertilised eggs not adults

REDUCE INTERACTION BETWEEN WILD AND FARMED AQUATIC ANIMAL POPULATIONS

through the design and location of aquaculture sites

Conclusion

- Disease interaction between wild and farmed aquatic animals is fundamental to the establishment and impact of introduced pathogens
- Disease interaction underpins the disease emergence driven by the introduction on NNS
- Current risk assessment do not take into account how international trade in live aquatic animals may drive disease emergence
- New risk assessment approaches need to be considered
- Measures that reduce disease interaction minimise the impact of the spread of disease and the risk of disease emergence