

Note: 2nd sea lice multination workshop Aberdeen

Resistance management → Integrated Pest Management:

- Identifications of R&D needs and suggestions forward

In the light of the evolving resistance challenges throughout the salmon farming industry the need for implementation of parasite control as a true integrated pest management strategy (IPM) is evident in aquatic food production. In this lays the need for validation and implementation of all mitigating measures, with R&D activities and the development of standard practices for the industry in parallel.

The sea lice multination platform has been initially based on three main working goals:

1. Identify main knowledge gaps and suggest R&D pathways for closing them
2. Identify cross territory synergies/links
3. Identify specific areas for sharing SOP/BMP` s on operational issues and mechanisms and responsibilities to do so

The first Sea lice multination (SLM) meeting were held in Bergen February 2010 and resulted in a matrix of six working groups (wg) on an IPM basis. Each wg is established with scientific coordinators and industry facilitators (not established in all wgs):

Table 1: SLM working groups

	Working groups	Scientific/Industrial coordinators
1	Structural measures and dispersion modelling	K. Boxaspen/S. Murray
2	Farming and use of wrasse	AB. Skiftesvik/PG Kvenseth
3	Biological measures and molecular knowledge building	F. Nilsen
4	Resistance challenges and use of medication	TE. Horsberg/G.Ritchie
5	Surveillance (farmed and wild fish)	C. Revie
6	Novel technologies	D. Jackson

The second SLM meeting took place in Aberdeen October 2010, with focus on two main working goals:

1. Identify how sea lice population dynamics and resistance development are monitored, and if current control measures taken against sea lice are efficient, secure and documented
2. Preparation of project descriptions from each of the working groups / thematic areas as basis for applications for future funding.

A key element for parasite control is surveillance; monitoring of both the parasite population dynamic and drug resistance. Therefore and as an introduction to the 1.5 days workshop, overviews on sea lice status were given from the industry of each of the participating countries.

The main activity during the Aberdeen meeting was working group discussions in the wgs 1 to 5. Discussions in wg 6 "Novel technologies" were not prioritized during

this meeting. Participants divided into wgs based on their interest/background. A change to the wg 4 was made, since the scientific coordinator Dr. Horsberg could not attend. The "resistance challenges" part was included in the wg 5, and the remaining "use of medication" part was coordinated by Dr. Dave Jackson during this workshop.

The first working group session task was sharing of knowledge and information of ongoing activities in the different thematic. Thereafter and based on this information prioritized new research proposals should be pointed out.

Further task in the wgs discussions were initially to outline project descriptions with subsequent working packages, but since this were a bit ambiguous, the task was altered to an achievable one. Each working group were challenged to look five years a head, set a goal for each thematic and outline a roadmap with responsibilities on how to reach there.

Each working group was asked to summarize the discussions and the different Wg summaries with suggested responsibilities are attached in Appendix. Following are an overview on the main tasks/activities and R&D needs that were suggested:

Working group 1: Structural measures and dispersion modelling

Attendees: Larry Hammel (UPEI), Sandy Murray (MS), Karin Kroon Boxaspen (IMR), Mark James (SARF, day 1), Nabeil Salama (MS), Berit Rabe (MS), Peder Jansen (NVI), Magne Aldrin (NCC), Rob Raynard.

Main goal: To develop scenario testing and decision support tools for a strategic approach to integrated pest management

Optimising use of assets in management decision for sea lice control, by building modelling tools to predict the best salmon production plans with deployment of cages and treatment/control strategies.

What tools do we want to have in a five to ten years perspective?

- Linking population models with hydrodynamic models
 - testing questions, decision support system (management)
- Developed as a standard framework
 - different work comparable
 - validation
 - usable by multiple users

How do we get there?

Need for data and new knowledge:

- Specific data missing by countries: Scotland: oceanographic data (inshore), sea lice data on farms. Norway: oceanographic data (inshore: coastal/fjord), sea lice counts (from index to count). Canada: small scale modelling so far (New Brunswick)
- General data missing (several specific aspects mentioned in detail in the wg summary attached):
 - Sea lice biology
 - Standardised sea lice counts
 - Treatment data
 - Necessary (standard) resolution for modelling
- Use of data in a better fashion in and between countries:
 - Make available database in each country for coastal areas regarding:
 - Hydrodynamics
 - Sea lice data (international standard of sea lice counting?)

Other:

The really long shot is to develop models which can give more knowledge on farmed-wild interactions and the North Atlantic dispersal of sea lice.

Funding and multinational cooperation:

- Issues point towards EU projects or MoUs that will release funding simultaneously in countries cooperating.
- Further cooperation between countries already working on these issue are very possible
- Need for industry involvements.

Working group 2: Farming and use of cleanerfish

Attendees: Anne Berit Skiftesvik, Per Gunnar Kvenseth, Howard Browman, Gunvor Øie, Synnøve Helland, Pamela Parker, Kjell Maroni, Clive Talbot and Derek Roberts.

Actions and need for more knowledge:

1. Intensive culture
 - a. Actions - organize a workshop for cleanerfish cultivation to identify knowledge gaps relative to the industry
2. Sustainable capture fishery
 - a. Establish more knowledge on biogeography of wrasses in the Atlantic with information on wrasse populations and effects of fishing
 - b. Develop selectivity of trapping gear with minimized by catch
 - c. Genotyping/markers for wild populations in the context of breeding program and brood stock
3. Sustainable use
 - a. Efficacy and economic cost-benefit analysis
 - b. Review articles on biology of wrasses and practical guides for collection and use
 - c. Establish cleanerfish as a marketable product when the sea cages are harvested
4. Fish health and welfare
 - a. Surveillance of disease bacterial/viral/parasites of cleaner fish in the wild and intensively cultured
 - b. Disease transfer (cleanerfish - salmon/salmon - cleaner fish)
 - c. Vaccine development
 - d. Welfare and mortality of cleanerfish in sea cages

Working group 3: biological measures and molecular knowledge building

Attendees; Frank Nilsen, James Bron, Bjarne Gjerde, Sam Martin, Alan Bowman, Sussie Dalvin, Fiona Provan, Giulia Micallef, Ralph Bickerdike, Catherine Collins, Bertrand Collet, Christer Røss Wiik-Nielsen, Philippe Tacon, Hugh Currie, Derek Robertson, Georgie Watson.

Main goal: To develop biological sea louse control that involves the use of measures which exploits aspects of the parasite or host's biology or environment.

This biological control strategy is based on use of in-feed supplements, vaccines and selective breeding of host fish as well as many others.

Short term tasks:

- Continued development of production systems for lice, experimental facilities, with sharing of best practice to improve research outcomes.
- Standardisation and characterisation of challenge models
- Development of a web-page with a collection of experimental protocols, links to genome resources and other relevant tools/methods
- Sea lice biology Workshop - status of knowledge
 - workshop for researchers

Long term tasks:

- Host parasite interactions; establish more knowledge on the nature and mechanisms underlying host responses to sea lice and determine which louse components are causing these responses
- Salmon louse biology: To elucidate details of salmon louse biology.
 - biological processes
 - copepodid biology
 - moulting process
 - endocrine regulation
 - intestinal function and digestion related processes
- Selective breeding, to elucidate response to selection
- Modulation of virulence; study variations of virulence as response to adaptation to more resistant fish
- Functional feeds; to gain more knowledge regarding mechanisms, response and components

While some of these issues have been addressed previously, our current understanding is far from satisfactory in all of these areas. Hence a multidisciplinary international effort would be an efficient approach to extending our knowledge regarding some of the key biological issues in sea lice. This would generate a key knowledge base, suitable for the identification of further targets that can be evaluated for use in vaccines or other novel control measures in the future.

Working group 4; Use of medication

Attendees: not noted.

Main goal: Ensure that re-infestation only occurs from wild source sea lice i.e. no added risk of lice infestation from fish farm.

Effective sea lice control with:

- Integrated Pest/Resistance Management
- Minimal use of therapeutants
- Optimal use of available therapeutants

Goals set in relation to use of medicines:

1. To determine the optimum intervention strategy for lice control in terms of treatment thresholds, timing and size of management areas.
2. To ensure access to effective use of a full range of medicines.
3. To put in place a risk based control on the use of medicines.
4. To develop the optimum use of medicines by developing protocols to select the most appropriate treatment, standardising measurements of treatment efficacy and developing robust treatment delivery methods fit for use under difficult environmental conditions.
5. To develop rapid and reliable sensitivity testing.
6. To develop and improve available technology in terms of effective treatment delivery in cages and well boats.

Tasks:

- Harmonisation of regulations and licensing of medicines e.g. EMEA approach
 - review of current status
 - identification of key issues/barriers
 - recommend solutions
- Tap into expertise from other areas of pest management/parasite control
 - Ask modellers to address issues of optimal control strategies
 - Invite expert to join group from outside of aquaculture
 - Initiate a subcommittee
- Assessment of treatment efficacy
 - initiate an multinational project to:
 - communicate treatment efficacy
 - inter-calibrate between different countries and research initiatives
- Sensitivity testing
 - Standardisation of existing methods
 - Development of new rapid farm-based methods
- Technology development, bath and in-feed treatments
 - Initiate R&D project on technology development
 - Workshop on dispersion and efficacy of treatments (bath and in-feed)
- Development of a generic best practice for sea lice control

Working group 4; Resistance and working group 5; Surveillance (farmed and wild fish)

Attendees: Dave Cox (Scotland), Andrew Grant (Scotland), Anna Ingvarsdottir (Norway), Catherine McMannus (Ireland), Stuart Middlemas (Scotland), Michael Penston (Scotland), Crawford Revie (Canada), Sigmund Sevatdal (Norway), James Simonson (Scotland), Clive Talbot (Scotland) and Ole Torrisen (Norway)

Main goal: Standardization and further development of efficient and robust sea lice surveillance methods regarding counting (wild and farmed fish) and assessment of treatment efficacy (bioassays and sea lice counting pre/post treatment)

Key research issues/gaps and tasks:

- Surveillance of sea lice on farmed fish:
 - Prepare a review of current protocols
 - Engage with WWF and ISO groups to ensure adequate international standards emerge
- Surveillance of sea lice on wild fish:
 - Identify subject specialists to help pin-point knowledge gaps to prioritize future research efforts
- Treatment efficacy metrics:
 - Literature review of treatment efficacy metrics currently or historical in use
 - Exploration of utility of these metrics using sample/historical data sets
- 'Classical' bioassays:
 - Update standard protocols to allow for flexibility of process and analysis, while ensuring comparability
 - Define data management formats to allow for comparison over time/space
- 'Threshold' bioassays:
 - Development and testing of pen-side single dose kits
 - Maintenance of various sea lice strains (susceptible, resistant to one compound, multi-resistant)
- Integration of data and systems:
 - Establish "meta data" standards to ensure that effective analysis of clinical (field counts), pen-side (single dose) and laboratory (bioassay) data can take place within regions, with the potential to make comparisons across regions in due course.

Some final remarks

Building resistance management strategy in aquatic environments requires known and unknown building blocks. Several working groups pointed at prioritizing implementation of an Integrated Pest Management at the top of the list. Activities and R&D suggestions are made, and they holistic fit into a roadmap towards control of sea lice infections. However, in order to carry out IPM, known from examples of entomological control, it is necessary to have enough information about the biology and ecology of a given pest, particularly concerning their spatial distribution and factors that affect the spatial distribution of a given species. Further, understanding of the geographic variability in distribution and densities of pests is required for any IPM program. Do we have this knowledge on sea lice, and do we understand the key factors that determine the sea lice population size and dynamics, for development for ecological/epidemiological models and pest management strategies in aquaculture?

The reliance on therapeutants needs to be altered, and when used it should be used optimal and in a rotational system with therapeutants with other modes of operation. Hence, a set of different therapeutants must be available and other effective control measurements (not therapeutants) must be dominant in sea lice control. The efficacy of the treatment and the success of combination with other differing control system should be measured both on sea lice levels on farmed and wild fish. Further, the effect and influence on both virulence and sensitivity of the sea louse population should be included to foresee an effective long lasting control strategy.

During the 2nd SLM workshop it was evident that monitoring of both sea lice numbers and resistance were differing between countries. Further focus on standardisation and establishment of a common repository of data both nationally and internationally is an essential "building block" for development of resistance management.

The suggestions from the second sea lice multinational workshops points to further work on standardisation, communication and sharing of knowledge through workshops both nationally and internationally and between industry and research.

Suggested research related to ongoing activities

Several R&D activities are ongoing in all the thematic discussed in the different working groups. We do have a general overview on ongoing research, however new research has been granted since the 2nd SLM meeting in Aberdeen. Salmon Louse Research Centre has been granted and it will be a major contributor to research specifically related to sea lice biology, molecular knowledge building, biological control measures and development of new therapeutics. The Centre is to be established and further details will be known following establishment (about autumn 2011).

New research on wrasse production (ballan wrasse) is as well granted and focus is mostly related to nutrition and water and egg /juvenile quality. The use of a lump

sucker species (*cyclopterus lumpus*) in sea lice control has been recognised and a new R&D project related to production and use of this potential cleaner fish has newly been granted.

Moreover, a new project on disease control strategies in salmon farming is granted and will focus on integrating economic, environmental and social dimensions, and will also include sea lice as one of the case studies.

Initiation of new projects should be related and complementary to ongoing activities and these newly granted R&D projects must be taken into consideration.

Table 2: Suggested main knowledge gaps and research priority not identified in granted R&D projects/activities:

WGs	Main prioritized knowledge gaps
1	Knowledge on spatial distribution, geographic variability and density of sea louse for development of a IPM decision support system
	Knowledge on farmed - wild interactions related to sea louse populations
2	Knowledge needed on wrasse populations and effects of fishing for sustainable capture
	Knowledge on health and welfare both in the wild and intensively cultured cleanerfishes
3	Knowledge on sea louse modulation of virulence. Study on variations of virulence as response to more resistant fish and as response to different control measurements
4	Knowledge on optimum use of medicines related to selection of the most appropriate treatment, treatment delivery methods and robust technology under different environmental conditions
5	Knowledge and standardisation for development on international “meta data” to ensure effective analysis within regions and potential comparisons across regions, related to field counts, pen-side bioassays (single dose) and laboratory data (classical bioassays).
6*	Development and validation of different novel non-medical technologies for sea louse control

*Not discussed in the Aberdeen workshop

Sea lice multination matrix

The idea of the six working groups established is to involve both research and industry to communicate and initiate new activities related to both R&D and knowledge implementations in practises/operational procedures. During the two SLM workshops the focus has been mostly research related.

Further involvement and considerable participation from industry should be accomplished keeping the discussions and knowledge sharing up to date with challenges in the industry and new knowledge from research.

The self appointed steering committee, existing of Gordon Ritchie, Kjell Maroni and Randi Nygaard Grøntvedt, were asked to continue their work on SLM organization and coordination. A further organization should include the coordinators and national industrial federations.

Next sea lice multination meeting

During the 2nd Sea lice multination meeting some suggestions on the 3rd SLM workshop were made. The suggestions were either a spring workshop in New Brunswick Canada, or a SLM happening related to the gathering AquaNor in August in Trondheim Norway.

Our suggestion is to carry out the 3rd Sea lice multination during late autumn (Oct/Nov) 2011.

Rapporteur:
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