General Topic Priority Ranking (1-5)	Objectives	Relevance to 2020 target	Potential deficiencies in infra-structure/Resource Requirements
1) The dispersal patterns of sea trout and salmon and subsequent distribution in relation to the Scottish Coast	Salmon smolts depart rapidly from home rivers but little is known about their subsequent distribution in relation to the Scottish coast. It is believed that, in general, sea trout remain near shore for their first two months at sea and then disperse more widely, although some may move further afield soon after entering the sea. Little is known about the scale of dispersal or whether it is uniform in direction relative to the home river. Sea lice affect both wild and farmed salmonids. In the life cycle of both salmon and sea trout it is the smolt stage that is most at risk from physiologically significant impacts of sea lice. From a wild fish perspective, it is important to have a better understanding of the migration pathways for salmon and key marine habitats for sea trout, in order that the potential impact of any interaction betrween wild and farmed fish can be better understood. From an aquaculture perspective, it is important to understand the migration pathways of both juvenile and adult fish (which will carry sea lice with the potential to infect fish within cages) in order to better understand and minimise the risks that arise from the presence of parasites and pathogens on wild fish. A number of the techniques used to chart fish movements are well-established. An opportunity exists to deal with gaps in understanding, by supplementing existing ongoing work in Scottish waters.	Work on the dispersal of wild salmon and sea trout would help inform management aimed at growing the aquaculture industry in a sustainable manner in accordance with 2020 growth targets	A multi-year research programme would be required. There is significant opportunity to tie in such research with existing and ongoing research relating to marine renewables. **HIGH PRIORITY**

2) The effects of sea lice at a population level on wild salmonids	It is the smolt stage of salmon and sea trout which is most at risk from physiologically significant impacts of sea lice infestation. The scale of any effect of sea lice on wild sea trout at the population level cannot be determined from existing published information. Knowledge gaps in the Scottish context are: • The scale of any association between levels of lice on salmon farms and on wild salmon. • The effect of sea lice on salmon at the individual level. • The effect of sea lice on salmon at the population level.	Information on the potential for sea lice present on farmed fish to impact on wild salmonids is incomplete and the issue remains controversial in relation to 2020 growth targets. Filling the knowledge gaps highlighted above is fundamental to meeting the 2020 target..	A multi-year research programme would be required. Work to answer these research questions would focus on the release of fish treated prophylactically with systemic sea lice medicines vs. untreated controls. Treatment will protect the fish, particularly in the first 6-8 weeks of their marine migration, and allow survival to the natal river to be assessed. Other than in a very small number of rivers, infrastructure to allow the recapture of treated and untreated fish is not in place in Scotland and having such infrastructure in a number of representative locations is important in achieving a statistically significant sample size for returning fish. **HIGH PRIORITY**

3) Improving understanding of sea lice dynamics	Interactions between sea lice, wild and farmed fish in open water are complex and specific to local geography, hydrodynamics, weather conditions, the number of fish farms and the number of fish within any given area. • Sea lice dispersal modelling is at a relatively advanced stage, but gaps in knowledge remain. Sea lice dispersal models should be developed to the stage that predictions relevant to the risk management requirements for new and modified developments are possible. • A greater understanding of the effects of farming stategies employed to manage and minimise lice numbers on sea lice dispersal is required. • Potential cumulative effects of multiple farms and/or increased fish numbers within sea lochs on the presence of sea lice in the environment need to be better understood.	Fulfilling the objectives would help inform management aimed at growing the aquaculture industry in a sustainable manner in accordance with 2020 growth targets	MSS and others have developed/are developing sea lice dispersal models in a number of areas of Scotland, but significant parts of Scotland are not currently covered and it is recognised that some knowledge gaps still remain.**HIGH PRIORITY**

4) Investigations of routes of emergence from subclinical infection of wild fish to disease in farmed fish	All diseases of farmed fish have emerged from existing infections occurring in wild fish[1]. However, many of these infections have been sub-clinical with little impact on their wild hosts. Identification of aquaculture practices that facilitate such emergence can be used to develop methods that reduce the probability of new diseases arising. A variety of techniques are available to assess these routes. Case histories of emerging diseases[2] can be used to identify conditions and practices that have led to emergence of existing diseases. Network analysis of contact structure can be used to assess conditions under which an emergent pathogen might spread[3]. Epidemiological modelling can assess practices that allow pathogens to emerge[4]. Risk analysis of production practices can be used to identify key stages that increase risk of emergence. There are key questions /research objectives that remain to be answered in order to allow the processes of emergence to be evaluated: • What are the environmental conditions affecting wild or feral populations that promote/retard risk of pathogen transfer to farmed fish? • How powerful is the surveillance for emerging diseases and how rapidly can sufficient information be collected to enable an objective assessment of control strategies to be made? • What is the economic trade-off between controlling production activities, including anthropogenic movements between farm sites, and reducing disease risk? • In what circumstances do such diseases significantly spill back into wild populations?	Avoiding emergence of new diseases is an important part of the Scottish Government's role in supporting sustainable development of aquaculture while protecting the environment. This will be of particular importance should new species be brought into aquaculture on a larger scale. This work would help inform management aimed at growing the aquaculture industry in a sustainable manner. Specifically, it would lead to tools for early identification of potential problems, leading to more cost effective surveillance for potential emerging diseases and hence tools to mitigate impacts. The project would benefit strongly from close collaboration between different interest groups, farmed and wild fish interests, academics and government and lead to the development of networks that could promote sustainable aquaculture.	The project will require a review of existing analyses and sources of data relevant to emergence of new diseases. Such a project would take around three years to complete. This research would help inform the ongoing development of the Industry Code of Good Practice; and surveillance and regulatory measures to reduce the risk of disease outbreaks. **HIGH PRIORITY**

5) Escapes of farmed fish	Introduction of non-native salmon into the environment may occur through accidental escapes from aquaculture facilities or historically through deliberate introductions of stocked fish. Non-indigenous fish (both from outwith Scotland, and from rivers systems across Scotland and the UK) will show varying degrees of genetic differences to indigenous stocks and may, in some way, be less well adapted to their new environment. Several studies outside of Scotland over the last decade report that hybridization and introgression by escaped farmed fish may incur a fitness cost to wild populations. In Scotland there has been a general and significant decline in reported escapes, due largely to farming industry initiatives to improve awarenesss, training and equiment standards. More recent initiatives, such as the Improved Containment Working Group[5] including moves towards a Scottish Technical Standard for Containment[6]. However there are key questions/research objectives that remain to be answered in order to allow the incidence, impacts and mitigation of introgression to be evaluated: • What are the incidences of introgression in the wild in Scotland, and where have the non-indigenous fish originated from? • What are the impacts of non-indigenous fish on populations of wild salmon in Scottish river systems?	The importance of avoiding genetic introgression in wild stocks is a priority for the Scottish Government to support sustainable development of aquaculture while protecting the environment[7]. Relatively little is known about the extent of any genetic interactions between indigenous and non-indigenous salmon.	The importance of this area has been acknowledged by the ICES Working Group on the Application of Genetics in Fisheries and Mariculture. At this point it would seem sensible to engage with this review, which is scheduled for 2014, rather than set up a separate piece of work [8]. Once standard tools have been agreed upon they could then be applied, although at present it is difficult to predict the time or cost that this would involve. **MEDIUM-HIGH PRIORITY**

BIBLIOGRAPHY WILD-FARMED INTERACTIONS

1.Murray, A.G. and Peeler, E.J. (2005). A framework for understanding the potential for emerging diseases in aquaculture. Preventive Veterinary Medicine, 67: 223-235.

2. Hall, L.M., Smith, R.J., Munro, E.S., Matejusova, I., Allan, C.E.T., Murray, A.G., Duguid, S.J., Salama, N.K.G., McBeath, A.J.A., Wallace, I.S., Bain, N., Marcos-Lopez, M. and Raynard, R.S. (2013).

3.Munro, L.A. and Gregory, A. (2009). Application of network analysis to farmed salmonid movement data from Scotland. Journal of Fish Diseases, 32: 641-644.

4.Werkman, M., Green, D.M., Murray, A.G. and Turnbull, J.F. (2011). The effectiveness of fallowing strategies in disease control in salmon aquaculture assessed with an SIS model. Preventive Veterinary Medicine, 98: 64-73.

5. http://www.scotland.gov.uk/Topics/marine/Fish-Shellfish/18364/18692.

6.SARF (2012). A report presenting proposals for a Scottish Technical Standard for Containment at Marine and Freshwater Finfish Farms. http://www.sarf.org.uk/cms-assets/documents/48448-527836.sarf073.pdf.

7. Homarus (2012). Impacts of Open Pen Freshwater Aquaculture Production

8.. ICES. (2013). Report of the Working Group on the Application of Genetics in Fisheries and Mariculture(WGAGFM on Wild Fisheries. Final report to Scottish Government. http://www.scotland.gov.uk/Resource/0040/00405814.pdf.), 7-9 May 2013. ICES CM 2013/SSGHIE:11. 52pp.

http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGHIE/2013/WGAGFM13.pdf.