Aquaculture development and regulation: incompatibility or harmony?

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Introduction
Aquaculture is the fastest growing food production system of the last decade, accounting for a quarter of total world food fish landings and 27% of shrimp product. Nine out of every 10 oysters, Atlantic salmon and cyprinids consumed are farmed. With a growing human population (and consequent demand for protein sources) but declining usable land mass and a decline in populations of wild fish, this is an opportune time to expand the cultivation of new fish species. Such species include some Gadidae (cod, haddock, hake etc), flatfish (turbot, flounder, halibut, sole etc), hybrid striped bass, seabass and other Mediterranean species, wolfishes, lumpfishes and tuna.

Development of new aquaculture species presents a number of challenges to the aquaculturist and regulator alike. The objective of this workshop was to explore the factors that may hinder the future development of new species cultivation in the EU. Dr. Ian Bricknell outlined the potential disease risks (and possible treatments) to emerging aquaculture species, while Dr. Hamish Rodger examined the influence of current EU legislation on this emerging sector. Members of the EU standing veterinary committee, government agencies, the OIE, the aquaculture industry and the scientific community attended the workshop, making for lively and informative exchanges, which are encapsulated here.

Challenges and Conflicts in Emerging Aquaculture Species
Expansion of novel marine finfish species aquaculture will require the development of large marine hatcheries to supply juveniles to sea farms and land-based sea farms. These sites may include older salmonid sites or retrofitted disused sites in addition to the development of new sites. It is also likely that there will be increased inter- and intra-community trade and increased involvement and investment from multinational aquaculture companies, whose operations by nature cross geographical boundaries. The challenges that face such developments include the control and prevention of disease in existing and emerg-
ing aquaculture species, water use conflicts and environmental concerns, the constraints imposed by existing EU fish health legislation and the timely development of new legislation that addresses these issues.

**Potential Disease Risks to Emerging Aquaculture Species**

Emerging aquaculture species, like more traditionally farmed fish species are susceptible, or thought to be susceptible, to a number of bacterial, viral and parasitic diseases (see Table 1). Some pathogens for which data are available in emerging species include:

**Vibrio anguillarum, other vibrios and Aeromonas salmonicida**
Known pathogen of many marine fish species, including farmed salmon and halibut as well as farmed cod and wild flatfish. These are common marine bacteria and have been associated with both larval and broodstock mortality. Antibiotics and vaccines can control them. However, no vaccines are currently licensed for emerging species in the UK although these have been reported as being successful in preventing infection in cod. In addition, there are problems with the formulation of injection or dip vaccines for emerging species and there is limited literature on the role of adjuvants in these species.

**Nodavirus**
A complex group of viruses with at least three immunological distinct groups that are associated with viral neural necrosis and have been found worldwide. Nodaviruses have been implemented in larval mortality in hali-

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Flatfish</th>
<th>Gadoid</th>
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<tbody>
<tr>
<td><em>Vibrio anguillarum</em></td>
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<tr>
<td>Other <em>vibrio</em> sp.</td>
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<tr>
<td><em>Aeromonas salmonicida</em></td>
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<td><strong>Bacteria</strong></td>
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<td>BKD</td>
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<td>ERM</td>
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<td><em>Piscirickettsia</em> sp.</td>
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<td>Mycobacteria</td>
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<td><strong>Parasites</strong></td>
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<td><em>Caligus elongatus</em></td>
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<td><em>Cryptocotyle ligulae</em></td>
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<td><em>Lernaeocera branchialis</em></td>
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<td><em>Gyrodactylus</em> sp.</td>
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<td>Pathogenic nematodes</td>
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<tr>
<td><strong>Virus</strong></td>
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<tr>
<td>IHN</td>
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<tr>
<td>VHSV (GT1)</td>
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<tr>
<td>VHSV (GT11 &amp; 111)</td>
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<td>ISAV</td>
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<tr>
<td>IPNV</td>
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<tr>
<td>Nodavirus</td>
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<tr>
<td>Salmonid pancreas disease virus (SPDV)</td>
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Table 1. Microbial agents and disease risks
but, cod and turbot. Associated mortality is very high in larvae and low in post metamorphosed animals.

IPNV
A member of the Birnaviridae (aquabirnavirus) that has been found in many fish species and apparently has global and ubiquitous distribution. IPNV is a notifiable disease in the UK and has been found in salmonids, wild cod, cultured turbot, halibut and wild lemon sole. It has also been isolated from frozen, uncooked, Atlantic cod in Japan and Australia and has been reported as causing significant mortality in larval halibut. Although there are no effective fish viral vaccines currently licensed in the UK, new IPNV vaccines are undergoing field trials and may be useful in protecting the larval stages of some susceptible emerging species.

VHSV
A member of the Rhabdovirus family that has been found in many fish species and apparently has a global and ubiquitous distribution. VHSV is a EU List II pathogen. Genotype (GT) I is the typical rainbow trout isolate from Europe while GTII and GTIII have been isolated from cod and haddock in the North Sea off Shetland and in the Baltic. VHSV has also been isolated from turbot in the marine environment. The variable genotypes of this virus are due to the fact that it is an RNA virus and prone to rapid host adaptation and change. It is very likely that host specific strains can develop very rapidly.

Control of Disease Risk

Current data on gadoids and flatfish
It is clear that disease risks exist in emerging species. However, while there is some literature on flatfish diseases, gadoid diseases are poorly studied. Control measures for which some data are available in emerging species include husbandry, vaccination (bacterial and viral diseases) and chemotherapy (anti-biotics and anti-parasite).

Husbandry
Husbandry measures should be based on recognition of a number of potential risk factors for transmission and maintenance of disease. These include the risk of importing disease with a stock (e.g. *A. salmonidica* carriers in Atlantic salmon); the risk of disease being contracted from a species used for biological control (e.g. *A. salmonicida* in goldsinny wrasse); the risk of species A being more susceptible than species B to a particular disease (e.g. where mixed species are contemplated on a single site). These potential risks form the backbone of most aquaculture codes of practice and must be adopted in the culture of any emerging species.

Vaccination
There are no vaccines currently licensed in the UK for emerging species, thus administration must be carried out under the veterinary cascade system. Companies are understandably nervous about the level of investment required to redress this situation in new and mainly untried fish species. In addition, the limited research carried out to date indicates that models of immune response developed
in salmonids may not apply in gadiods and flatfish. In response to an IP vaccine cod do not produce specific antibodies to the antigens, rather there is an increase in non-specific antibodies and in serum Ab levels. Therefore, protection elicited by vaccination in this species in probably cell mediated. In contrast, specific antibody production has been demonstrated in halibut and both cell mediated and antibody mediated protection occur in this species.

From the few studies carried out on methods of vaccine administration in emerging species dip vaccination would appear to confer good protection but be of unknown duration. In addition, calculation of the dose per animal is impossible and it is possible that the vaccine may target the wrong arm of the immune system. The advantages of dip vaccination are the low stress levels associated with this method and the ease of administering boosters in tank-held fish. Administration of dip vaccination at sea is difficult. There is little data on the efficacy of oral vaccination in emerging species, although this method would have the advantage of low stress and easy booster. Both IP and dip vaccination has been successful in cod but there is limited literature on the role of adjuvants in this species. Administration of oil adjuvants causes serious adhesions in flatfish, so administration by oral or dip is preferable. The advantages of IP vaccination include long duration of protection and control of the dose per animal. On the downside, IP vaccination is stressful, may cause physical damage, booster shots are difficult and the side effects of adjuvants, especially in flatfish, may be unacceptable.

**Disease and life cycle**

Evaluation of broodstock health is an important disease-control measure. However, there are currently no tests available for emerging species which are non-destructive, sensitive, and OIE approved. Information on larval health is also critical, for example what bacterial and viruses can infect larval fish and when can these fish be vaccinated. There is little data available on these issues at present.

**Constraints Imposed by Legislation**

**Current legislation**

Finfish disease legislation comes under EU Council Directives 91/67/EEC and 93/53/EEC (plus amendment 2000/27). These directives group certain fish diseases or pathogens into three lists (I, II & III) with differing requirements for control in each group. List I diseases (ISA) currently require total eradication, although amendment 2000/27 opens the door to vaccination where an efficacious vaccine is available. However, implementation of a vaccine policy has implications for zoning as ‘disease-free’. List II diseases (VHS and IHN) require containment with the aim of gradual eradication, that is, fish can be grown to harvest size before slaughter. This category also allows movement of infected fish to other infected farms. The confirmation of a List II disease on a farm will result in loss of approved zone status, where it exists, for all farms in that hydrographic/geographic area or region. This can have significant implications for trade.

EU fish health legislation was drawn up and directives enacted “to ensure the rational development of the sector (aquaculture) and to increase productivity...avoiding the spread of
infectious or contagious diseases.” Within the EU such legislation was the first for many member states that included any aspect of fish disease, however, some member states already had existing national legislation which may have been stimulated by concerns of disease in wild fish e.g. The Diseases of Fish Act (1937) in Great Britain. Existing legislation allows for some flexibility of enforcement at a regional/zonal level. Legislators would argue that VHS is only a problem for countries who wish to maintain a ‘disease-free’ approved status and that it is down to national policy whether such status should be maintained or re-established once it has been lost. National policy must take into account the type of aquaculture carried on (e.g. predominantly rainbow trout in Denmark where a stringent eradication programme is underway) and the prevalence of the disease in wild fish in national waters (e.g. the prevalence of VHS in Japanese wild fish is 18% and a stringent eradication programme in this instance would be pointless). In Ireland, the government policy on List II diseases has recently been changed to allow phased withdrawal of fish stocks over 18-24 months, with a 6-8 week fallow period prior to restocking with juveniles from approved zones.

**Impacts of current legislation**

The impacts of these directives have, in some instances, been devastating. Following the confirmation of ISA in Scotland thousands of tonnes of salmon were culled and the exportation of ova and juveniles curtailed. Despite the eradication policy for this List I disease, no official compensation package was available to farmers, leading to loss of livelihoods. Currently, where ISA is confirmed, the EU and the affected country pay compensation on a 50/50 basis following stock eradication, however, if the member state has no provision for compensation then no EU monies are provided. Confirmation of VHS led to the closure of two turbot farms (Scotland and Ireland) with no provision at that time for compensation for List II disease losses, although this situation may be changing in some member states. Such measures naturally result in a lack of investor confidence in the development of new species. One suggested solution to the VHS difficulty would be a separate definition of rainbow trout (GTI) VHSV and marine rhabdovirus (GTII & III). An EU scientific working group has considered moving marine VHSV to List III. However, because reliable discrimination has only recently become possible much data still needs to be collected to strengthen the case for this approach and to allay fears of transfer of virulent strains from the marine to fresh water. It has also been argued that should List I and II diseases prove to be endemic in the marine environment, with resultant difficulties in prevention of re-infection and re-introduction, then there is no logic in current eradication policies.

**Models for the formulation of fish health controls**

For any fish health controls to be effective consultation between industry and legislative bodies is vital. Such consultation would, naturally carry with it responsibilities. In Australia, where the industry is seen as a partner in the formulation of control policies and is intensively consulted, the industry bears part of the cost of the control programmes. However, in return the policies reflect the concerns of both industry and government. For exam-
Disease control in veterinary medicine

From a veterinarian’s point of view, the strategies that may be adopted to control fish diseases range from no action to test and slaughter, with an array of intermediate interventions as appropriate. These include:

- Surveillance (passive or active)
- Therapy
- Modification of physical/environmental conditions
- Alteration of production schemes
- Vector control
- Carrier elimination
- Quarantine
- Mass vaccination of target species
- Mass vaccination of wild reservoirs
- Development of resistant stocks
- Facilities certification or specific pathogen free (SPF) stocks

A combination of some of these strategies has been successfully applied to the control of the bacterial disease furunculosis in salmonids, nodavirus in Mediterranean species and pancreas disease in salmonids. In these three examples above, legislation played little or no part in the successful control of the disease and all were originally of much more serious clinical impact than those current List I and List II diseases.

Lessons and Opportunities

Any attempt to guard fish health and the sustainability of the industry while minimising potential negative impacts to wild fish stocks and the environment must consider a number of issues. It must be asked whether legislation is an appropriate control strategy for a given disease or whether other approaches might be more successful. In examining this issue all stakeholders must be consulted and the goals (prevention, control, eradication) articulated clearly in an achievable manner. This is particularly important in situations where the disease itself may not be well defined or diagnosable. The strategies adopted will also be informed by whether a cost-benefit or risk benefit analysis approach is favoured and by the resources available to carry out the chosen strategies.

A number of gaps in our current knowledge about disease and disease agents in novel species need to be plugged, if future fish health legislation is to be meaningful. Areas for investigation include:

- Prevalence of VHSV, IHNV, nodavirus and ISAV in wild marine fish
- Risk-benefit analysis of potential courses of action
- Pathogenesis of the viruses in novel mariculture species
- Means of transmission of diseases within novel species and between these and other species
- Computerisation of fish stock movements for European aquaculture
- Further vaccine development, and study of the immunology of novel species.
Conclusion
In the EU, changes in legislation to reflect the concerns of the aquaculture industry currently have a low priority. In order to move legislation forward and facilitate the development of emerging species aquaculture, pressure will need to be brought to bear by the aquaculture industry, national task forces and member state governments. Control strategies must be based on sound scientific data on the epidemiology of disease in novel species and the efficacy of therapies and other control strategies. But above all, it is vital that any legislation that is developed is based on intensive consultation and input from all stakeholders.

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Note: Dr Bricknell has requested that as this is a report of a workshop, the views contained herein do not necessarily reflect his views or those of his employers.