

Caligus

A newsletter on the biology and control of sea lice distributed free to researchers, aquaculture and fisheries industry, educators, consultants and management authorities

<http://www.ecoserve.ie/projects/sealice>



Salmon cages, Austevoll Marine Station, Norway

Sea Lice 2003

6th International Conference on Sea Lice

1st - 4th July 2003, St Andrews, New Brunswick, Canada

Co-hosted by the Huntsman Marine Science Centre and the St Andrews Biological Station (DFO)

Subject

The 6th conference focuses on various aspects of sea lice, including management considerations and biology. Topics include epidemiology, dispersal, genetics, modeling, biology, treatments and ecotoxicology.

Registration and Accommodation

Registration and Accommodation forms as well as Presentation Guidelines for the conference are available at the Huntsman Marine Science Centre website:
www.huntsmanmarine.ca/workShops.html

Registration Fees

Until May 30th:

Regular: CD\$240 Student: CD\$200

After May 30th:

Regular: CD\$270 Student: CD\$240

For full conference programme and poster presentations list, see back page

Proceedings

Papers submitted for publication will be published in a special issue of the international journal *Aquaculture Research* following the normal peer-review process (<http://www.blackwellpublishing.com/journals/ar/default.htm>).

Excursions

On Friday 4th July 2003 there will be two excursion options (and you can do both!):

- Tour of HMSC land-based aquaculture facilities and public Aquarium

- Boat trip – see whales, porpoises, seals, salmon farms, herring weirs, eagles, around the bay and islands.

For persons wishing to do their own personal tours, please visit:

www.town.standrews.nb.ca

Contents

This issue of *Caligus* includes:

	Page
● Sea Lice 2003	1
● Hydrogen peroxide and its effects on sea lice fecundity	2
● Towards a North American sea lice network	2
● Database of people interested in sea lice	5
● 2001 Sea Lice Management Conference, Aberdeen	6
● Publications	6
● Sea Lice 2003 Programme	8



Goldsinny cleaning salmon

Acknowledgements

The newsletter, sea lice bibliography, and preparation of the Sea Lice 2003 Conference are supported by the Natural Research Council Industrial Research Assistance Program, Department of Fisheries and Oceans, Canada, The Huntsman Marine Science Centre, and Ecological Consultancy Services Ltd (EcoServe). This newsletter was prepared by April Stevens and edited by Mark J Costello, Les Burrigge and Blythe Chang. Page layout by C  ill  n MacLochlainn.

Copyright statement:

The information in *Caligus* may be published elsewhere without prior permission provided its source is clearly acknowledged.

Join our sea lice e-mail discussion group

The *Caligus* listserv is an e-mail discussion group which enables people interested in lice biology and control to discuss information with others in the group.

To join the group: (a) send an e-mail to listserv@listserv.heanet.ie, (b) leave the 'subject' line blank, and (c) type the following command in the main part of the email message: "SUBSCRIBE CALIGUS your first-name surname". Do not include your signature or any other text.

To leave the group, send an e-mail saying "SIGNOFF CALIGUS" to the same address.

Sending an e-mail to CALIGUS@listserv.heanet.ie will send the message to all subscribers in the group.

All e-mails sent to the listserv are archived by month at: <http://listserv.heanet.ie/caligus.html>

Effects of hydrogen peroxide on subsequent fecundity of sea lice chalmus stages

J.P.G. Toovey and A.R. Lyndon

Department of Biological Sciences, Heriot-Watt University, Riccarton, Edinburgh, EH14 4AS, UK (e-mail: J.P.G.Toovey@hw.ac.uk)

Introduction

Hydrogen peroxide (H_2O_2) is currently used in salmonid aquaculture as an anti-sea louse chemical. It is known to be effective against adult life-stages of the lice (Bruno and Raynard, 1994). The peroxide effects on chalmus stages are equivocal, with many remaining attached after treatment (Thomassen, 1993). It was noted in the field, however, that gravid lice in the month after a peroxide treatment had a discoloration of the egg strings, suggesting an adverse reaction on those lice which had survived the treatment. This study aimed to determine whether chalmus stages remaining attached after treatment with hydrogen peroxide had their fecundity altered when they eventually matured, and also to determine whether the visual appearance of louse-egg strings related to their viability.

Methods

Gravid lice (*Lepeophtheirus salmonis*) from farmed salmon (*Salmo salar*) were collected from a commercial salmon site located on the west coast of Scotland during 1998-1999, and any anti-lice treatment administered during the previous month was recorded. The sea temperature during this period was between 9°C and 11°C.

The appearance of the egg strings and whether they had remained attached to the adult lice during transportation were noted. The gravid lice and unattached egg strings were placed into flasks containing oxygenated, autoclaved seawater ($n=5$ in each case). The egg strings were incubated at 12°C until the first copepodid stage, at which point counts were conducted of the numbers of the nauplius and copepodid life-stages produced by each of the egg strings.

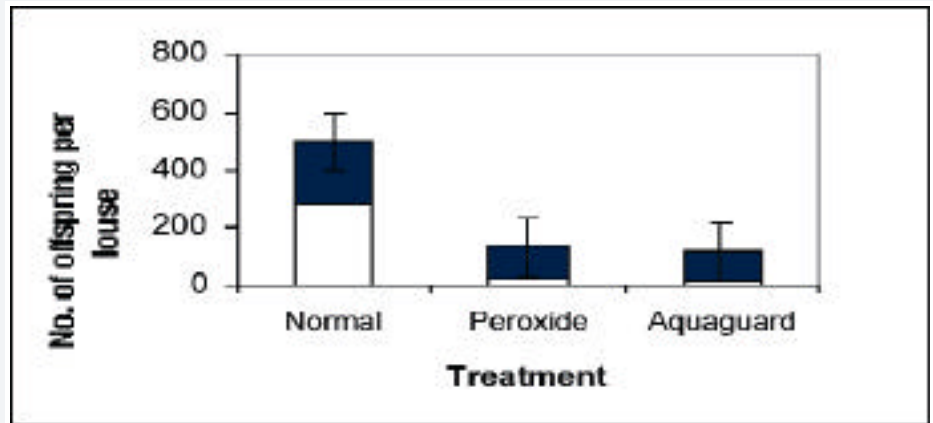


Figure 1. Fecundity and subsequent development of nauplii (shaded) and copepodites (clear) of salmon lice experiencing treatment at chalmus stage.

Results and Discussion

It was found that dark grey-coloured egg strings produced larvae regardless of attachment to adult lice. Egg strings of a translucent or light-brown colour were found to produce larvae only if left attached to the adult until they reached the dark coloration. Egg strings which were opaque and white in colour failed to produce larvae, even if left attached to the adult. This was the type of egg string most commonly found attached to those lice which had recently been subjected to hydrogen peroxide or Aquaguard treatments.

Figure 1 shows that lice treated with either peroxide or dichlorvos (as Aquaguard) produced very highly significantly ($p < 0.001$; Oneway ANOVA) less larvae and, of those larvae produced, a smaller percentage progressed to the copepodid life-stage.

From these results, it seems likely that hydrogen peroxide treatment, whilst having little visible effect on the chalmus stages, does

detrimentally affect the subsequent reproductive capacity of the lice, both in terms of fecundity and also in terms of the subsequent development of the off-spring. These results also indicate that egg-string colour could be a useful indicator of the most effective time for anti-lice treatments to be administered.

References

- Bruno, D.W. & Raynard, R.S. (1994). *Aquaculture International* 2: 10-18.
Thomassen, J.M. (1993). pp 290-295 in: Boxshall G.A. & Defaye D. (eds.), *Pathogens of Wild and Farmed Fish: Sea Lice*. Ellis-Horwood, New York.

Acknowledgments

This study was made possible by the assistance of Marine Harvest McConnell and, in particular, Simon Wadsworth.

Towards a North American sea lice network

Report of a meeting held at the Department of Fisheries and Oceans Gulf Fisheries Centre, Moncton, 10 March 2002

Mark J Costello and Blythe Chang

The Huntsman Marine Science Centre, 1 Lower Campus Road, St Andrews E5B 2L7 and

Department of Fisheries and Oceans, Biological Station, Brandy Cove Road, St Andrews, New Brunswick, Canada

This meeting was organised to (a) assess the interest in establishing a network of people interested in sea lice biology and control in Atlantic Canada; (b) review current status of the sea lice problem in salmon farming, and (c) review current research on sea lice.

Sixteen people attended and

fifteen sent their apologies for being unable to attend (Table 1). This interest included federal and provincial government agencies, university and government agency researchers, government and private veterinarians, industry representative organisations, aquaculture companies and a biotechnology company. Although

no special effort was made to contact persons outside Atlantic Canada due to the short notice for the meeting, interest was also expressed by researchers from British Columbia and USA. Had pharmaceutical companies been contacted, it is likely they would also have expressed an interest in attending. There is thus an interest

in sea lice research across industry, government and research sectors, in both Atlantic and Pacific Canada and in the United States of America. This mirrors the range of participation in the European network. It may be expected that about fifty persons would thus be active in a North American sea lice network.

Current situation

The problem with sea lice in the Atlantic salmon industry was summarised by industry veterinarians and managers at the meeting, and from comments from others prior to the meeting. They concluded that in New Brunswick:

- sea lice ranked in the top three issues for farmers (with ISA + fish performance);
- the problem varied from moderate to severe on a site by site basis;
- there were 1-3 treatments per cage per grow-out cycle (reduced from a few years ago);
- sea lice cost the NB industry hundreds of thousands to millions of dollars a year, direct and indirect.

The problems were similar in New Brunswick and Maine:

- both species of lice involved; *Lepeophtheirus* was main problem, but *Caligus* sometimes;
- limited number of treatments (drug, pesticide, medicine) available;
- fallowing probably not very effective due to closeness of farms;
- no regional strategy (as there is for ISA).

Sea lice were less of a problem in Nova Scotia, probably due to the relative isolation of farms. In British Columbia, sea lice were apparently not a consistent problem throughout the industry, but recent first-hand information was desirable.

Available chemotherapeutant treatments

There still are problems with chemotherapeutant availability, in terms of lack of approved treatments and/or difficulty in getting permission to use. This prevents the alternation of treatments to prevent build-up of resistance in sea lice. However, studies by Burka and colleagues had found no evidence of sea lice resistance to azamethiphos in NB. Recently used or considered chemotherapeutants are:

- **Slice (emamectin):** an emergency drug release in Canada; expect full registration later this year. Is now the most commonly used treatment. Also available as

INAD in Maine. Expensive to use on large fish, and its withdrawal period prevents its use on salmon close to harvest.

- **Salmosan (azamethiphos):** has approval in Canada, but is not being used much; mainly for large fish only. The manufacturer (Novartis) may not wish to keep the product registered because of low usage now.

- **Excis (cypermethrin):** not approved in Canada; no longer available in Maine (INAD has expired).

- **Calicide (teflubenzuron):** just received full registration in Canada (about a month ago); needs vet prescription. Less persistent than Slice, so may have to treat more often than with Slice. Is about 90-95% effective on all lice stages, but not as effective as Slice.

- **Ivermectin:** was available as off-label vet prescription, but apparently not used in Canada now. Cheaper than emamectin but less effective and more hazardous to the fish.

Other methods of treatment

Fallowing of sites and bays has been effective in Europe but may not be so effective in New Brunswick and Maine due to the proximity of sites. However, it is felt that the bay management efforts in NB are making a difference and can only be a helpful measure. Year-class separation, and avoidance of 'holding-over' fish, will also reduce sea lice transmission.

Integrated Pest Management

IPM involves coordinated management of stocking of sites and treatment measures to minimise sea lice transmission, to control infestations and to avoid resistance development.

It is recognized that to avoid resistance there should be a move toward IPM that strategically uses alternative treatments. In addition, there would need to be greater coordination of farm stocking, fallowing, and treatment timing on a regional scale.

continued next page...

Table 1. List of attendees and persons who sent apologies for being unable to attend.

Attended:

Blythe Chang: Department of Fisheries and Oceans, St Andrews
Chris Kohler : New Brunswick Department of Agriculture, Fisheries and Aquaculture
Gary McClelland: Department of Fisheries and Oceans, Moncton
Gilles Olivier : Department of Fisheries and Oceans, Moncton
Jillian Westcott: Atlantic Veterinary College, Prince Edward Island
John F Burka: Atlantic Veterinary College, Prince Edward Island
Jonathan Moran: Microtek
Lar ry Hammell: Atlantic Veterinary College PEI, & NB DAFA
Laura Br own: National Research Council
Les Burridge: Department of Fisheries and Oceans, St Andrews
Mark Fast: National Research Council
Mark J Costello: Huntsman Marine Science Centre
Neil Ross: National Research Council
Sharon McGladdery: Department of Fisheries and Oceans, Ottawa/Moncton
Stewart Johnson: National Research Council
Vance Pendleton: Aquaculture Association of New Brunswick

Apologies:

Bill Robertson: Heritage Salmon
Julia Mullins: Veterinarian, Heritage Salmon
Fr ed Whorisk ey: Atlantic Salmon Federation
Neil Halse: New Brunswick Salmon Growers' Association
Inigo Novales Flamarique: Simon Fraser University
Jennifer Ramsay: Atlantic Veterinary College, Prince Edward Island
John O'Halloran: Veterinarian, St Stephen
Dan McPhee: Veterinarian, St George
Ste ve Backman: Veterinarian, Moore-Clark
Sandi McGeachy: New Brunswick Department of Agriculture, Fisheries and Aquaculture
Ahmed Mustafa: Indiana University/Purdue University, USA
Mike Opitz: University of Maine, USA
Mike Pietrak: University of Maine, USA
Alasdair McVicar : Department of Fisheries and Oceans, Ottawa
Jay Parsons: Department of Fisheries and Oceans, Ottawa

Possible additional participants:

New Brunswick veterinarians: Mark Moore
Nova Scotia veterinarians: Roland Cusack
Nova Scotia industry: Marli MacNeil (NS Aquaculture Association)
Maine/USA government and veterinarians
Environment Canada
Department of Fisheries and Oceans: Henrik Kreiberg (Nanaimo), Edward Black (Ottawa)
British Columbia: Joanne Constantine (BC Ministry of Agriculture, Food & Fisheries), Scott McKinley (UBC)
Bill Hogans (The Huntsman Marine Science Centre)
NB industry: Stolt Sea Farms, Fundy Aquaculture, Jail Island Salmon, Cooke Aquaculture, Atlantic Silver, Harbour DeLoutre Products
Maine industry: Atlantic Salmon of Maine, Sebastian Belle
Pharmaceutical manufacturers and distributors: Schering Plough (Rick Endris), Moore-Clark Nutreco (Mike Beattie), Novartis

Current Research

Burridge (DFO)

► Effects of chemicals on non-target organisms (mainly lobster larvae and adults). Mostly lethality studies, but some sublethal (reproductive effects of azamethiphos and Slice; growth effects of Slice).

Burka and students (AVC)

► Just finished five-year project with NRC and Salmon Health Consortium.

► New project SEARCH (handout circulated at meeting) in collaboration with several European organisations.

► Partners include AquaNet, AVC, NBSGA, Schering-Plough, NRC.

Moran (Microtek, NRC)

► Looking at vaccine targets. Looking at different stages of lice (Johnson and Brown, NRC).

► Genomics approach. Includes collaboration with Microtek.

► Program to isolate, quantify and study virulence of salmon louse and host gene expression.

► Evidence of some interaction between salmon and lice, and immuno-modulation of both.

► Why do you not see processes such as inflammation in Atlantic salmon when infected by lice?

Ross and Fast (NRC)

► First looked at mucous interface. Found change in enzymes in mucous; sea lice are secreting digestive enzymes into mucous of salmon; these enzymes may stimulate immune response.

► Looked at response of lice to different salmon; and response of different salmon species to lice. Found that rainbow trout, Atlantic salmon and coho salmon all attracted lice; but with coho, all lice fell off in a few days. Also, rainbow trout had lower infection rates than Atlantic salmon. Something in coho mucous may be inhibiting lice feeding mechanism.

► Vaccine would not have to be 100% effective – if it reduced stress on fish and the number of treatments needed, then it could be beneficial.

Environment Canada (Moncton)

(Information provided by Burridge)

► Has developed assays for emamectin in fish food.

Kohler (NBDAFA)

► Had small-scale monitoring program several years ago, but not in recent years. Companies and vets may have information on sea lice numbers, but data is not public.

Hammell (AVC/NBDAFA)

► Vets are routinely involved, but sea lice are not a big issue because of the effectiveness of Slice and the accepted need to keep lice numbers low, because of ISA. So there is less emphasis on sea lice counts than in previous years.

► Last year, there were only 17 treatments with

Salmosan and five with tetubenzuron; most treatments were Slice.

► Issue in Grand Manan: lobster fishermen would like to see reduced treatments in August-September to protect juvenile lobsters (may be just a perceived problem).

► In-feed treatments may not work as well for slinks, since they may not be feeding. Vance Pendleton indicated that Slice is so effective that even slinks seem to be protected.

Costello

Summary of other research in Europe:

► Modeling epidemiology (Strathclyde University).

► Semiochemicals (University of Aberdeen).

► Lice-host interactions at cellular level (Marine Lab Aberdeen and Stirling University).

► Monitoring and/or epidemiology on wild and farmed salmonids including *Salmo salar* and *S. trutta* (several groups in Ireland, Scotland and Norway).

Identification of Gaps

To promote discussion, several topics concerning apparent gaps in research were proposed.

Genetics

John Burka reported that some work is ongoing on sea lice genetics between North America (Pacific and Atlantic coasts) and Europe, as well as in other areas, primarily by European researchers. He also has “wild” lice from Magaguadavic River for comparison with “farmed” lice to forward to them. Also, NRC are pursuing research on sea lice genomics which will fill major gaps in knowledge about sea lice and may lead to novel methods of treatment. Thus, additional work to these on sea lice population genetics is not considered a priority.

Modeling

Sea lice abundance has been predicted from sea temperature and generation times, and efforts to assess infestation risk from farmed, escaped farm, and wild fish are continuing in Norway. However, no mathematical model of sea lice population dynamics linked to dispersal rates is available that could be used to predict the risk of infestations at farm sites.

Stewart Johnson felt modeling of lice populations might be very site-specific, but could be useful in identifying factors that are important in sea lice infestations.

Mark Costello felt a quantitative approach to estimating the risk of sealice infestations would help sealice management by identifying the most important factors influencing infestations in different situations, and as a tool for predicting the need for treatment. New insights would be gained from comparing the situation in east Atlantic, west Atlantic and Pacific oceans, where sea temperature, climate, and the occurrence of wild salmonid species, varies significantly.

Dispersal

Sea lice larvae are planktonic but probably control their distribution in the water column to maximise their encounter with a host. Most planktonic organisms have developed mechanisms to influence their distribution in the sea. Laboratory and cage experiments suggest lice may use vertical migration behaviour, but how this may affect host encounter is not known. This information is critical to estimating the risk of infestation between farms, and between wild and farmed fish. Recent research on lice reaction to light by Dr Inigo Novales Flamarique (Simon Fraser University) suggests it may be more sophisticated than realised, and that light traps might be usefully developed for larval sampling or as lice-traps.

Treatments

Gaps remain in knowledge of chemotherapeutic efficacy:

► How effective are treatments; how long is protection; timing of treatments with respect to smolt entry timing.

► Environmental impact of treatments.

► Identification of risk factors (we understand many of the hazards).

► How to reduce amount of chemical getting into environment by refining treatment strategies.

► Impact of husbandry factors on sea lice infestations, e.g., net fouling (frequency of net changes or treatment).

Several groups are studying chemotherapeutics, including manufacturers, government agencies and AVC. This work should continue.

Other methods of reducing lice abundance may work in some sites, including exposing fish to freshwater for a period (hours to days), use of cleaner-fish (successful in Norway but less options in Canada), and lice capture during grading and harvesting of fish (so lice are not released back into the sea where they will re-infest other fish).

It was also suggested that there was a need for an aquaculture research farm for conducting experiments due to the difficulties and compromises when conducting research on commercial farms.

Funding Sources

There is a range of funding opportunities (Table 2). Several are being used or applied for by Canadian researchers, such as NSERC, AquaNet, NRC and Genome Canada.

DFO (Les Burridge) and HMSC (Mark Costello) have been awarded a joint internship for 2002-2003 that will assist with developing the sea lice network, including mailing lists, newsletters, maintenance of a bibliography of publications, email listserver, and organisation of meetings.

Conclusions

Sea lice network

- Agreed this would be useful; should start with "small" goals – initially would be mainly a communications network.
- No specific research proposals at this time.
- Need to expand network to include more industry reps, especially vets. Also need to include pharmaceutical companies.
- Suggested having annual meetings.

Sea lice 2003: North American Workshop

- Suggested having a workshop at St Andrews Aquaculture Fair in June 2003.
- Talks would be targeted at letting industry know what research is going on.
- Could include invited speakers.
- Mark Costello and Blythe Chang to work on organising it.
- May get DFO and/or AquaNet sponsorship.

Sea lice 2003 International Conference

American Society of Parasitologists annual meeting will be around 3-6 August 2003 in Halifax, in association with the British Parasitology Society.

- Suggest having sea lice meeting in St Andrews immediately before, for two days (depending on interest); expect 60-100 delegates.

Table 2. Some areas of potential funding for research on sea lice in North America

- Natural Sciences and Engineering Research Council (NSERC) (for Canadian universities), Strategic, Collaborative (international), Industrial (need industry cash), Research Network, Centre of Excellence
- AquaNet – NSERC Network
- Genome Canada
- Aquaculture Collaborative Research and Development Program (for DFO and industry)
- Atlantic Canada Opportunities Agency, Atlantic Innovation Fund (ACOA AIF)
- National Science Foundation USA
- Visiting fellowships programs
- Industrial Research Assistant Programme/National Research Council (IRAP/NRC), industry fish farms, chemotherapeutant manufacturers, biotechnology companies.

- The EU SEARCH project may hold its Canadian meeting in association with this conference.
- Leave topic broad, e.g., 'Advances in Sea Lice Biology and Control.'

- Stewart Johnson offered to be liaison with ASP meeting.
- Neil Ross and John Burka also offered to help organise the meeting.
- Mark Costello and Blythe Chang to be local organisers.
- Agreed to proceed.

Recommendations

Network

Establish a network of persons interested in sea lice biology and control with the aim of communicating information of mutual interest and thereby facilitating development of new research activity and better management.

2003 workshop

Investigate holding a:

- Day workshop with a few invited speakers, and
- Briefing for industry of current sea lice research and development in association with the St Andrews Aquaculture Fair this June 2003.

2003 International Conference

Proceed with planning for an international conference in July 2003 in St Andrews, prior to the American Society of Parasitologists annual meeting (3-6 August 2003 in Halifax). ■

Database of people interested in sea lice biology and control

A database of people interested in sea lice biology and control was compiled as part of the EU FAIR-CT96-1615, "Biology and Management in the Control of Lice on Fish Farms," final report. At present, there are 308 individuals in the projects database, from 27 countries (Table 3) and, at present, approximately 33% of the people in the database are from industry (Table 4) whereas 27% were from industry in 1999.

Table 3. Number of subscribers per country

UK	106	Russia	2
Norway	64	The Netherlands	2
Ireland	57	Brazil	1
Canada	27	Denmark	1
USA	12	Egypt	1
Chile	8	Faeroe Islands	1
Australia	3	Germany	1
Finland	3	Israel	1
France	3	New Zealand	1
Japan	3	Republic of China	1
Argentina	2	Republic of Korea	1
Greece	2	Spain	1
Northern Ireland	2	Sweden	1
		Switzerland	1
		TOTAL	308

Table 4. Occupation of persons in the database

Position	Number	Percentage (%)
Academic/government (general)	95	30.8
Researcher	54	17.5
Industry (general)	50	16.2
Lecturer/professor, researcher	18	5.8
Researcher	16	5.2
Research student	11	3.6
Manager/Director	9	2.9
Fish veterinarian	9	2.9
Fish farmer	7	2.3
Aquaculture consultant/advisor	7	2.3
Laboratory/Technical/Veterinarian	2	0.6
Sales and Marketing	2	0.6
Fisheries inspector	1	0.3
Unknown	27	8.8
TOTAL	308	100

Salmon farming: towards an integrated pest management strategy for sea lice

Report on the international conference on sea lice management, Aberdeen Scotland, June 18-19, 2001

The Aberdeen conference was attended by approximately 100 delegates from government and non-government agencies, universities, the salmon farming industry, pharmaceutical companies and feed companies from five different countries.

Invited speakers addressed topics relating to sea lice management, ranging from recent scientific advances to current management practices as well as regulatory frameworks in various European salmon farming countries.

There was considerable interest in the discussion on practical aspects of managing farms to limit sea lice and therefore the number of treatments necessary.

A poster session was held, with approximately 20 posters presented. Papers dealt with historical aspects, veterinary medicines, resistance development, control strategies using semiochemicals, biological control using cleaner-fish and potential pathogens of sea lice, selective breeding of salmon for sea lice resistance, vaccine development, epidemiology and models, interactions between farms and wild fish, and role of regulatory processes and discharge consents. Items of interest included:

- Sea lice products make up less than 1% of animal care pharmaceuticals – it remains a small player, therefore difficult to get companies to develop products.
- In Scotland and Ireland, >5% of annual production is lost to the effects of sea lice and sea lice treatments. Ireland estimates a cost of

£80-100 (~Can\$200) per tonne of production to treat for sea lice.

- In-feed treatments seem very popular, but you can't be sure every fish has eaten; it's possible that fish that don't eat provide a source of young lice.
- No vaccines in the foreseeable future.
- Infestations of lice are two times greater at 0-4m of water column than at 4-8m. Demand feeders can keep fish lower in the water and help manage the problem.
- Some advances with semiochemicals. It appears as though lice can be attracted to a salmon "smell" and that there may be a future for traps – this is still very much a research area.
- Work is ongoing with heritability of resistance in salmon and with managing resistance in lice. Suggestion is to use several therapeutants in a coordinated manner within bay management areas – may require farmers to use a pesticide they don't like.
- Ireland has a monitoring program that clearly defines triggers for treatment. Includes monthly reports; no two-sea winter fish; all results are made public.
- Epidemiological models are being developed using Marine Harvest's database. Interesting to note fallowing for longer than 30 days doesn't improve louse numbers compared to a 30-day fallow. Increased stocking density may actually lower the number of mobile lice!
- Strategic treatments: It is well known in

Scotland and Norway that single year-class management plus fallowing eliminates the need for treatment in year one of the production cycle. A significant chalimus spike occurs between week 22 and 25. Some suggestion to treat bays (they use hydrogen peroxide) on weeks 11, 17 and 23. This reduces the chalimus spike by 60%, reduces the number of treatments by 50%, and results in better growth and quality. Advocate prophylactic treatment of bays in late fall or early spring. Recommend larger bay management areas. Keep fish satiated at depth (>4m). Finally, crop rotation with gadoids.

➤ Interference with wild fish: Could plan production cycle to avoid having second-year fish near estuaries with known trout/salmon runs. Therefore no treatments in the spring of the year.

➤ Norway also has enforced monitoring with specific triggers for treatment and public records of use of chemotherapeutants.

- The conference was organized by Dr A.J. Mordue (Luntz) and Dr A.W. Pike on behalf of the Scotland section of the SCI at the University of Aberdeen, 18-19 June, 2001.

- The conference proceedings volume contained nearly all of the presented papers and was published as a special issue of Pest Management Science Volume (2002) Vol 58: pp.513-629.

- This article was prepared from text kindly provided by L. Burrige, A.J. Mordue and A. Pilgrimage.

Publications related to sea lice biology and control, 2000-2002

Anon (2000). "New approach to louse treatment." *Fish Farmer* May/June 2000: 39.

Abgrall P., R.W. Rangeley, Burrige, L.E., and Lawton, P. (2000). "Sub-lethal effects of azamethiphos on shelter use by juvenile lobsters (*Homarus americanus*)." *Aquaculture* 181: 1-10.

Bell, S., J.E. Bron, and Sommerville, C. (2000). "The distribution of exocrine glands in *Lepeophtheirus salmonis* and *Caligus elongatus* (Copepoda: Caligidae)." *Contributions to Zoology* 69(1/2): 9-20.

Bjorn, P.A., B. Finstad, and Kristoffersen, R. (2001). "Salmon lice infection of wild sea trout and Arctic char in marine and freshwaters: the effects of salmon farms." *Aquaculture Research* 32: 947-962.

Bjorn, P.A., and B. Finstad (2002). "Salmon lice, *Lepeophtheirus salmonis* (Kroyer), infestation in sympatric populations of Arctic char, *Salvelinus alpinus* L., and sea trout, *Salmo trutta* L., in areas near and distant from salmon farms." *ICES Journal of Marine Sciences* 59: 131-139.

Boxaspen, K., and T. Naess (2000). "Development of eggs and the planktonic

stages of salmon lice, *Lepeophtheirus salmonis*, at low temperatures." *Contributions to Zoology* 69(1/2): 51-55.

Boxaspen, K., and J.C. Holm (2001). "The development of pyrethrum-based treatments against the ectoparasitic salmon lice *Lepeophtheirus salmonis* in sea cage rearing of Atlantic salmon *Salmo salar* L." *Aquaculture Research* 32: 701-707.

Branson, E. (2000). "Chance to get on top of sea lice problem." *Fish Farmer* 23(1): 8.

Branson, E.J., S.S. Ronsberg, and Ritchie, G. (2000). "Efficacy of teflubenzuron (Calicide) for the treatment of sea lice, *Lepeophtheirus salmonis* (Kroyer 1837), infestations of farmed Atlantic salmon, *Salmo salar* L." *Aquaculture Research* 31(11): 861-867.

Bron, J.E., A.P. Shinn, and Sommerville, C. (2000). "Moulting in the chalimus larva of the salmon louse *Lepeophtheirus salmonis* (Copepoda, Caligidae)." *Contributions to Zoology* 69(1/2): 31-38.

Bron, J.E., A.P. Shinn, and Sommerville, C. (2000). "Ultrastructure of the cuticle of

the chalimus larva of the salmon louse *Lepeophtheirus salmonis* (Kroyer, 1837) (Copepoda: Caligidae)." *Contributions to Zoology* 69(1/2): 39-49.

Burrige, L.E., K. Haya, Page, F., Waddy, S.L., Zitko, V., and Wade, J. (2000). "The lethality of the cypermethrin formulation Excis to larval and post-larval stages of the American lobster, *Homarus americanus*." *Aquaculture* 182 (1-2): 37-47.

Burrige, L.E., K. Haya, Waddy, S.L., and Wade, J. (2000). "The lethality of anti-sea lice formulations Salmosan (azamethiphos) and Excis (cypermethrin) to stage IV and adult lobsters (*Homarus americanus*) during repeated short-term exposures." *Aquaculture* 182 (1-2): 27-35.

Costelloe, M., J. Costelloe, O'Donoghue, G., Coghlan, N., and O'Connor, B. (2000). "A review of field studies on planktonic larvae of *Lepeophtheirus salmonis* on the west coast of Ireland." *Caligus* (6): 15-16.

Davies, I.M. and G.K. Rodger (2000). "A review of the use of ivermectin as a treatment for

- sea lice, *Lepeophtheirus salmonis* (Kroyer) and *Caligus elongatus* Nordmann, infestation in farmed Atlantic salmon *Salmo salar* L." *Aquaculture Research* **31**(11): 869-883.
- Devine, G.J., I. Denhlo, and Horsberg, T.E. (2000).** "Chemotherapeutant resistance in sea lice: what is it and what can be done about it?" *Caligus* **(6)**: 12-14.
- Fast, M.D., J.F. Burka, Johnson, S.C., and Ross, N.W. (2001).** "Sea lice (*Lepeophtheirus salmonis*) secretions in the presence of salmonid mucus." *Aquaculture Association Canada, Special Publication No 5*, 46-49.
- Fast, M.D., N.W. Ross, Mustafa, A., Sims, D.E., Johnson, S.C., Conboy, G.A., Speare, D.J., Johnson, G., and Burka, J.F. (2002).** "Susceptibility of rainbow trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*) and Atlantic salmon (*Salmo salar*) to experimental infection with *Lepeophtheirus salmonis*." *Diseases of Aquatic Organisms*, **52**, 57-68.
- Fast, M.D., J.F. Burka, Johnson, S.C., and Ross, N.W. (2003).** "Enzymes released from *Lepeophtheirus salmonis* in response to mucus from different salmonids." *Journal of Parasitology*, in press.
- Finstad, B., P.A. Bjorn, Grimnes, A., and Hvidsten, N.A. (2000).** "Laboratory and field investigations of salmon lice, *Lepeophtheirus salmonis* (Kroyer), infestation on Atlantic salmon (*Salmo salar*) post-smolts." *Aquaculture Research* **31**(11): 795-803.
- Glover, K.A., F. Nilsen, Skaala, O., Taggart, J.B., and Teale, A.J. (2001).** "Differences in susceptibility to sea lice infection between a sea run and a freshwater resident population of brown trout." *Journal of Fish Biology* **59**: 1512-1519.
- Gonzalez-Alanis, P., G.M. Wright, Johnson, S.C., and Burka, J.F. (2001).** "Frontal filament morphogenesis in the salmon louse *Lepeophtheirus salmonis*." *Journal of Parasitology* **87**: 561 - 574.
- Heuch, P.A., J.R. Nordhagen, and Schram, T.A. (2000).** "Egg production in the salmon louse, *Lepeophtheirus salmonis* (Kroyer), in relation to origin and water temperature." *Aquaculture Research* **31**(11): 805-814.
- Heuch, P.A., J.A. Knutsen, Knutsen, H., and Schram, T.A. (2002).** "Salinity and temperature effects on sea lice overwintering on sea trout (*Salmo trutta*) in coastal areas of the Skagerrak." *Journal of the Marine Biological Association, United Kingdom*, **82**: 887-892.
- Johnson, S.C., K.V. Ewart, Osborne, J.A., Delage, D., Ross, N.W., and Murray, H.M. (2002).** "Molecular cloning of trypsin cDNAs and trypsin gene expression in the salmon louse *Lepeophtheirus salmonis* (Copepoda: Caligidae)." *Parasitology Research*, **88**, 789-796.
- Johnson, S.C., K.V. Ewart, Osborne, J.A., McIntosh, S.E., Stratton, L., and Ross, N.W. (2001).** "Expressed sequence tags (ESTs) of the salmon louse, *Lepeophtheirus salmonis*." *Bulletin of the Aquaculture Association of Canada* **100**(1): 8-12.
- Lyndon, A.R. and J.P.G. Toovey (2001).** "Occurrence of gravid salmon lice, *Lepeophtheirus salmonis* (Kroyer), on saithe (*Pollachius virens*) from salmon farm cages." *Bulletin of the European Association of Fish Pathologists* **21**(2): 84-85.
- McCarney, P., L. Copley, Kennedy, S., Nulty, C., and Jackson, D. (2002).** National survey of sea lice, *Lepeophtheirus salmonis* (Kroyer) and *Caligus elongatus* Nordmann, on fish farms in Ireland, 2001. Marine Institute, Galway.
- Mustafa, A., G.A. Conboy, and Burka, J.F. (2001).** "Life span and reproductive capacity of sea lice, *Lepeophtheirus salmonis*, under laboratory conditions." *Aquaculture Association of Canada Special Publication No 4*: 113-114.
- Nagasawa, K. (2001).** "Annual changes in the population size of the salmon louse *Lepeophtheirus salmonis* (Copepoda: Caligidae) on high-seas Pacific salmon (*Oncorhynchus* spp.), and relationship to host abundance." *Hydrobiologia* **453/454**: 411-416.
- Nolan, D.T., N.M. Ruane, van der Heijden, Y., Quabius, E.S., Costelloe, J., and Wendelaar Bonga, S.E. (2000).** "Juvenile *Lepeophtheirus salmonis* (Kroyer) affect the skin and gills of rainbow trout *Oncorhynchus mykiss* (Walbaum), and the host response to a handling procedure." *Aquaculture Research* **31**(11): 823-833.
- Novales Flamarique, I., H.I. Browman, Belanger, M., and Boaxaspen, K. (2000).** "Ontogenetic changes in visual sensitivity of the parasitic salmon louse *Lepeophtheirus salmonis*." *Journal of Experimental Biology* **203**: 1649-1657.
- Poole, W.R., D. Nolan, and Tully, O. (2000).** "Modelling the effects of capture and sea lice *Lepeophtheirus salmonis* (Kroyer) infestation on the cortisol stress response in trout." *Aquaculture Research* **31**(11): 835-841.
- Revie, C.W., G. Gettinby, Treasurer, J.W., and Rae, G.H. (2002).** "The epidemiology of the sea lice, *Caligus elongatus* Nordmann, in marine aquaculture of Atlantic salmon, *Salmo salar* L., in Scotland." *Journal of Fish Diseases* **25**: 391-399.
- Roth, M. (2000).** "The availability and use of chemotherapeutic sea lice control products." *Contributions to Zoology* **69**(1/2): 109-118.
- Schram, T.A. (2000).** "The egg string attachment mechanism in salmon lice *Lepeophtheirus salmonis* (Copepoda: Caligidae)." *Contributions to Zoology* **69**(1/2): 21-29.
- Shinn, A.P., B.A. Banks, Tange, N., Bron, A.P., Sommerville, C., Aoki, T., and Wootten, R. (2000).** "Utility of 18S rDNA and ITS sequences as population markers for *Lepeophtheirus salmonis* (Copepoda: Caligidae) parasitising Atlantic salmon (*Salmo salar*) in Scotland." *Contributions to Zoology* **69**(1/2): 89-98.
- Stone, J., S. Boyd, Somerville, C., Richards, C., and Varma, K.J. (2002).** "An evaluation of freshwater bath treatments for the control of sea lice, *Lepeophtheirus salmonis* (Kroyer), infections in Atlantic salmon, *Salmo salar* L." *Journal of Fish Diseases* **25**: 371-373.
- Stone, J., I.H. Sutherland, Sommerville, C., Richards, C., and Varma, K.J. (2000).** "Field trials to evaluate the efficacy of emamectin benzoate in the control of sea lice, *Lepeophtheirus salmonis* (Kroyer) and *Caligus elongatus* Nordmann, infestations in Atlantic salmon *Salmo salar* L." *Aquaculture* **186**: 205-219.
- Stone, J., I.H. Sutherland, Sommerville, C., Richards, C., and Varma, K.J. (2000).** "Commercial trials using emamectin benzoate to control sea lice *Lepeophtheirus salmonis* (Kroyer) infestations in Atlantic salmon *Salmo salar* L." *Diseases of Aquatic Organisms* **41**: 141-149.
- Stone, J., I.H. Sutherland, Sommerville, C., Richards, R.H., and Endris, R.G. (2000).** "The duration of efficacy following oral treatment with emamectin benzoate against infestations of sea lice, *Lepeophtheirus salmonis* (Kroyer), in Atlantic salmon *Salmo salar* L." *Journal of Fish Diseases* **23**: 185-192.
- Treasurer, J.W., S. Wadsworth, and Grant, A. (2000).** "Resistance of sea lice, *Lepeophtheirus salmonis* (Kroyer), to hydrogen peroxide on farmed Atlantic salmon, *Salmo salar* L." *Aquaculture Research* **31**(11): 855-860.
- Tucker, C.S., C. Sommerville, and Wooten, R. (2000).** "The effect of temperature and salinity on the settlement and survival of copepodids of *Lepeophtheirus salmonis* (Kroyer, 1837) on Atlantic salmon, *Salmo salar* L." *Journal of Fish Diseases* **23**: 309-320.
- Tully, O. and Y. McFadden (2000).** "Variation in sensitivity of sea lice *Lepeophtheirus salmonis* (Kroyer) to dichlorvos on Irish salmon farms in 1991-92." *Aquaculture Research* **31**(11): 849-854.
- Waddy, S.L., L.E. Burrridge, Hamilton, M.N., and Mercer, S.M. (2002).** "Preliminary results on the response of the American lobster to emamectin benzoate, the active ingredient in Slice." *Aquaculture Canada 2001: Proceedings of the Contributed Papers to the 18th Annual Meeting of the Aquaculture Association of Canada, Halifax, N.S., May 6-9, 2001. Aquaculture Association of Canada Special Publication No 5*: 56-59.
- Waddy, S.L., L.E. Burrridge, Haya, K., Hamilton, M.N., and Mercer, S.M. (2002).** "Response of preovigerous lobster to azamethiphos varies with concentration, number of exposures, and time of year." *Aquaculture Canada 2001: Proceedings of the Contributed Papers to the 18th Annual Meeting of the Aquaculture Association of Canada, Halifax, N.S., May 6-9, 2001. Aquaculture Association of Canada Special Publication No 5*: 60-63.
- Waddy, S.L., L.E. Burrridge, Hamilton, M.N., Mercer, S.M., Aiken, D.E., and Haya, K. (2002).** "Emamectin benzoate induces molting in American lobster, *Homarus americanus*." *Canadian Journal of Fisheries and Aquatic Sciences* **59**: 1096-1099.

Draft Timetable

Sea Lice 2003 Conference, St Andrews Biological Station Conference Centre

<p>Wednesday 1st July 2003 08:00-21:00: Welcome Reception and Registration at Anderson House</p>	<p>16:00-16:20 B.A.Dixon, J.B. Taaggart, A.P. Shinn, C. Sommerville Analysis of genetic differentiation in <i>L.salmonis</i> populations in Scotland 16:20-16:40 J.E.Bron, C. Sommerville, A.J. Teale, H.H.Reese Differential gene expression in the copepodid larva of the salmon louse <i>L.salmonis</i> 19:30 Conference Dinner at Anderson House</p>
<p>Thursday 2nd July 08:00-09:00 Registration and Opening 09:00-09:10 Welcome (Tom Sепhton) 09:10-09:20 Introduction (Mark Costello)</p> <p>EPIDEMIOLOGY ON FARMS 09:00-09:40 Peter Heuch, C.W. Revie, G. Gettinb y Comparison of epidemiological patterns of salmon lice (<i>Lepeophtheirus salmonis</i>) infections in Norway and Scotland 10:00-10:10 John Burka, K.L.Hammel, J.M.Ramsa y Initial, laboratory and field studies to monitor and control sea lice infestations on farmed Atlantic salmon 10:00-10:20 P.J.Douglas, R. Wootten, C. Sommerville Experimental <i>Lepeophtheirus hippoglossi</i> infections of Atlantic halibut: an experimental study 10:20-10:50 Break and poster session</p> <p>EPIDEMIOLOGY - DISPERSAL 10:50-11:10 James Treasurer Experimental and natural routes of <i>L. salmonis</i> and <i>Caligus elongatus</i> challenge and consequences for distribution of chlamydia on salmonids 11:10-11:30 Brid O'Shea, A.J.Mordue (Luntz), I.R.Bricknell Host preferences of the salmon louse, <i>L.salmonis</i> 11:30-11:50 Margaret McKibben, D.W. Haya Seasonal planktonic distribution of salmon lice <i>L. salmonis</i> larvae in inter-tidal plankton samples in Loch Torridon, Western Scotland, in relation to local salmon farm sea lice levels 12:10-12:30 M.J. Penston, M.McKibben, D.W. Haya, W. and P.A.Gillibrand Distributions of sea lice larvae in Loch Shieldaig, Western Scotland 12:30-13:00 Lunch</p> <p>EPIDEMIOLOGY - WILD FISH 13:00-13:50 G.Gettinb y, K.McCart, E.McKenzie, C.W. Revie Time series models of sea lice <i>Caligus elongatus</i> abundance on Atlantic salmon <i>Salmo salar</i> in the Loch Sunart region in Scotland 14:00-14:10 Jonathan Carr, F. Whorisk ey Sea lice infestation rates on wild and escaped Atlantic salmon in the Magaguadavic river, New Brunswick 14:10-14:30 A.Morton, R.Routledge, Cory Peet, A.Ladwig Establishment of the salmon louse <i>L. salmonis</i> on juvenile pink salmon <i>Oncorhynchus gorbuscha</i> in British Columbia 14:30-14:50 Alasdair McVicar Are salmon lice infections in farms a real hazard to wild salmonid populations? 15:00-15:20 Break and Poster Session</p> <p>GENETICS 15:40-16:00 M. Freeman, A.Bell, C. Sommerville First report of a microsporidian hyperparasite infecting the salmon louse, <i>L.salmonis</i>: a phylogenetic study based on ribosomal DNA sequences 16:00-16:10 Oivind Oines Using mitochondrial DNA to discern population differences in the sea louse <i>Caligus elongatus</i></p>	<p>Thursday 3rd July 09:00-09:10 Introduction (Blythe Chang)</p> <p>BIOLOGY 09:10-09:30 I.R.Bricknell, J.E.Bron, P. Cook, K.Adamson Is blood an important component of the diet of sea lice? 09:30-09:50 S.Bell, J.E.Bron, C. Sommerville Histochemical properties and functional considerations of the exocrine glands of <i>salmonis</i> 09:50-10:10 Derek J.Jamieson Aspects of the biochemistry of the sea louse, <i>L.salmonis</i> 10:10-10:30 Mark Fast, S. C. Johnson, J. F. Burka, N. W. Ross Differences in comparative susceptibility and its relationship to possible immunomodulatory compounds secreted by <i>L.salmonis</i> 10:30-11:00 Break and Poster Session</p> <p>TREATMENT 11:00-11:20 Michael Pietrak, H.Michael Opitz Evaluation of three potential methods for preventing the spread of the salmon louse 11:20-11:40 Per Gunnar Kvenseseth, J.Solgaard, J.Andreassen Successful control of sea lice (<i>L.salmonis</i>) in full-scale salmon farming in Norway fry farm to smolt transfer until slaughtering by the use of cleanerfish 11:40-12:00 Jillian Westcott, K.L.Hammel, H.Stryhn, J.F. Burka Monitoring sea lice treatments and sea lice resistance to emamectin benzoate (SLIC) in Atlantic salmon 12:00-12:30 Lunch</p> <p>ECOTOXICOLOGY 13:40-14:00 Kate Willis, N.Ling The toxicity of sea lice chemotherapeutants to non-target planktonic copepods 14:00-14:20 Burridge, L.E., M.N.Hamilton, S.L. Waddy, K.Haya, S.M.Mercer, R.Greenhalgh, R. Tauber, L.Crouch, P.Wislocki, R.Endris Acute toxicity of emamectin benzoate in fish feed to the American lobster, <i>Homarus americanus</i> 14:20-14:40 Kenny Black "The ecological effects of medicines used for controlling sea lice on farmed salmon in Scotland" 14:40-15:30 Break and Poster Session</p> <p>DISCUSSION 15:30-16:30 Discussion on best practice in sea lice control (Chair: Mark Costello)</p> <p>19:00 Dinner at Anderson House</p> <p>Friday 4th July: FIELD TRIPS</p>

Poster Presentations

Number	Authors	Title
1	Tom Walsh, A.R. Lyndon, D.J. Jamieson	The manganese superoxide dismutase (MnSOD) of the sea louse, <i>L. salmonis</i>
2	Tom Walsh, A.R. Lyndon, D.J. Jamieson	Identification of cDNA clones from <i>L. salmonis</i> encoding for proteins expressed in response to trichlorophen by suppression subtractive hybridization
3	R. Norman, R. Gratacap, C. Sommerville	A mathematical model of sea lice (<i>L. salmonis</i>) population dynamics on Atlantic salmon <i>S. salar</i>
4	D. Schnapp, D. Harper, C. Sommerville, D. Watt, S. Durand, and M. Martin	Microorganisms with potential for use as biological control agents for <i>L. salmonis</i>
5	A.P. Shinn, J.E. Bron, Clegg	The discrimination of Scottish <i>L. salmonis</i> populations: an investigation using cuticular elemental signatures
6	Nicholas Tribble, F.S.B. Kibenge, J.F. Burka	Investigation of P-glycoproteins as a mechanism for sea lice resistance to avermectins
7	Kate Willis, Elizabeth Cook, and Matias Lozano-Fernandez	Aquaculture-related introductions of the caprellid amphipod <i>Caprella mutica</i>
8	Antoine Vigneau, I. Bricknell, R.S. Raynard, and P. Billingsley	Sea louse amino-peptidase: a unique form of this enzyme
9	Martin Krkosek, Mark Lewis, and John Volpe	The mathematical epidemiology of sea lice (<i>L. salmonis</i>) in salmon farms and the interaction between aquaculture and wild Pacific salmon
10	Sandra Bravo	Efficacy of the treatments used for the control of <i>Caligus</i> in Chile
11	Les Burridge, Kats Haya, and Blythe Chang	A summary of ecotoxicological studies with anti-sea lice pesticides conducted