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Annual Report
Salmon Health Consortium

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Prepared by R Armstrong, DVM, DVSc
Executive Director
31 March, 1995

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Executive Summary

The Salmon Health Consortium (SHC) continues to work toward approval of safe and effective therapeutants for Canadian fish culture. The second year of the project has seen completion of the following major milestones:

- approval of PARASITE-S as an ectoparasiticide for fish;
- completion of an Investigational New Drug submission for a Gram negative antimicrobial;
- granting of emergency permits for sea lice treatment in New Brunswick; and
- co-sponsorship of three workshops on fish therapeutant and health management issues.

The SHC is also working with product manufacturers to prepare regulatory submissions for therapeutants to meet the remaining priorities of Canada's fish culture industry.

The SHC's Second Annual Report is not an update of the first report, but rather provides additional new information for fish culturists on:

- a technical pharmaceutical meeting sponsored by the Atlantic Veterinary College and the SHC;
- the contribution of the Department of Fisheries and Oceans to the approval of safe and effective fish culture therapeutants;
- quality assessment/quality control, HACCP, fish culture, and therapeutant use in Canada;
- quality control and fish culture in Chile.

These reports were all circulated in draft form to SHC supporters throughout the year for their information and comment. Please contact the SHC on how to become a supporter if you find this report useful.

The technical pharmaceutical meeting addressed basic scientific questions regarding fish pharmacokinetics that need to be resolved to assist regulatory approval of safe and effective aquaculture therapeutants. The first SHC Annual Report estimated that a $2 million investment in basic pharmacokinetic research is required to address this area.

The basic scientific questions relate to:

- difficulties in designing study protocols to generate pharmaceutical regulatory data;
- developing the "crop-grouping" concept;
- physiologically-based pharmacokinetic models for aquaculture pharmaceutical use.

The Department of Fisheries and Oceans (DFO), as lead agency for aquaculture, has assisted with aquaculture pharmaceutical research. Further progress toward SHC objectives can be facilitated with support from DFO, and the SHC First Annual Report recommended that DFO:

- recognize the immediate need for availability of additional safe and effective treatments for fish culture management in Canada;
- provide funding for, and cooperate in, the development of essential safety data to secure this availability;
- facilitate and lead an interdepartmental and federal–provincial initiative to resolve identified therapeutant availability and use concerns; and
- ensure that people with industry experience and technical qualifications are placed in industry development positions.

DFO has achieved progress toward these objectives, but future actions could be reduced by program review and budget cuts. Aquaculture will be a part of the fishery of the future, and DFO has an opportunity to guide and support sustainable development of this industry as a part of the solution to current fishery crises. The new Federal Aquaculture Strategy identifies this opportunity and now must be implemented to resolve aquaculture development constraints. Therapeutant approval is one constraint — and one that can be addressed by government–industry partnerships.

Product inspection and quality control to prevent tissue residues is an activity that has involved government–industry partnerships. Responsible and accountable therapeutant use in Canadian aquaculture ensures a continued supply of high quality, fresh, cultured Canadian

salmon in international markets. Responsible therapeutant use is provided by veterinary supervision of disease diagnosis and treatment application. Industry accountability is ensured through random testing by government inspectors.

Regulatory authorities around the world are replacing test-based inspection programs with audit-based systems. The latter require processors to maintain their own safety procedures, conduct their own tests, and keep detailed records of these actions. In Canada, DFO has introduced a Quality Management Program (QMP); in the United States, the Office of Seafood Safety, USFDA is introducing a mandatory Hazard Analysis at Critical Control Points (HACCP) regulation; and European Community nations are requiring the ISO 9002 system.

Audit programs are extending product inspection beyond processors to include fish producers, where actions are required to control tissue residues. The programs create a direct link between quality assurance at the processing plant and therapeutant use procedures on fish culture operations. Processors monitor fish received at the plant as a "Critical Control Point" for residue prevention and ensure that producers have safe treatment application procedures in place. A large proportion of Canadian fish are exported to the United States; therefore Canadian processors and producers will have to meet the mandatory HACCP regulation being introduced in the US. The US program proposes "zero tolerance" for unapproved therapeutant use. This could affect therapeutant use on Canadian farms because approved aquaculture therapeutants differ between Canada and the United States.

Audit based quality control programs are reported to cost governments less, improve safety control procedures, and further reduce the risk of residues. However, this additional safety is not mirrored by changes in therapeutant approval regulations. Residue testing by processors will raise technical questions about the inherent errors of very sensitive testing procedures, and could be more advantageous to industry if conducted before harvest.

Chilean exporters to the United States will also have to meet the HACCP requirements, and may be affected differently than Canadians, who already work within an audit-based QMP system. This could be an advantage for Canada, that will be lost if the Canadian QM Program is not accepted as equivalent by the US administration, or if the QMP system is not flexible in adapting to US–required changes.

Chilean producers are reported to have the advantage of industry self-regulated therapeutant use, although therapeutant use regulations are now being updated by the Chilean government in consultation with fish farmers. However, Chilean salmon also enjoy a reputation for quality on international markets and Chilean producers recognize the importance of quality standards to their international market share. The Chilean Salmon Farmers Association has a quality control (QC) program that sets baseline standards for processors. Products that meet the standards are entitled to use a quality seal for market recognition.

The Chilean QC program extends beyond processing to include production therapeutant use by recommending a mandatory withdrawal period of 500 degree days. This withdrawal period is based on international scientific literature and health management requirements of Chilean producers. Other Chilean actions related to production quality control are:

- a commitment to professional fish health management;
- development of improved treatment methods; and
- support for research into health management alternatives.

The Salmon Health Consortium looks forward to a third year that will see continued progress toward approval of safe and effective therapeutants for Canadian fish culturists. Fish culturists can assist approvals by:

- supporting the SHC through their aquaculture associations;
- purchasing and using only approved products;
- working with veterinary professionals in the diagnosis and treatment of fish health problems; and
- ensuring that governments recognize that approved safe and effective treatments are a priority for successful fish culture.

Toward Salmon Health in the Year 2000: Aquaculture Pharmaceutical Research

Report completed June 30, 1994

Acknowledgements

Many individuals assisted in the planning, preparation and running of this successful meeting. In particular James Bellamy, Gerald Johnson, Jim Brackett, Don Rainnie, and Kim Whitman from the University of Prince Edward Island; John Cosmopoulos, Dan Stechey and Shawn Connors of DFO; Gordon Snow and Alain Gauthier of Agriculture and Agri-Foods Canada and Sandra Matheson of Enterprise PEI provided significant support.

Introduction

Basic fish pharmacokinetic research is one of eight priorities that need to be addressed to resolve the therapeutant availability predicament of Canadian fish farmers. The SHC estimates that a $2 million investment in basic pharmacokinetic research is an initial requirement to address this area.[1] This investment is based on eight "scientist years" of work — perhaps two full-time researchers devoted to this topic for four years — with sufficient funding to support salaries, technicians and laboratory overhead. This research does not need to be completed in Canada and success could be achieved through international collaboration.

The objective of the research will be to resolve several basic questions regarding the way fish absorb and metabolize therapeutants, to ensure that efficient regulatory approval of safe and effective products can be achieved. Three of these questions are:

- How similar are different species? Can drugs can be labelled for use in all salmon based on work in a single species, or for use in halibut based on salmonid research?
- Is fish physiology sufficiently similar in fresh and salt water that pharmacokinetic data from one environment is appropriate in the other?
- How do water temperature changes affect fish pharmacokinetics?

Answers to these questions will allow safety and efficacy data that apply to a broad range of physical drug use circumstances to be developed under a limited range of laboratory conditions.

A technical meeting to review this possibility, sponsored by the Atlantic Veterinary College and the Salmon Health Consortium, was held June 8 and 9, 1994, in Charlottetown, Prince Edward Island. Experts from Canada, the United States and Norway met to address these questions and anticipate the projects and resources that will be required. Four keynote speakers provided the core scientific expertise:

Dr. D. Rainnie,
Atlantic Veterinary College;
Dr. W.H. Gingerich,
United States National Biological Survey;
Dr. F.C.P. Law,
Simon Fraser University; and
Dr. T.E. Horsberg,
Norwegian College of Veterinary Medicine.

Each scientist made one or more presentations, and participated in a wrap-up forum that addressed specific issues. The titles of keynote presentations were:

- Constraints affecting design of pharmaceutical study protocols required to meet regulatory data needs, D. Rainnie;
- Aquaculture pharmaceutical development issues in the United States, W.H. Gingerich;
- Developing the "crop-grouping" concept for the US aquaculture industry, W.H. Gingerich;
- Development and significance of physiologically-based pharmacokinetic models for aquaculture, F.C.P. Law;
- Aquaculture pharmaceutical development issues in Norway, T.E. Horsberg; and
- Use of a pre-slaughter screening program

to facilitate pharmaceutical availability in Norway, T.E. Horsberg.

Additional presentations were made by:

- Dr. R. Armstrong, Salmon Health Consortium;
- Dr. J. Brackett, Atlantic Veterinary College;
- Dr. D. Wilson, Canadian Animal Health Institute;
- Dr. M. Joyce, Private Consultant;
- Dr. P. Dick, ELANCO Animal Health;
- Dr. R. Le Gouvello, Stermor;
- Dr. D. Doering, AquaPharm Technologies;
- Dr. L. Hammell, Atlantic Veterinary College;
- Dr. M. Sheppard, Moore-Clark Company (Canada);
- Dr. D. Landry, Bureau of Veterinary Drugs.

This report is not a proceedings, but a discussion of issues raised during the meeting, with a view to establishing directions for aquaculture pharmaceutical research. These scientific issues are divided into two sections: *Problems to be Addressed* and *Potential Solutions.*

Readers interested in details of the presentations are advised to contact the speakers.

Problems to be addressed

Each speaker identified a number of considerations that must be addressed in designing and completing pharmacokinetic studies in fish. The majority of the considerations relate to Human Safety requirements, focusing in particular on residue depletion. It is not surprising that this issue receives the most intense scrutiny given the need to ensure consumer safety and confidence in aquaculture produce. The following is an outline of these problems grouped into general subject areas.

Lack of fish pharmacokinetic knowledge

Water temperature has a significant effect on fish pharmacokinetics because temperature changes alter the rate of fish metabolism. However, the specific effect of water temperature on tissue residue distribution and depletion is not well described. The concept of "degree days" has been used to resolve this issue for regulatory purposes in some jurisdictions. However, degree days do not work well under all circumstances; therefore this concept has not been acceptable to Canadian regulators. For example, lower water temperatures at the time of treatment do not necessarily mean that longer residue depletion times will be required because low water temperatures reduce feeding rates and rates of drug absorption.

Therefore, what water temperature should be used for fish pharmaceutical work? Experimental work could be completed at a "species optimum" temperature, but how is "species optimum" determined? An alternative may be to develop a "worst case scenario" and complete residue depletion studies under this specific set of conditions. The withdrawal period would be established based on the worst case, and then modified by the prescribing veterinarian if conditions are more favourable.

Procedures such as anesthesia can interact with fish metabolism and affect study results. For example, it may not be advisable to treat fish with tricaine methanesulfonate before oral gavaging in pharmacokinetic studies. What effect do other common laboratory procedures have on study results?

Drug issues

Classes of drugs may have specific behaviours in different fish species that prevent development of approvals for multiple food fish species. How can these products be identified? Traditional fish treatments, e.g., Chloramine-T for control of Bacterial Gill Disease, may have a narrow margin of safety that will be a concern for regulatory approval agencies. Analytical method development is a problem with older drugs for which sensitive chemical techniques have not been developed and validated. In the United States, specific requirements for interlaboratory comparisons among residue detection procedures need to be completed. Interlaboratory variation will become a more prominent issue as processors are required to complete their own product testing when the mandatory US FDA HACCP program is introduced.[2]

Financial issues

Regulatory requirements for fish therapeutant approvals are more extensive than for mammalian species because of these temperature and species considerations. This increases the cost of approvals, reduces product availability and increases costs to producers. For example, manufacturers cannot afford to use two fish residue depletion studies to replace the one study that would be required for an equivalent mammalian food animal approval. Regulators, scientists and industry must cooperate to develop cost-effective alternatives that will permit approval of safe and effective products for aquaculture.

Regulatory issues

Fish drug approval has a major focus on residue prevention, and regulatory concerns naturally centre on human safety questions. Harmonization of approval requirements, rather than just residue levels, with other countries would be a worthwhile objective. Regulatory agencies can take greater advantage of a "worldwide body of knowledge" supporting therapeutant approval data. An initial step would be to harmonize approval requirements so that similar research protocols are required for data development.

Manufacturers also need a formal approval system for their experimental protocols, perhaps through closer collaboration with regulatory agencies in many countries. One particular example related to fish residue research is the uncertainty over whether muscle residue depletion times should be ascertained with skin on or off.

Regulatory guidelines are needed that can be realistically fulfilled and that consider the cost-benefit of the resulting data — eco-toxicity study requirements in particular can be an "endless story".

Orphan (unpatentable) drugs[3] may need specific regulatory consideration to ensure manufacturer support. Canadian regulators are proposing a solution to this problem — give manufacturers five years of protection for generic drugs that receive an approval based on new information.

Some regulations related to both therapeutant approval and fish disease management discourage farmers from consulting health professionals. The effect of these regulations may be counter to their intention. Another regulatory concern, particularly in the United States is that lack of available treatments could put a threatened species in further jeopardy. Concerns regarding endangered species have led to compassionate INAD's for malachite green in the United States.

Experimental animals

A homogeneous population of fish is not yet available that can be used for planning experimental protocols. Lack of an experimental animal makes it difficult to obtain results that can be readily replicated. Fish for a study should also represent the most probable field treatment population — in contrast to the need for a uniform population.

Large numbers of fish may be required for studies and fish of the desired size for a study may not be available at the time the experiment is starting. Studies may have to be timed to fish availability.

Fish are extremely sensitive to husbandry changes and water quality. Therefore, considerable planning is required to ensure that studies reflect the manipulated experimental variable and not environmental changes in the holding facilities.

Experimental models are not available for some economically significant fish diseases such as *Vibrio salmonicida* infection.

Field trial issues

Field trials require detailed planning, and are generally the last stage in completing research on a product before submission for approval. However, the inherent uncertainties of commercial activities can lead to failure to complete field studies. Problems include mortality from plankton blooms or other diseases; unexplained loss of fish, possibly through predation; and unpredicted changes in farm ownership or management. All parties involved must recognize the need for confidentiality on the part of both the manufacturer and the farm. Some fish pro-

ducers find the risks too high to consider participation in field trials. Negative controls are perceived to be a source of health problems for the farm — although compensation for mortalities may help to bring farms into trials. Finding revenue for this compensation may be a problem given the already high cost of approval research.

Communication and careful planning are required to ensure that farm management and workers comply with the trial protocol. Routine regrouping of fish as a normal husbandry activity is a particular problem to consider in trial design.

Manufacturer issues

There is great market risk in developing therapeutants for fish, because sales are not likely to recoup development costs. Therefore manufacturers can only consider products for development that have a low technological risk. Therapeutants for fish culture tend to be extensions of products already developed for use in terrestrial animal veterinary medicine.

Therapeutant manufacturers must work to build partnerships with the fish culture industry, in spite of possible conflicts of interest. These collaborations may be with multinational producer corporations and supply industries, particularly in the feed manufacturing industry.

One participant summarized the above issues by describing therapeutant approval as an R&D component of a vicious cycle facing fish culture (Figure 1). This cycle can be broken through cooperative support of research and development, requiring both public and private funding possibly through industry/government partnerships. Cooperative investment in R&D leading to therapeutant approval will increase industry production efficiency and lead to increasing profitability, and so on around the cycle.

Two potential solutions

This section of the report describes two scientific concepts that could help to resolve scientific questions and facilitate approval of safe and effective therapeutants for fish culture.These two solutions primarily address the issue of tissue residue depletion under the variable conditions encountered in commercial fish culture because of the importance of human safety questions. The concepts are: *Physiologically-*

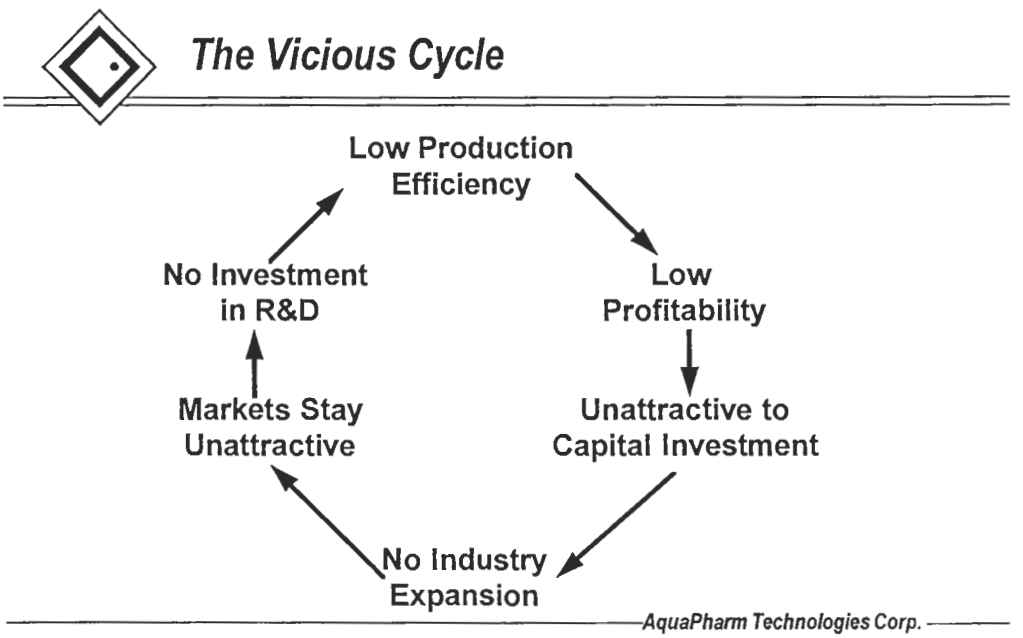

Figure 1.

based Pharmacokinetic Models and *Crop-grouping.*

A third concept discussed at the meeting was *the Norwegian Pre-harvest Residue Screening Program.* This program has been described previously.[1]

Physiologically-based pharmacokinetic models

These are mathematical models that calculate the distribution of a drug into fish tissues over time. The equations are based on blood flow rates into a series of body compartments. These "physiological" models are distinct from the "classical" model which forms the basis for current regulatory decisions. The classical model considers the body as a single compartment and describes the residue depletion rate as an exponential mathematical function. Physiological models can be more readily adapted between different physiological conditions such as different age, size or even species by changing the blood flow rate parameter. However, classical models do not adapt well to different physiological situations. (For a scientific review see Gerlowski and Jain[4]).

The ready availability of powerful computers, and the development of physiological data for fish have helped Dr. F. Law of Simon Fraser University to create a model for oxytetracycline treatment of salmon. This initial model has performed very well in field tests, where actual tissue residue levels in treated fish were compared to those the model predicted at different time periods. Further refinement of the model could lead to reasonably accurate prediction of tissue residue depletion times under the changing dosages, temperatures, ages and species of fish that may be treated in fish culture.

Crop-grouping

The National Biological Service (NBS) is a US scientific agency that is working to address the approval of therapeutants for public fish culture use. This group estimates that approval of one drug for treatment of one disease in one fish species will cost US$3.5 million. Extension of this approval to another disease of fish or another species will cost at least a further US$250,000. Therefore this agency calculates that approvals to meet the needs of the 52 fish species they culture will cost a total of US$170 million. One way to reduce this cost is to present evidence to regulatory agencies proving that an approval in one species provides the data that also supports approval in another species. In this "crop grouping" concept, a single surrogate species may represent multiple like–species.

Dr. W. Gingerich of the NBS has been involved in designing and initiating research work to support crop-grouping. The initial steps have been to look at "abiotic" (environmental) and "biotic" (fish) variables that affect fish pharmacokinetics. Greater taxonomic separation between species increase the range of biotic variables, while differences in abiotic variables (e.g., water temperature and chemistry) increase between different fish habitats. Consideration of habitat and taxonomic variation is the basis for an example crop-grouping proposal shown in Figure 2 — that possibly best illustrates the complexity of the concept. Generally the crop grouping concept is not as relevant to Canadian aquaculture at present which grows salmonids almost exclusively. Future diversification to new species will increase the relevance of this concept.

Each of the four invited scientists was presented with a specific question to discuss with the objective of recommending solutions. Dr. Don Landry of the Bureau of Veterinary Drugs also participated and commented on the issues from a regulatory perspective.

Questions for discussion

The specific question for discussion is printed in italics. Abbreviated recommendations, concerns and ideas produced by the whole group during the discussion are listed in point form following the question.

Dr. D. Rainnie

Is it possible to standardize experimental conditions for international acceptance of approval data?

- How should the optimum temperature be determined?
- How do fish metabolism and excretion change at different temperatures?

- Downward temperature acclimation of experimental animals must be very slow to be successful.
- Good Laboratory Practices (GLP) substantially increase costs, but are necessary if protocols are to be accepted internationally.
- Protocols must be directed at managing disease problems as they occur in fish culture.
- Protocols must be standardized without becoming overwhelmed in detail.

Dr. T. E. Horsberg

How can consumer safety be assured if fish are marketed after treatment with pharmaceutical products still in the approval process?

- Regulatory agencies should ensure mammalian metabolism and depletion studies are in place before use on food fish.
- An experimental withdrawal period with an increased safety margin can be established.
- A two-step approval process resolving residue questions first will encourage field trials.

Dr. W. Gingerich

Is there a way to simplify approval requirements for multiple species drug applications?

- This is not a problem in Canada considering the focus on salmonids.
- The problem could be resolved by facilitating off-label use rather than by changing approval requirements.
- Inherent withdrawal times that occur as a result of fish culture practices should be considered in label extensions to new species.
- Approval data requirements must be restricted to key safety issues only.
- International harmonization of regulatory requirements is a key factor, and international harmonization of product approvals is a desirable goal.
- Manufacturers could seek pre-approval of experimental protocols in those countries where approval will be sought.

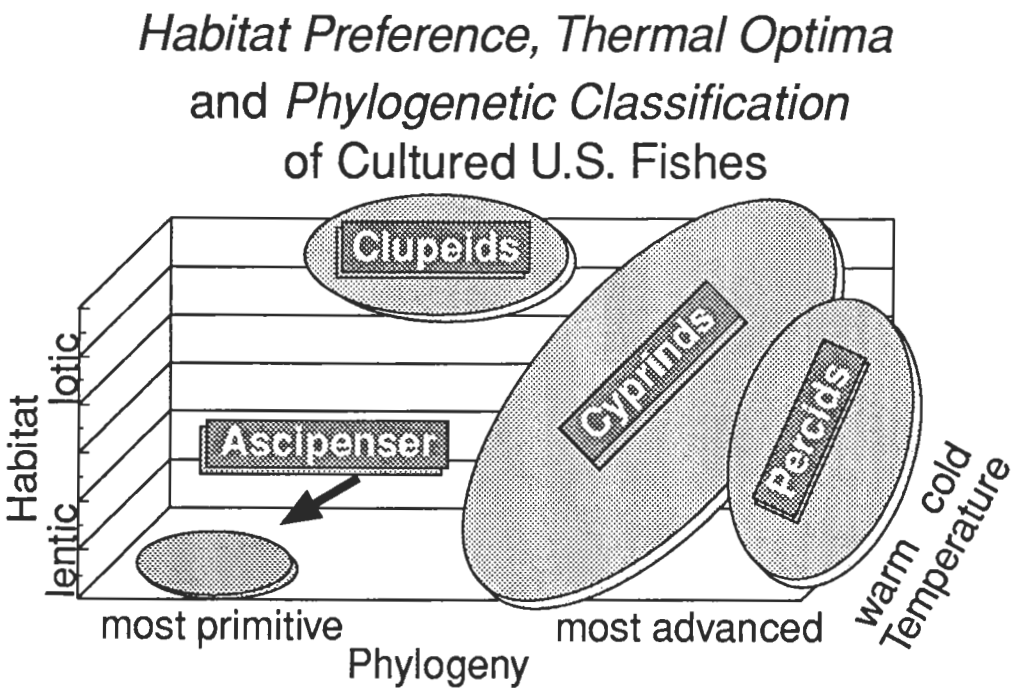

Figure 2.

Dr. F. Law

How can pharmacokinetic models be incorporated into regulatory requirements?

- The model must have sufficient validation to be acceptable for regulatory requirements.
- Physiological models could be used in parallel with classical models until they receive wider acceptance by regulators and industry.
- A marker tissue for residues must still be identified.
- Harmonization between Canadian and American requirements could be a problem if Canada adopts a new approach.
- How will results from these models be incorporated into product labels?
- Will prescribing veterinarians be liable if residues occur in fish treated with prescription including a withdrawal period based on a model?

Conclusions

It will not be simple to resolve the scientific questions raised by the need for approval of safe and effective fish culture therapeutants. However, the human safety component of aquaculture therapeutant approval is the critical area to address because of its importance to consumer confidence and regulatory cost. This area should be a priority for fish pharmacokinetic research funding. There must be increased international cooperation in the sharing of product approval data and regulatory agency review decisions.

Physiologically-based pharmacokinetic models are an available and valid potential solution that require further exploration. However, they do not fit well into current regulatory requirements that rely on the classical model. These models may be better adapted for use outside of the drug approval framework, for example by providing guidance in off-label use of a therapeutant. Pharmaceutical manufacturers will need time to assess the use of physiological models before they can adopt these models as a marketing tool for new products. Fish health practitioners will need to assess the liability concerns in using withdrawal periods based on mathematical models. A pre-harvest screening program could be a solution to this liability concern, while further enhancing consumer safety and product quality.

One suggestion that has come from discussions at the technical meeting is to use a "worst case" scenario for approval, possibly leading to a lengthy recommended withdrawal period. Veterinarians could then reduce this period on off-label prescription, using a validated physiological model to establish the shortened residue depletion time. Approval costs for manufacturers would be reduced because a single set of experimental parameters would be required for residue depletion work. Model development would not be a regulatory requirement, it would be developed as a technical support service possibly through cooperation ("partnership") between manufacturer, producer and government. Finally, a pre-harvest test could be applied to the treated fish. The Bureau of Veterinary Drugs sponsored a follow-up meeting in Ottawa, 13 April 1995, to discuss physiologically based pharmacokinetic models in fish.

Crop-grouping is a valuable concept requiring considerable work; however, the concept still requires a great deal of thought and development before it can be considered for regulatory use. In Canada, crop-grouping is not a priority because of the overwhelming fish culture emphasis on salmonid species. The crop-grouping concept will become more important in future as the fish culture industry diversifies.

The Department of Fisheries and Oceans has supported the concept of industry/government "partnerships" to conduct research. The next section further explores DFO contributions toward therapeutant approvals.

The Contribution of the Department of Fisheries and Oceans to Approval of Safe and Effective Fish Culture Therapeutants

Report completed September 30, 1994

Acknowledgements

Many individuals assisted by providing information for this report. In particular, Mr. John Cosmopoulos provided invaluable assistance in assessing DFO progress in support of therapeutant development. Ms. Iola Price of DFO Science prepared several documents that provide much of the information discussed herein, and took time on a number of occasions to discuss the issue at length. This task would not have been undertaken without her contribution.

Introduction

The Salmon Health Consortium Annual Report for 1993 summarized the role of the Department of Fisheries and Oceans in supporting the availability of safe and effective therapeutants for Canadian fish culturists.[5] This report concluded with specific recommendations, including a number of suggestions how DFO could assist in the resolution of problems caused by lack of approved treatments.[6] These recommendations were that DFO, as the federal lead agency for aquaculture:

> A. Recognize the immediate need for availability of additional safe and effective treatments for fish culture management in Canada;
>
> B. Provide funding for, and cooperate in, the development of essential safety data to secure this availability;
>
> C. Facilitate and lead an interdepartmental and federal provincial initiative to resolve identified therapeutant availability and use concerns; and
>
> D. Ensure that people with industry experience and technical qualifications are placed in industry development positions.

This report expands on each of these recommendations, examines achievements the Department has already made and describes current DFO activities. Finally, there is a look at the future, in the context of program review, budget cuts and the Federal Aquaculture Development Strategy.

Recognition of the immediate need for availability of additional safe and effective treatments for fish culture management in Canada

This recommendation was made because previously published DFO policy regarding aquaculture therapeutants[7] did not support the legitimate need of the aquaculture industry for therapeutant availability.

DFO has now released the Federal Aquaculture Development Strategy,[8] a document that specifically recognizes the need for therapeutant availability.

The strategic plan has general commitments that support the need for available safe and effective therapeutants under several headings including research, technology transfer, training and development, regulatory framework, environmental sustainability, and product safety and inspection. The Strategy hands the responsibility for addressing competitiveness factors, including therapeutant availability, to industry (p. 9). Industry must respond by taking the lead in identifying priorities, and developing partnerships that will resolve the problem.

The Aquaculture Development Strategy commits to the following specific actions related to therapeutant development (followed by the component where the action is identified):

- Enhance research efforts to develop techniques for monitoring therapeutant residues in products (Research);
- In conjunction with the provinces/territories, design and deliver seminars, workshops and training programs to industry on inspection, product safety, and the safe use of therapeutants in aquaculture (Product Safety and Inspection);
- Coordinate approaches to ensure the availability of safe and effective therapeutants for use in aquaculture (Product Safety and Inspection).

These actions give DFO Science a continuing role in therapeutant approval related research, but the Strategy places the coordinating role for therapeutant development within the Product Safety and Inspection group. This is a progressive step given the growing emphasis on safe and effective therapeutant use as a requirement of international quality control programs.

The objective now is to implement this strategy, and the aquaculture industry must continue to pressure the federal government to turn this supportive document into supportive actions. Industry representatives to proposed Aquaculture Implementation Committees must ensure that therapeutant availability continues to be a priority. The implementation of the Strategy will be affected by the outcome of the DFO corporate review process, part of the overall government corporate review undertaken to meet reduced budgets. The corporate review process could take DFO in the opposite direction from supporting aquaculture development, and industry must continue to monitor the Department's actions to ensure the goals of the Federal Strategy are achieved.

Funding for, and cooperaion in, the development of essential data to secure available safe and effective treatments

DFO has contributed considerable resources (money and personnel) over the past ten years to "increase the number of safe and effective therapeutants for the aquaculture industry". This work was documented in a table prepared, and widely distributed, by DFO Science.[9] However, as recognized in a letter from the Honourable Brian Tobin,[10] this effort has not yet led to regulatory approval of any new therapeutants. This underlines the SHC position that therapeutant approval is a difficult and time consuming objective.

A critical question to address is: How can this public investment be made more effectively so that successful approvals are achieved? The answer to this question has two components: 1) Focus on a few priorities, and 2) Work closely with product manufacturers.

Focus on a few priorities

DFO Science has recently come under criticism[11] for the management of its investment in R&D. The NABST report produced a number of general recommendations for improving R&D investment, including the need to establish a system for priority-setting. There is evidence that DFO investment in therapeutant R&D is moving toward industry priorities, perhaps

Table 1. Department of Fisheries and Oceans R&D investment in industry therapeutant priority areas.

Year	O&M$ on priority	Total O&M$ for Therapeutant Research	Proportion on Priority
1989/90	0	32,200	0
1990/91	0	15,000	0
1991/92	0	53,950	0
1992/93	12,000	67,250	19
1993/94	93,725	143,725	65

in response to the efforts of the SHC. This evidence is presented in the following recalculation of DFO investment in priorities (Table 1).

The trend to support of industry needs demonstrates the value of having an industry–led initiative to bring important issues to the attention of administrators in Ottawa. Some aspects of past conflicts between industry and the Department may have been the result of miscommunication or misunderstanding.

Work closely with product manufacturers

The manufacturing section of a product submission (NDS) is an essential component for regulatory approval. The Bureau of Veterinary Drugs does not review other sections of the NDS until it has cleared the manufacturing review. Then, the manufacturer must maintain the submission and respond to possible additional requirements once the Notice of Compliance (giving approval for sale in Canada) has been granted. Therefore, cooperation with a supportive pharmaceutical manufacturer is absolutely essential in the effort to obtain additional safe and effective therapeutants. Only ten of the thirty projects identified by the DFO report were conducted with endorsement from the product manufacturer. The difficulties in encouraging DFO–manufacturer cooperation include:

- need for confidentiality agreements;
- difficulty of arranging payment for public laboratory services by private sources;
- need for meeting corporate deadlines in completing final reports;
- lack of GLP certification at DFO laboratories; and,
- differences between research priorities of private and public institutions.

These difficulties are not insurmountable, and one valuable function of the SHC is to bridge the gulf between public and private R&D requirements. As a model for this, the SHC has been able to facilitate cooperation between the non-government Huntsman Marine Science Centre, the DFO laboratory at St Andrews, the New Brunswick Department of Fisheries and Aquaculture, and the New Brunswick Salmon Growers Association to prepare and fund a proposal for environmental impact research on sea lice treatments.

Facilitation and leading of an interdepartmental and federal/ provincial initiative to resolve identified therapeutant availability and use concerns

The Aquaculture Policy and Strategic Planning Group in DFO has brought together an interdepartmental steering committee to address federal government issues regarding the aquaculture industry. The Salmon Health Consortium has made a presentation to this steering committee regarding the importance of therapeutant availability to fish culture industry competitiveness. To assist DFO with background for the Federal Strategy and for preparing a departmental policy, the Salmon Health Consortium made a similar presentation to a meeting of DFO headquarters staff concerned with this issue.

DFO is now preparing the policy on aquaculture therapeutant use, and there have been indications of considerable progress on this objective. The Federal Aquaculture Development Strategy[12] specifically includes references to available safe and effective therapeutants and offers federal commitments, described earlier in this report. Furthermore, the Strategy recognizes that available safe and effective therapeutants are a factor in ensuring that the Canadian industry remains internationally competitive.

A supportive Strategy is not a solution — implementation is now critical. The first action is a review of federal regulations and policies affecting aquaculture. The SHC has identified the following problems for this review:

- High regulatory requirement costs, slow regulatory reviews, small market size and scarce public research funds to support regulatory science have led to lack of approved safe and effective therapeutants for aquaculture. Priority areas with no approved products are: an anesthetic, a sea lice treatment, a Bacterial Gill Disease treatment, and a Gram positive antibacterial. Lack of therapeutant availability compared to other producing countries is restricting the ability of producers to man-

age disease and therefore the international competitiveness of Canadian fish culture.
- Slow reviews of veterinary biologic submissions are impeding development of new vaccine products for the fish culture industry.
- The DFO Inspection system needs to have a policy that negotiations toward acceptance of QMP as equivalent by the US FDA HACCP program are a priority. This will help avoid potential export barriers to the US, the largest market for Canadian cultured fish.
- Lack of harmonization between the Fisheries Act and Pest Control Products Act, and between federal and provincial pesticide requirements; experimental and restricted uses are obstructing the development and testing of sea lice control products.
- The Patent Medicine Prices Review Board is affecting aquaculture product approval by manufacturers even though product price is a market issue between fish culturists and manufacturers.
- Current Fish Health Regulation guidelines specify egg disinfection procedures and identify specific products although no drug has been approved for this indication.
- Public fish culture facilities (federal and provincial) must have a policy in place that enforces the use of only approved therapeutants in fish culture operations.

At least five provincial issues will also need to be addressed:
- Provincial environmental regulations, including pesticide permits and water discharge permits, affect therapeutant use.
- Provincial fish culture facilities require approved therapeutants for fish management.
- Provincial Pharmacy and Veterinary Acts affect product sales and distribution.
- Provincial funding support for industry development research needs to be coordinated to support the national problem of therapeutant approval.
- Provincial technical extension experts can assist industry in safe and effective therapeutant use.

There is considerable consultation between DFO and provincial government representatives on a wide range of issues, and fish culture therapeutant availability should be included as a topic for discussion.

Provincial governments are supporting the Salmon Health Consortium project. The BC Ministry of Agriculture, Fisheries and Food is a major sponsor with a strong financial contribution. The Ontario Ministry of Agriculture, Food and Rural Affairs and the Prince Edward Island government are providing project funding. The Consortium is also working with representatives of other Maritime provincial governments, where fish culture represents an important industry providing revenue and employment.

Placement of people with industry experience and technical qualifications in industry development positions

The 1995 federal budget is not going to permit increases in DFO staffing — the opposite is expected. However, when opportunities arise to add to Departmental staffing in aquaculture developmental positions, then industry experience should be a critical consideration. This will give DFO the background depth necessary to understand, and participate in the resolution of, complex technical issues — like therapeutant approval. The Department has moved progressively in this direction, for example by contracting a consultant with considerable industry experience, Mr. Dan Stechey, to lead the Aquaculture Policy and Program Planning group.

Perhaps the focus of this recommendation should be on retaining people with proven records of productivity because reduction in DFO staffing levels is projected. DFO Science is the largest departmental section by employee numbers (person years, or py), and this section could be hard hit by downsizing. DFO scientists are likely to face reductions of already constricted base budgets and will have to look increasingly beyond the Department for their research funding. The result will be more partnerships with universities, research institutes and industry. These partnerships will be directed toward industry research priorities to get industry funding, with consequently less need for central coordination of DFO scientific activity. However, as noted in the recent Program

Review report by the Science team, this group is already "top-heavy at the Director level".[13]

There are many examples of successful partnerships between the aquaculture industry and scientists in regional DFO research institutes. These partnerships will increase the opportunity for industry to obtain research support to address its priorities, but industry will have additional responsibilities as well. These include:

- increased stable funding for research that includes some basic and applied components;
- effective communication of priorities to public administrators; and,
- a long term horizon when establishing research priorities.

A stable, long term approach addressing a few priorities is critical for therapeutant approvals. A successful therapeutant project can take several years to complete, and frequent changes in priorities will result in few projects reaching completion.

The future

The Department of Fisheries and Oceans is now at a crossroads. Decisions taken in the next year will have a long term effect on the development of the aquaculture industry, and, more specifically, fish culture therapeutant approval research. It is critical that the Department accept that it has a positive role in aquaculture industry development, as part of a future sustainable fishery. This positive DFO role will include, as paraphrased from the Strategy:

- assistance with research leading to approval of safe and effective therapeutants for fish culturists;
- delivering training programs on inspection, product safety, and the safe use of therapeutants in aquaculture;
- coordinating approaches to ensure the availability of safe and effective therapeutants for use in aquaculture (Product Safety and Inspection).

DFO could take the other fork at this crossroads and follow a substantial body of opinion within the Department that endorses a very conservative mandate. This would see DFO focusing solely on conservation and protection — important objectives that are receiving a lot of public attention as a result of recent events, such as the crisis in East Coast groundfish stocks, conflicts with other fishing nations, and the disappearance of Pacific salmon in the Fraser River. These crises are particularly serious clinical signs of a worldwide trend.[14] The Department must reduce its budget, therefore it is tempting for DFO to retreat to these areas of core expertise and traditional responsibility.

A pure conservation and protection mandate would lead to DFO involvement with aquaculture as a regulatory agency only. This DFO mandate would be equivalent to Environment Canada objectives on land — objectives that are increasingly becoming provincial responsibilities. Therefore, DFO could merge with Environment Canada into a broader "resource conservation" agency, and possibly become a provincial responsibility if it chooses to follow this direction.

A more positive approach would be for DFO to accept a responsibility for sustainable development of the fishery in addition to resource conservation and habitat protection. The aquaculture industry will be a part of this fishery of the future. "Sustainable development" is a concept that has many different interpretations, but it accepts that industry, including aquaculture, can be a long term activity in balance with its environment. DFO support for this concept will provide the rationale to accept aquaculture development and work with the industry to address regulatory and technical constraints. Therapeutant approval is one such constraint that should be addressed, and needs the Department's support.

Quality Assessment/Quality Control, HACCP, Fish Culture, Therapeutants and the Salmon Health Consortium

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Introduction

The Salmon Health Consortium is working to ensure that approved effective therapeutants are used safely by the industry when necessary. The aquaculture industry recognizes that consumer concerns arise from therapeutant use in food animals, and that producers, veterinarians and governments must cooperate to continue to prevent the occurrence of therapeutant residues in fish sold for consumption. Responsible and accountable therapeutant use will ensure a continued high quality supply of fresh cultured salmon in the market place.

Responsibilities that come with approved therapeutant use include:

- obtaining professional diagnosis and administering treatments based on prescriptions;
- producer compliance with therapeutant label and prescription directions;
- strict adherence to prescribed withdrawal periods, exceeding these where possible.

Fish culture industry accountability is provided through independent verification, including random testing of products. In Canada, the federal government conducts a system of random checks, supervised by the Inspection Branch, Department of Fisheries and Oceans, under a Memorandum of Understanding with Health Canada. DFO Inspection maintains testing laboratories, has analytical techniques for residues of approved therapeutants, and takes random samples of fish tissue from processing lines and imported products for residue analysis. A positive sample is reported to Health Canada and followed up by increased sampling and holding of fish from that source.

This system of "policing" compliance by a series of random checks has worked effectively to provide the consumer with a safe product. However, there is increasing interest from regulatory authorities in moving to an audit system that ensures processors and producers maintain their own safety procedures and keep detailed records of these procedures. An audit system puts the responsibility for maintaining safety onto the industry and gives government the roles of setting standards and checking records ("auditing") to ensure that appropriate safety procedures are being carried out.

Audit programs may allow government to monitor safety throughout the production and processing industries with fewer staff. Industry will be required to pay for their own product inspection, and sampling, while residue analyses will be provided by competitive private service suppliers. This system is expected to improve safety while reducing government expenditures, rather than using cost recovery through charges for existing inspection programs.

This report describes:

- the main features of audit safety programs;
- producer quality assurance measures associated with therapeutant use;
- issues that arise from the introduction of these programs.

Audit safety programs

In Canada, the Department of Fisheries and Oceans has worked with processors since 1986 to prepare and introduce a Quality Management Program (QMP) for fish processing plants. In the United States, the Office of Seafood Safety (USFDA) is introducing a mandatory Hazard Analysis at Critical Control Points (HACCP)[15] regulation as an audit program, expected to be in place in 1996. European Community nations are introducing equivalent programs based on the 18 element ISO 9002 system:

> ISO 9002, Quality systems — Model for quality assurance in production and installation. For use when conformance to specific requirements is to be assured by the supplier during production and installation.[16]

1. Management responsibility
2. Quality system
3. Contract review
4. Document control
5. Purchasing
6. Purchaser supplied product
7. Product identification and traceability
8. Process control
9. Inspection and testing
10. Inspection, measuring and test equipment
11. Inspection and test status
12. Control of nonconforming product
13. Corrective action
14. Handling, storage, packaging and delivery
15. Quality records
16. Internal quality audits
17. Training
18. Statistical techniques

Residue control is one of many quality and safety issues for aquaculture products that are addressed by audit-based programs; product freshness, processing plant hygiene and natural marine toxin contamination are examples of other issues. Although residues of approved therapeutants are not a major food safety risk, they are a concern that generates considerable consumer interest.[17] Therefore, the residue prevention aspect of food quality assurance programs must meet close public scrutiny. Remember that one objective of audit-based safety programs is to increase consumer confidence in aquaculture or other seafood products.

These audit-based programs extend quality and safety control beyond processors to include the producer, who must meet required quality standards as a supplier of raw product. Processors are required to document how the fish they receive were cultured and to ensure that specific standards have been met. Therapeutant residues are the major concern; therefore, safe therapeutant use by producers is the major issue that must be proved in this documentation.

The USFDA (Office of Seafood Safety) proposed HACCP regulation provides a model showing how safety requirements will be extended from processors to producers. The regulation requires processors to monitor the fish they receive and ensure that safety procedures to control residues are in place. For example, a draft USFDA *Fish and Fishery Product Hazard Assessment Guide*[18] identifies aquaculture drugs as *Hazard Number 9* and provides the following description: *Contamination of raw material at receipt with unapproved animal drugs or excessive levels of approved animal drugs.*

This guide (pp. 62-65) suggests the critical control point for control of this hazard is the reception of raw product at the plant. Two options are outlined:

1. The processor receives cultured fish directly from a producer, and is knowledgeable of the culture practices.
2. The processor does not know the culture practices.

Under Option 1, the FDA advises the following control measures (summarized):

- determine the harvest location for each lot of fish;
- determine the producer's therapeutant use before harvest, e.g., by annually reviewing production, feeding and medication;
- reject all shipments produced with unapproved or misused therapeutants.

And, under Option 2:

- periodically monitor incoming fish for therapeutants that may have been misused (3 times/supplier/year);

- reject shipments from all suppliers providing fish that exceed critical limits unless convincing evidence can be obtained that only approved therapeutants have been used in a proper manner.

The critical limits suggested by FDA are zero tolerance for use of unapproved therapeutants or detection of unapproved therapeutant residues. "Zero tolerance" will cause problems for analytical laboratories, and could lead to friction between processors, producers and regulators, particularly over the definitions of "unapproved therapeutant". These difficulties will be magnified when variations between practices across international boundaries are considered.

Responsibility and accountability for therapeutant residue control will be given to processing plants under proposed audit regulations. The processor, in turn, hands this on to the producer by seeking assurances of approved therapeutant use and monitoring fish for residues using private laboratory services. In Canada, the QMP program of DFO requires that the processor obtain an affidavit from the producer regarding therapeutant use. There have been questions regarding the legal status of this requirement, as the federal government may not be able to impose a duty on the processor to require an action from a supplier. In British Columbia, specific provincial regulations require producers to provide an affidavit to processors stating that therapeutants have not been used on fish for processing within the previous 105 days, or that the prescribed withdrawal period has been met if less than 105 days has elapsed since the last treatment.

The Canadian QMP program had considerable influence on FDA development of the HACCP regulation, as seen in this excerpt from the Federal Register:[19]

> When faced with similar pressures, Canadian health authorities responsible for seafood safety came to the following conclusion: *The Canadian government, as well as other western governments will be under constant pressure to limit spending as the aging population places more and more demands on services and as the Federal deficit is addressed. This means inspection programs cannot expect to have ever increasing resources to meet the challenges of the 1990's. Smarter and more cost effective ways must be developed to carry out their mandate. The "smarter and more cost effective way" chosen by Canada is* HACCP.

This regulation has a potentially huge impact on Canadian producers and processors because the penalty for exporting companies that are not in compliance could be loss of access to the US market.[20] The industry can avoid this disaster by meeting QMP, HACCP and ISO 9000 regulations as individual companies. However, a more effective solution would be for the Canadian fish culture industry to work with DFO Inspection to ensure the QM Program is considered to be "equivalent" to US and European programs. Industry would then have to meet the needs of only one set of regulations. Discussions are under way on equivalency of US and Canadian quality programs as part of the Free Trade working groups. Progress in this area may have received a set-back with the departure of Mr. Tom Billy, previously Director of the USFDA Office of Seafood Safety, to join the USDA — although international negotiations should not be dependent on individuals.

The extension of safety programs to producers, combined with the emphasis on therapeutant residues, results in a direct relationship between government safety programs and therapeutant use procedures on fish culture operations. This relationship is clearly expressed in the "Quality Analysis/Quality Control" task force co-chaired by USFDA and USDA and reporting to the US Joint Subcommittee on Aquaculture (JSA).[21] This group is addressing the lack of available therapeutants for the US aquaculture industry and at the same time facilitating quality control program development for producer groups that make up the US aquaculture industry.

Canadian producer organizations can also work with quality control regulations by developing standard operating procedures or codes of practice that fulfil audit based program requirements.

Producer quality assurance

Producer Quality Assurance programs are not designed solely for residue prevention, they are "Standard Operating Procedures" that touch on most aspects of farm management. In Europe, several production companies in the United Kingdom and Ireland have obtained ISO 9002 certification on all aspects of production, husbandry, processing and marketing.[22] However, residue prevention is the need that is driving the development of these programs. As described earlier, in the United States a Quality Assessment/Quality Control task force is working on the issue of quality assurance program development for producer groups. The Catfish Farmers of America were one of the first groups to prepare and publish a program. Other programs have also been prepared, or are under development, by the US Trout Farmers Association and the Tilapia Growers Association.

The Catfish Farmers of America (CFA) describe their quality assurance program as "an educational program designed to maintain the consumer love affair with farm-raised catfish".[23] However, the program objective is to educate producers, not consumers, by:

> *improving the skills and knowledge of catfish farm managers, increasing production efficiency.*

Examples of topics covered by the CFA program are:

- Production site selection
- Water supply, quality and management
- Hatchery and brood stock management
- Feeds and feeding management
- Health management

The issue of therapeutant use is covered under the latter section, and includes information on:

- Stress prevention
- Drugs
- Pesticides
- Product labels
- Handling and applying medication
- Extra-label use
- Withdrawal times
- Environmental considerations
- Record keeping
- Storage and disposal of pesticides

The entire program manual is 14 pages long, therefore a lot of subjects are covered in a short space and basic material is presented in an easily understood format for quick reference. This is a voluntary program and producers are encouraged to register with the Catfish Farmers of America to:

> *be included with the many others that are serious about preserving and enhancing the image and market for farm-raised catfish in the United States.*

The Trout Producer Quality Assurance Program[24] identifies the following critical control points (p.19):

- Production site
- Water
- Feed
- Fish health management plan
- Use and administration of FDA approved drugs
- Use and administration of EPA approved water treatments
- Complete quality assurance checklist annually and verify fish wholesomeness

Canadian industry associations are developing Quality programs — the New Brunswick Salmon Growers Association has a technical manager preparing a producer "Code of Practice". It will be critical for such programs to meet the needs of the US mandatory HACCP regulation (until QMP is accepted by US authorities as equivalent), because of the proportion of Canadian cultured fish destined for that market.

Issues arising from audit program introduction

The question that the Salmon Health Consortium would like answered is: "How will quality assurance programs increase the availability of safe and effective fish culture therapeutants?"

This question has received little attention in US producer association program documents or during the US QA/QC group meetings. Quality control programs are desirable because they improve and generalize safety control procedures thereby further reducing the risk of tissue residues. However, these programs are not linked to any review of regulatory requirements

for therapeutant approval. It would be logical to consider that a superior product quality and safety system should allow reduced product review requirements in the therapeutant approval process. Therefore, it is important to ensure that therapeutant approval agency officials are kept aware of safety improvements in fish harvesting, processing and marketing. Improved quality cannot be achieved if the result is that industry products are priced out of international markets.

The linkage between increased safety monitoring of products and the increased availability of therapeutants to producers has not been made in North America. However, the Norwegian therapeutant approval system presents an example of how increased fish culture therapeutant availability can work well with a rigorous product inspection system.[25] Therapeutant regulatory agencies feel comfortable in assisting industry with product availability, knowing that there is careful inspection of products before entering the marketplace. The Chilean experience, described later in this report, shows that an industry driven quality control program can maintain access to international markets and a reputation for quality under a less rigorous therapeutant approval system. North American therapeutant approval regulations should be reviewed to determine which requirements can be reduced after a mandatory and effective quality control program is in place.

Imposing HACCP requirements on countries that export to the US could affect competition between Canadian and Chilean salmon farmers for US markets. Canadian exporters have the advantage of working already with a mandatory government audit-based QM Program — an advantage that could be lost if the Canadian program is not accepted as equivalent by the US. Chilean salmon farmers have an industry-run quality program (described in the next section). This may initially be a disadvantage in negotiating with US officials, who will likely prefer government to government contact. However, this system should offer large, well organized Chilean companies more flexibility in modifying their quality control programs to meet US requirements. Canadians may find our system less flexible or easily adapted if US authorities do not accept the existing QM Program.

Canadian producers will need to consider their legal use of unapproved therapeutants under veterinary off-label prescription. The rights of professionals to use extra-label prescriptions are different between Canada and the US, where extra-label prescriptions cannot be used to prepare medicated feed. Off-label prescriptions would not meet the zero tolerance for unapproved drugs standard set by the US HACCP program, although they would meet the standards of the Canadian QM Program, as long as all prescription requirements were met. Establishing equivalency between QMP and HACCP would resolve this issue.

The Canadian therapeutant approval system is independent from the US system; therefore, products may receive approval for Canadian use, but not for US use. Safe residue levels of such products will be established and legal in Canada, but not in the US. This issue can be resolved by harmonizing Maximum Residue Limits (MRL's) for both countries — an objective of one slowly progressing Free Trade Agreement working group.

The audit-program requirement for residue testing by processors and producers using private laboratories raises technical questions. These include:

- inherent errors of very sensitive testing procedures

  The testing procedures for therapeutant residues are operating near their tolerance limits, and very small variations in procedure can lead to relatively large differences in results. These differences could have a significant impact if regulatory analytical results differ from those of private facilities providing services for processors. This problem has already surfaced as differences among results from tests on the same samples at different labs.
- timing of testing

  Producers would like tests to be carried out before fish are harvested, allowing fish to be held for further residue depletion if there are any concerns from test results. Processors and regulators need to accept the results of pre-harvest fish testing, and producers need to introduce

standardized pre-harvest testing procedures. Standardizing programs of this nature may be best administered through fish culture associations.

The SHC is working with Canadian fish producer associations to educate farmers about responsible, safe and effective therapeutant use. Producers must also carry out this responsibility in a way that meets the needs of government audit-based QMP and HACCP programs. A future role for the SHC may be to monitor audit-based program regulatory requirements and communicate these to producer associations so that they can update their Codes of Practice to meet international quality standards.

Canadian fish culturists will look at the move to audit-based programs and ask:

- Will these programs increase consumer confidence in seafood?
- Will the Canadian QM Program be accepted as equivalent to the US FDA HACCP?
- What will these programs cost the industry?

Answers are not in this report, but readers may like to refer to other sources for more information.[26] It has been suggested that one impact of the proposed US FDA HACCP regulations will be to divert seafood products from the US into expanding new markets.[27] This is not likely to be the case for Canadian farmed salmon, given the international competition for salmon markets.

Critics of the HACCP program in the US suggest the program is a cosmetic change to an unmanageable situation — *like rearranging deck chairs on a seafood Titanic.*[26]

The principal objective of audit-based programs is to ensure consumer confidence; a commodity that is easily lost if there are poor seafood products in the marketplace, or there is significant negative media coverage. Consumers may not distinguish between sources of fish (e.g., commercial harvest vs farmed), therefore the reputation of farmed fish could suffer from problems in commercially harvested fish. To be effective, audit-based programs must be implemented across all domestic and import seafood sources, and the importance of compliance understood by all processors and producers. A single bad-apple could negate the positive efforts of all other sectors of the industry.

Quality Control and Fish Culture in Chile

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Introduction

The Salmon Health Consortium (SHC) is working to ensure that approved safe and effec-

tive therapeutants are available to Canadian fish culturists when necessary. Therapeutant availability is important because effective health management is necessary to maintain our international competitiveness. Over 80% of fish grown in Canada is exported, and Canadian fish competes in international markets with products from countries where access to additional therapeutants contributes to a lower cost of production.

Therapeutant availability in Chile was described in a previous SHC report[28] as essentially self regulated by industry. However, this has been successfully managed by Chilean producers, who have a very good product quality reputation on international markets. Chemical residues in fish tissues have not been a problem in the approximately 600 tonnes of Chilean fish that pass import inspection annually by the Department of Fisheries and Oceans for sale in Canadian markets.

The Individual Training Initiative of the Seafood and Marine Products Branch, Agriculture and AgriFoods Canada and private Canadian corporate sources provided support for an investigation of quality control procedures used in Chile. This report provides results from this investigation, discusses the emphasis within Chile on producing high quality fish for export, and attempts to draw lessons for Canadians from the Chilean success.

The Chilean salmon farming industry

The Chilean salmon farming industry has enjoyed very rapid growth over the last nine years, and farmed fish are now Chile's largest agricultural export. With total production of 80,000 t in 1994, Chile is the second largest producer in the world. Chilean producers export 99% of their fish, with 60% going to Japan, 29% to the US, 7% to Europe, 1% to Canada, and the remainder to other Latin American countries. Production is divided between three species: Atlantic salmon (35,000 t), trout (20,000 t) and coho (25,000 t). Coho and trout are exported almost exclusively to Japan and Europe, while nearly 70% of the Atlantic salmon produced go to North American markets. Total production for 1995 is expected to be close to 100,000 t.

Chilean producers enjoy good production conditions with relatively few fish health problems. The most significant health problem is the Salmon Rickettsia Syndrome (SRS). BKD and sea lice are other endemic infectious health problems, while furunculosis has not been diagnosed on Chilean farms. Average Atlantic salmon mortality level from smolt introduction to harvest is reported to be around 10%, with about half of this due to SRS. BKD is considered to be the next most frequent cause of mortality. SRS occurs primarily in the first sea winter in Atlantic salmon, when the fish are between 500 and 700 g. At this time, producers will frequently treat fish for the condition if the mortality rate is rising rapidly. Fish will not be treated if the condition occurs, but mortality rates stay low. The first fish harvest does not occur until grilse are taken out about 6 months later. Following the first outbreak, Atlantic salmon are apparently resistant to SRS because there is usually no recurrence in the second winter. This resistance suggests that there is a good opportunity for development of a vaccine. Other endemic problems are BKD in coho production and sea lice (*Caligus*) infestation in sea trout production.

While it may appear to outsiders that therapeutant use in Chile is self regulated, producers explain that this is not the case. Pharmaceutical approval regulations are administered through the Public Health Institute and Health Ministry — these allow the use in food fish of products approved in other food animal species. However, there has been a delay in updating government regulatory actions to keep pace with industry growth. Government ministries are now correcting this, and therapeutant use regulations are under development through the Subsecretary for Fish in the Ministry of the Economy.[29] This process will involve consultations with the fish culture industry through the Producers Association[30] and Fundación Chile.[31]

Salmon producers join the Association by paying a fixed membership fee and contributing a further assessment based on their production. Fundación Chile is a private non-profit corporation established in 1976 through a US$25 million grant from ITT Corporation with matching funds from the Chilean government.[32] Its primary role is to develop and transfer technology that builds and diversifies the Chilean econ-

omy. This is achieved by creating companies that demonstrate new technologies to investors and show that the operations can be profitable. New industries are not abandoned once created — Fundación Chile continues to provide technical support to the industry and cooperates closely with the government. Continuing activities in aquaculture include new species development, a substantial commitment to fish health management, and consultation on industry regulations.

Chilean producers are very concerned about their international reputation for quality, and recognize how important this reputation is to market share. Therefore, it is not surprising that the industry is sensitive to criticism, particularly when it is unjustified. For example, a recent scientific article describes an apparent case of Ciguatera intoxication and makes several unsubstantiated references to Chilean salmon.[33] This sensitivity is exacerbated by the experience of the fruit industry several years ago, which has not been forgotten in Chile (grape exports were affected). However, salmon producers suggest that there is international recognition of a notable quality in Chilean salmon, that they think may be associated with rapid growth of their fish in favourable water temperatures.

There is interest from other countries in Chilean quality control procedures. Representatives of the US FDA recently spent several weeks in the salmon farming regions of Chile, meeting with the industry and examining production and treatment procedures. Apparently the FDA representatives expressed favourable comments regarding the industry practices, although there is some frustration in Chile that no report has been made public by the US agency as a result of these visits.

Given this interest in product quality, it is not surprising that the Chilean salmon farming industry has developed their own detailed quality control program.

Quality control programs in Chile

The producers association quality control program

This discussion of Chilean Quality Control will begin with a brief overview, then look at issues related to therapeutant residue prevention. Quality control (QC) program development for Chilean salmon producers was initiated in 1986 through cooperation among large private production corporations, Fundación Chile, and the Salmon Producers Association. Development of this program apparently occurred when many groups independently recognized the need for a QC initiative to meet international market demands. There is now widespread pride in the QC program, perhaps shown by the number and variety of groups that take credit for its initiation. The objective of the Chilean quality control program is to set baseline standards to be met or exceeded by complying processors and producers.

Details of the QC program are published in four manuals:[34]

Manual for salmon processing plants
February 1990, Chilean Salmon Producers Association

Manual for salmon processing
September 1992, Chilean Salmon Producers Association

Sanitary-hygienic code of practice
November 1992, Fundación Chile

New system for quality control
August 1993, Chilean Salmon Producers Association

These manuals focus principally on processing plant management and techniques; each subsequent manual provides additional detail showing the evolution of the program. The first manuals tend to focus on plant hygiene, with later volumes describing a quality seal and recommending standards for additional procedures such as grading. The quality seal was introduced by the Producers Association to provide international recognition for products that were processed according to their quality control

standards. The Producers Association has two QC managers on staff who supervise the program, which now includes 38 different plants processing 80% of Chilean production. The largest of these plants processes 10,000 t annually. Additionally, the Association has contracts with three private companies who carry out random daily processing plant inspections.

The Producers Association is working to develop a strong reputation for the quality control seal in countries that import Chilean salmon. The seal is therefore an international marketing benefit for participating producers. Large production companies enroled in the Producers Association QC program may also have their own internal quality control programs that are superior to the baseline standards set by the Producers Association. At least one company has also sent staff members to the United States to receive education in the HACCP program. Not all Chilean production companies participate in the QC program, although the largest of the non-participants has its own QC program geared to Japanese requirements, and is reported to have expressed interest in joining the Producers Association program in the future.

Another benefit of the Producers Association QC program is the opportunity to complete advance preparations for coming international regulations on quality control standards. The European Community will require ISO 9000 standards for all imports after April 1995, the French government already has very strict QC demands for salmon importers, and the US FDA HACCP program is expected to be mandatory in 1996. Meeting international standards may in the future require that the Producers Association QC program receive Chilean government approval. The government agency involved will be the Servicio Nacional de Pesca (SERNAP), a group within the Economy Ministry. The Producers Association is now working closely with SERNAP to prepare for this eventuality.

The Producers Association recognizes that the QC program must extend beyond processing and apply from "eggs to export" (this sounds similar to the "farm to fork" objective of the US FDA HACCP program). The *Manual for Salmon Processing,* September 1992, introduces this objective in a section entitled *Management of Salmon before Harvest.* This section describes standards or guidelines for: nutrition, therapeutant use, fasting before harvest, and sedation, bleeding, and transport to the plant.

The recommended standard for therapeutant use is a single mandatory withdrawal period of 500 degree days for all treatments with "antibiotics or chemotherapeutics", except Nuvan® (dichlorvos) for which a four day withdrawal period is recommended. The reported minimum water temperature for Chilean production is 8.5°C, therefore this translates to a maximum 58–day clearance time. The three antimicrobial drugs approved for fish use in the United States are also noted in the manual, along with their tolerance levels and the cautionary reminder that tissue residues of any other medications are not permitted in imports to the United States.

The selection of a mandatory 500 degree day withdrawal period is based on review of international scientific therapeutant use literature by the Producers Association, and on the fish disease treatment requirements of Chilean farms that export to North America. The latter companies are exclusively producing Atlantic salmon, with the major treatment indication being SRS in the first sea winter. As stated previously, the first harvest of these fish will not occur for at least another 6 months, providing a considerable inherent withdrawal period. Adoption of the degree day approach suggests the influence of United Kingdom regulations, where withdrawal periods are stated in this way. Future changes in production techniques, health problems, or treatment products may require that the Producers Association review this recommendation. Additionally, with the development of new therapeutant use regulations, producers may wish to adopt a broader range of withdrawal period options based on the pharmacokinetic behaviour of different fish treatments.

Chilean producers recognize that a reputation for quality production can be easily damaged. Some industry representatives suggested the possibility that government help may be useful where a particular company consistently fails to meet quality guidelines, perhaps through non-compliance with the Association QC program. Additionally, Chilean government endorsement will be necessary for recognition of the QC program by regulatory agencies in importing countries.

Additional QC actions related to therapeutant use

Chilean producers have a strong commitment to professional veterinary supervision of fish treatment and production health as both fish health professionals and farm managers. One large producing company has ten veterinarians on staff, and there are more than 30 vets employed in the salmon farming industry in the Puerto Montt region. Additionally, five veterinarians work with the fish health services of Fundación Chile in Puerto Montt and on Chiloe Island. Fundación Chile has one veterinarian based in Santiago working with new species and they would like to hire a shellfish disease expert. Fundación Chile provides the fish diagnostic service to farmers as part of their technical follow up support for the industry. This service includes monthly monitoring, advice on treatments for health problems and further research and development.

The responsibility for keeping therapeutant use records rests with production companies, who must track their own treatment administration and monitor to ensure that withdrawal periods are passed before treated cages are harvested. Some companies also maintain in-house residue monitoring laboratories for bacteriological testing of fish tissue, with back up HPLC analysis. Larger companies will also conduct their own research into therapeutant use, largely focusing on fish efficacy and safety. One topic of particular interest is to investigate the most effective timing for treatment application relative to the increase in mortality rate associated with a developing outbreak. Company laboratories will also monitor drug sensitivity patterns, and individual sites will participate in product trials with pharmaceutical manufacturers.

One method of reducing the risk of tissue residue occurrence is to develop improved treatment procedures and health management alternatives. The top Chilean fish health research priority — identified by several corporate and association representatives — is the production of a vaccine for SRS control. An additional activity is investigation into concerns about the accuracy of residue analytical techniques, for example it is possible that the presence of organic acids in fish tissues could be confused with therapeutant residue peaks in HPLC.

The recognition by the Chilean government that salmon farming is the country's largest agricultural export has led to stronger funding for aquaculture R&D. There are a wide array of support initiatives including:

- Fondo Investigación Pesquera y Acuicultura (FIPA) — This organization provides smaller grants to academics and institutions (up to US$100,000) specifically for research and development, with a total budget of approximately US$3 million. About US$500,000 is specifically targeted for salmon and shellfish aquaculture.
- Corporación de Fomento Producción (CORFO) — This organization provides a quick response to support industrial research and development. The composition of the funding must be 20% Industry and 80% CORFO. This 80% is divided equally into a low interest loan, with a long period before the first payment is due, and a direct grant. The total funding package should not exceed US$500,000. The 20% industry contribution can include in-kind support such as salaries and facilities. The Chilean Salmon Producers Association has developed a research group named Intesal with a prime objective of developing CORFO support for industry priorities.
- FONDEF — This source is managed by the Fondo Nacional de Ciencia y Tecnología (FONDCIT) and provides industry/government grants to university researchers. FONDEF grants require a 40% contribution by industry.

Chilean researchers also have access to international grants for developing countries including support from the:

- UN FAO, European Community (for example through association with a researcher in Spain);
- US AID (Agency for International Development);
- Fondo de las Americas — a World Bank administered program.

Additionally, Fundación Chile will undertake its own research projects, including investigations into therapeutant efficacy and safety. The fish health group at Fundación Chile is investigating the use of injectable treatments as a more effective alternative to oral treatment. The nutrition group within Fundación Chile is using

HPLC and other techniques for residue detection in fish tissues and feed pellets. The Fundación Chile research budget is variable because the funds are provided from revenues earned through services to industry. However, their estimated expenditure on fish health R&D for 1994 is US$95,000. There is some competition between Fundación Chile and the Producers Association for R&D activities and funding. For example, both groups have been conducting independent investigations into potential vertical transmission of SRS.

Therefore, there is a flexible and wide-ranging industry-led commitment to quality control in Chile that should continue to serve fish culturists well in future. What messages can Canadian fish culturists and government agencies take from the Chilean experience?

Implications for Canada

Chilean farmed salmon production has grown to twice the size of Canada's in about half the time. This explosive growth has its associated problems, but a reputation for quality is apparently not an area that has been affected. What can the Canadian salmon farming industry, producer associations, and government agencies learn from Chilean quality control activities?

In Canada, quality control initiatives have been led by government standards for processors under the well regarded QMP program, with industry managing quality control programs at production sites. In Chile, quality control at processing plants and production operations has been led by industry in cooperation with Fundación Chile, a private non-profit economic development organization. The approaches in both countries have been successful given that both enjoy a reputation for quality, possibly demonstrated by the willingness of producer associations in both countries to cooperate on an international generic salmon marketing program.

However, although both countries maintain a reputation for quality cultured fish, the therapeutant availability situation in the two countries is quite different. The message for Canadian producers is that careful attention to quality control during production and processing is a more critical factor than extremely rigorous regulation of therapeutant availability for maintaining an international reputation. This does not mean that consumer or employee safety is compromised; however, the Canadian therapeutant approval process involves many more considerations than safety.

One opportunity available to Canadian producers is the respected government leadership in establishing processing plant quality standards. Government development, support and monitoring of the Canadian QMP will be a big advantage in obtaining acceptance of these standards at the international negotiating table by US FDA officials as equivalent to HACCP and by European Community officials as equivalent to ISO9000. However, the Chilean industry may need to obtain government endorsement of their industry-led approach before acceptance of the program by importing country regulatory agencies. Individual Chilean companies may resolve this problem through in-house programs; however, importing country governments may be less ready to negotiate with individual corporations. The company approach has already worked well for Chilean companies exporting to Japan. International acceptance of QC programs is critical to both Chile and Canada because of the high proportion of product exported.

Canadian producers and processors could develop the opportunity for international recognition of QMP by developing closer alliances among producer and processor associations and DFO Inspection. Objectives of these alliances would be:

- increased intelligence gathering for industry regarding activity and progress in international negotiations — for example, NAFTA (North American Free Trade Agreement) Working Groups or meetings with US FDA on HACCP equivalency; and
- refinements to QMP reflecting the specific needs of aquaculture producers.

Government could benefit from these alliances through effective on-going consultation with producer associations on industry needs.

Canadian government agencies are emphasizing the development of partnerships with industry to manage the impacts of decreasing budgets. Mechanisms for establishing partnerships

are not yet clear, but the Chilean research funding opportunities suggest some innovative ways. Examples of this flexibility are:

- Use of low interest loans from government to industry with long periods before the initial payment is due;
- matching grants between government and multinational corporations to foster overall aquaculture sector diversity; and,
- encouragement of cooperative industry/government funding to support university and institutional research.

The Canadian government may not use these specific mechanisms, but they provide examples of the kind of funding flexibility required to develop government/industry partnerships and address industry research and development priorities.

A final opportunity for Canadians is potential scientific and technical cooperation with Chilean associations and agencies. The British Columbia Salmon Farmers Association has signed a memorandum of understanding with Intesal to encourage cooperation on pre-competitive research and development. Pharmaceutical research can be mutually beneficial because product research applicable to both regions will apply to a larger eventual market. A larger market is more likely to encourage manufacturers to pursue product development and participate in funding research. Exchange of technical information is a good first step toward cooperation.

Notes and References

1. *Salmon Health Consortium Annual Report.* Bulletin of the Aquaculture Association of Canada 93-3, p. 51.

2. Further information on this program is provided in the third section of this report (p. 19) describing quality control issues.

3. *Salmon Health Consortium Annual Report.* Bulletin of the Aquaculture Association of Canada 93-3, p. 26, for further information on "orphan drugs".

4. Gerlowski LE, Jain RK. 1983. J. Pharmaceutical Science 72(10):1103-1127.

5. *Salmon Health Consortium Annual Report.* Bulletin of the Aquaculture Association of Canada 93-3, p. 12.

6. Ibid. p. 60.

7. *Cultivating the Future: An Aquaculture Strategy for the 90's.* Communications Directorate, Department of Fisheries and Oceans, Ottawa, 1991.

8. *Federal Aquaculture Development Strategy.* Communications Directorate, Department of Fisheries and Oceans, Ottawa, 1995.

9. Memorandum — to Distribution from the Director of Aquaculture and Habitat Science, Biological Sciences Directorate, Department of Fisheries and Oceans, Ottawa, 11 July 1994.

10. Letter — Honourable Brian Tobin to Mr. Don Tillapaugh, Chairman, Salmon Health Consortium Board, August 8, 1994.

11. National Advisory Board on Science and Technology, *Final Report to the Prime Minister*, p. 43-44, 4 February 1994.

12. *Federal Aquaculture Development Strategy.* First Draft — For Discussion Only, p. 12. 10 June 1994.

13. Angel J. 1994. *Draft Program Review Report, — Science Team,* 22 July 1994, p. 16. Department of Fisheries and Oceans, Ottawa.

14. *The Tragedy of the Oceans.* The Economist. 19 March 1994, p. 21-24.

15. HACCP involves the identification of the likely hazards that can cause the product to be unsafe to consumers; identification of "critical control points" in the production process where a failure could cause the hazard to occur; the establishment of "critical limits" or operating parameters for each critical control point; and the establishment of procedures for monitoring the critical control points and recording the results of the monitoring. (Williams and Zorn [15a] p. 5).

15a. Williams, RA, Zorn, DJ. *Preliminary regulatory impact analysis of the proposed regulations to establish procedures for the safe processing and importing of fish and fishery products.* USFDA 200 C St. SW, Washington DC 20204. [These authors estimate the cost to US consumers at about 1% of the $16.5 billion US seafood market, (p. vi).]

16. *International Standard.* International Organization for Standardization. First edition. 1987-03-15.

17. *Perception overshadows reality in drug residue issues.* 1989. J. Am. Vet. Med. Assoc. 195(6):710-711. [Report of a speech by Dr. Gerald Guest, USFDA to the Symposium on Prevention of Unwanted Drug Residues.]

18. Draft Presented to the US JSA meeting, New Orleans, 12 January 1994.

19. Spencer H. 1992. *The role of government in a mandatory HACCP based program.* Dairy, Food and Environmental Sanitation, July 1992, p. 502. [As quoted in: Federal Register, Friday 28 January 1994, 59(19):4147].

20. Woodhouse CF. 1994. *How HACCP will affect seafood producers.* Fish Farming International November 1994, p. 48-49 and *The HACCP Challenge.* Fish Farming International, December 1994, p. 39.

21. The Salmon Health Consortium Annual Report for 1993 contains additional discussion on the formation and activities of this group (Bulletin of the Aquaculture Association of Canada 93-3:52-59).

22. *ISO 9002 status for Golden Sea Produce.* Fish Farmer, November/December 1994, p. 52.

23. *Catfish Quality Assurance.* Publication 1873. Extension Service of Mississippi State University, cooperating with US Department of Agriculture.

24. *Trout Producer Quality Assurance Program.* United States Trout Farmers Association, 1994, 28 pp.

25. For more information refer to the Salmon Health Consortium Annual Repory, Bulletin of the Aquaculture Association of Canada, 93-3:19-39.

26. Evans T, Lovitt R. 1994. *The ABCs of hazard analysis.* Seafood Leader, May/June 1994, p. 34-47.

27. Fish Farming International. November 1994, p. 48.

28. *Salmon Health Consortium Annual Report.* Bulletin of the Aquaculture Association of Canada 93-3, p 5.

29. El Mercurio, March 3, 1995. Anuncio la Subsecretaria de Pesca: Reglamentaran el uso de medicinas en salmonicultura.

30. Asosiación de Productores de Salmón y Trucha de Chile. Pedro Montt 160, Of. 22, Puerto Montt, Chile. Ph 011 56 65 256666, fax 011 56 65 257776.

31. Fundación Chile, Av Parque Antonio Rabat Sur 6165, Casilla 773, Santiago, Chile. Telephone 011 56 2 218 5211, fax 011 56 2 242 6900.

32. Fundación Chile Annual Report, 1993, p. 1.

33. DiNubile MJ, Hokama Y. 1994. *The ciguatera poisoning syndrome from farm-raised salmon.* Ann. Intern. Med. 122:113-114.

34. These manuals are in Spanish — any errors in translation are the fault of the author of this report.

Calendar

•**Atlantic Aquaculture Exposition, Conference and Fair,** 22-25 June 1995, St. Andrews, NB Canada. Events: trade show, dinner dance, salmon BBQ and mussel feast, tours, industry sessions, public information sessions, aquaculture for kids, sea farmers' market, boat and aerial tours, twilight cruise, U-fish pond, golf tournament, exhibitor reception and aquaculturist of the year award. For information telephone 506 529-4578 or fax 506 529-8095.

•**Aquaculture Expo VIII** will join with **Aquaculture in the Mid-Atlantic**, 22-27 June 1995, Washington, DC. Designed primarily for producers, with emphasis on marketing, governmental relations and business aspects, Aquaculture Expo is the American industry's largest annual trade show. This event will showcase aquaculture to legislators and regulators and will include presentations on investments and marketing, visits to congressional offices, receptions for members of Congress and federal agency representatives, intensive production sessions, and the largest aquaculture trade show on the east coast since 1983. Information: Carroll Trosclair (tel 800 571-7631) or Bill Glasscock (tel 800 467-3350).

•**Cape Town '95 — Second World Conference on Resources, Markets, Technology and Equipment.** Small Pelagics and Hake, International Fisheries Conference, 28-30 June 1995, Cape Town, South Africa. Information: Messe- und Ausstellungsgesellschaft, Hansa (MGH) Bremen GmbH, Bischofsnadel 1-2, 28195 Bremen, Germant (fax 49 421 32 14 85).

•**8th International Conference of the International Federation of Science Editors**, 9-13 July 1995, Barcelona, Spain. Conference will cover every aspect of science communication: among scientists (science authors, science editors) and the public (science writers, journalists). Information: IFSE-8 Secretariat, Apartado 16009 E-08080 Barcelona, Spain (fax 34 3 3341079).

•**Aquaculture Europe 95 and AquaNor,** 9-12 August 1995, Trondheim, Norway. Information: European Aquaculture Society, Aquaculture Europe 95, Coupure Rechts 168, B-9000 Belgium (fax 39 9 223 76 04).

•**American Fisheries Society, 1995 Annual Meeting and Trade Show,** 27-31 August, Tampa Convention Center, Florida. Information: Amy Fink, American Fisheries Society, 5410 Grosvenor Lane, Suite 110, Bethesda, Maryland 20814 USA (tel 301 897-8616; fax 301 897-8096).

•**British Trout Farming Conference,** 6-8 September 1995, Sparsholt College, Hampshire, United Kingdom. Program includes: new developments in the technology of salmonid farming, egg and fingerling production and economics, European trade in trout products, predatory birds, pigmentation in fish feeds, tilapia production in the UK, genetic manipulation, diseases. A trade exhibition is an integral part of the conference. A highlight is the social atmosphere of the beautiful campus of Britain's leading aquacultural training college. Contact: Shaun Leonard, Department of Fish, Game & Wildlife Management, Sparsholt College, Winchester, Hampshire, UK SO21 2NF (tel 01962 776441; fax 01962 776587).

•**Larvi 95,** 5-8 September 1995, University of Ghent, Belgium. Larvi 95 will bring together researchers and professionals to evaluate recent progress, identify problem areas and stimulate future cooperation in research and industrial production of freshwater and marine fish and shellfish larvae. Contact: Larvi 95, Laboratory of Aquaculture and Artemia Reference Center, University of Ghent, Rozier 44, B-9000, Ghent, Belgium (tel 32 9 2643754; fax 32 9 2644193).

•**European Association of Fish Pathologists,** 7th International Conference on Diseases of Fish and Shellfish, Palma de Mallorca, Balearic Islands, Spain, 10-15 September 1995. Sessions include: Recent ad-

vances in research on new diseases, Diseases of channel catfish, Transgenic fish, Suitability of molecular biology techniques for fish diseases diagnostic work, Current trends in delivery systems for vaccines, Problems of challenge models in infectious disease, Effects of nutrition on the immune system, Methods to assess environmental impact of drugs in aquaculture, Immunization against parasites. Contact: Eva-Maria Bernoth, EAFP meetings Secretary, CSIRO Australian Animal Health Laboratory, Fish Diseases Laboratory, PO Bag 24, Geelong, Victoria 3220, Australia [tel 61 52 275000; fax 61 52 27 5555).

•**25th Annual Symposium of the Estuarine and Coastal Sciences Association,** Strategies and methods in coastal and estuarine management. 11-16 September 1995, Trinity College, University of Dublin, Ireland. ECSA25, Environmental Sciences Unit, Trinity College, Dublin 2, Ireland (fax 353-1-6718047).

• **Second International Symposium on Research Funding,** 13-15 September 1995, Citadel Inn, Ottawa. Conference is intended for funding councils and industrial agencies concerned with getting the best return from their research funding and research activities. The Symposium will cover the changing nature of the research enterprise, the use and abuse of current tools for performance measurement, and the experience of different countries or sectors. The primary focus will be the impact of research output on science and technology policies, on the distribution of funds in different sectors, and on the S&T structure of a country or sector of the economy. Information: Dawn Conway, Policy and International Relations Directorate, Natural Sciences and Engineering Research Council of Canada, 350 Albert Street, Ottawa K1A 1H5 (tel 613 995-1818; fax 613 992-5337).

•**Fish Asia 95,** 19-21 September 1995, Suntec City, Singapore. Fish Asia will provide a showcase for all aspects of the fish industry, from aquaculture goods and services, ornamental fish, leisure fishing to the seafood industry in general. Abstract deadline: 30 March 1995. Organized by RAI Exhibitions Singapore Pte Ltd. For information contact: RAI Exhibitions Singapore, 1 Maritime Square, #09-49, World Trade Centre, Singapore 0409. Fax 65-2726744.

•**Second International Conference on Ecological Engineering,** 18-22 September 1995, Wardenswil, Switzerland. Conference will focus on ecological technologies for the reuse and recycling of resources in wastewater such as wastewater aquaculture, composting and urine-separating toilets and greywater reuse technologies. Information: Conference Board c/o Jean-Bernard Bachtiger and Regula Treicher, P.O. Box 335, Ingenieurschule Waedenswil, CH-8820, Waedenswil, Switzerland (tel 41 1 798 99 25; fax 41 1 789 99 50).

•**50th Anniversary of the Food and Agriculture Organization (FAO),** 11-16 October 1995, Quebec City, Canada. Meeting is composed of an International Symposium (11-13 Oct), Exhibition (11-14 Oct), and 50th Anniversary Celebration (16 Oct), and World Food Day (16 Oct). Theme: People at the heart of development: food security through knowledge. Sub-themes: Managing natural resources, Managing markets and Managing know-how and technology. Contact: Forum Québec, 30 Grand Allée Ouest, Québec (Québec) Canada G1R 2C6 (tel 418 524-8093; fax 418 529-1172).

•**Fourth Asian Fisheries Forum,** 16-20 October 1995, Beijing International Convention Center. Special symposia on aquaculture, pollution and environment; development trends and scientific issues in capture fisheries and aquaculture; fishery policy and investment; and shrimp culture. Contact: The China Society of Fisheries, 31 Min Feng Lane, Xidan, Beijing (tel 861 6020794; fax 861 6062346).

•**Pollution Processes in Coastal Environments,** 6-10 November 1995, Mar del Plata, Argentina. Aim: a global view of the occurrence, distribution, accumulation, transference and circulation of pollutants in coastal environments. Characterization of the health status of coastal areas from different latitudes as well as an assessment of transference routes (rivers, atmospheric circulation, etc.) will be attempted. Information: Dr. J. E. Marcovecchio, President, Organizing Committee, Lab. de Contaminacion, INIDEP, Casilla de Correo 175, 7600 Mar del Plata, Argentina [fax 54 23 51-7442].

•**ECOSET 95**, International Conference on

Ecological System Enhancement Technology for Aquatic Environments, 6-10 November 1995, Nihon University, Tokyo, Japan. International forum for the exchange of information on all aspects (creation, enhancement, improvement, conservation, management, utilization, mitigation, etc.) of aquatic ecological systems associated with artificial reefs, estuaries, wetlands, tidal flats, rivers, lakes and other natural and man-made habitats. Information: Japan International Marine Science & Technology Federation, Kyodo Bldg, Room 65, 1-3-5 Nihonbashi-Kakigara-Cho, Chuo-Ku, Tokyo 103 Japan (fax 81-3-3667-7174).

•**The VIIth Industrial Biotechnology Conference,** 4-6 December 1995, Sheraton Centre, Montreal, Canada. The National Research Council of Canada holds conferences on industrial biotechnology every second year. Highlights of the 1995 conference include including an exhibition of biotechnology research organizations and biotechnology in Canada. Contact: Doris Ruest, Conference Services, National Research Council Canada, Montreal Road, Ottawa, Canada K1A OR6 (tel 613 993-9228; fax 613 956-9828).

•**World Aquaculture 96 and the Bangkok Seafood Show**, 30 January – 2 February 1996, Queen Sirikit National Convention Center, Bangkok, Thailand. The annual conference and exposition of the World Aquaculture Society is being hosted by the Thailand Department of Fisheries and the Chulabhorn Research Institute. Information: Sea Fare Expositions, 850 NW 45th Street, Seattle, Washington USA 98107 (tel 206 547-6030; fax 206 548-9346).

•**Aquaculture America 96 National Conference and Exposition**, 14-17 February 1996, Arlington Convention Center, Arlington, Texas, USA. Sponsored by the US Chapter of the World Aquaculture Society and hosted by the Texas Aquaculture Association. Technical sessions, producer seminars, and trade show. Tours to aquaculture facilities, reception at the Circle R Ranch. Information: Sea Fare Expositions, 850 NW 45th Street, Seattle, Washington 98107 (tel 206 547-6030; fax 206 548-9346).

•**Refrigeration and Aquaculture Colloquium,** 20-22 March 1996, Bordeaux Convention Centre, France. Will provide the opportunity to review the applications and consequences of refrigeration in aquaculture, from the scientific and technological viewpoint, as well as economic aspects. This colloquium is one part of the major scientific, professional and commercial forum of Bordeaux Aquaculture. Information: Bordeaux Congrès Service, Palais des Congrès, Quartier du Lac, 33 3000 Bordeaux Lac, France (tel 33 56 11 88 88; fax 33 56 43 17 76).

•**Second World Fisheries Congress,** 28 July – 2 August 1996, Brisbane Convention and Exhibition Centre, Brisbane, Australia. Theme: Developing and sustaining World Fisheries Resources, the state of science and management. Congress is being hosted by the Australian Society for Fish Biology. Abstract deadline: 31 August 1995. Information: Second World Fisheries Congress, P.O. Box 1280, Milton, Queensland 4064, Australia [tel 617 369 0477; fax 617 369 1512].

•**International Congress on the Biology of Fishes,** 14-18 July, 1996, San Francisco State University. This congress combines several established meetings (GUTSHOP, Amazonian Fishes, High Performance Fish, Pacific Biotech, Smolt Workshop, Fish Larvae/Eggs, Anadromous and Catadromous Fish, Fish Stress) into one venue to discuss fish biology. Themes: Metabolic Performance, Tropical Fish Biology, Biotechnology Applications, Functional Anatomy, Feeding Ecology & Diet, Contaminant Impacts, Environmental Adaptation, Species Specific Symposia. Deadlines: Session proposals: 15 September 1995; Paper titles 15 November 1995; Abstracts 15 February 1996; Papers 15 April 1996. Contact: Don MacKinlay, Fisheries and Oceans, 555 West Hastings Street, Vancouver, BC V6B 5G3 (tel 604 666-3520; fax 604 666-3540).

•**International Astacology Association,** Eleventh Symposium, 11-16 August 1996, Lakehead University, Thunder Bay, Ontario, Canada. For information contact: Dr. Walter Momot, Department of Biology, Lakehead University, 955 Oliver Road, Thunder Bay, Ontario P7B 5E1 Canada (tel 807 343-8277; fax 807 343 8023).

New Publications and Videos

Atlantic Fisheries Adjustment Program (AFAP) Aquaculture Science Project Reports (Project Reports 1991-92; Project Reports 1990-91; Project Summaries 1993-1994), Department of Fisheries and Oceans. AFAP was a five-year, $584 million program announced in May 1990 that ended on 31 March 1995. The program was designed to promote a long-term fishing industry for Atlantic Canada while assisting individuals and communities to adjust to declining stocks and changing economic circumstances. The aquaculture science component of AFAP provided money for aquaculture research on: culture of new species; genetics, disease prevention and control; nutrition; environmental impact of aquaculture and the carrying capacity of sites and ecosystems; and predator control. These reports are available in either English or French from Ms. Iola M. Price, Director, Aquaculture & Habitat Science Branch, Fisheries Science Directorate, Fisheries and Oceans, Ottawa K1A 0E6.

Turbot Culture: Problems and Prospects (P. Lavens and R. A. M. Remmerswall, eds.), European Aquaculture Society, Special Publication No. 22 (1994) — Proceedings of contributions presented at the turbot workshop at World Aquaculture 93 in Torremolinos, Spain. Softcover, 360 pp. Price 2450 Belgian Francs (approx. US $77.) plus handling and shipping. To order, contact the European Aquaculture Society, Coupure Rechts 168, B-9000 Gent, Belgium (fax 32 9 2237604).

NAFTA and the Fish and Fish Products Sector, Minister of Supply and Services Canada, 1994. Booklet was published in collaboration with Industry Canada and has been specifically tailored to highlight the key elements of the agreement that directly affect fish processors and exporters. It is part of a series of NAFTA sector–specific publications designed to help Canadian firms become familiar with the provisions of NAFTA. Copies of the booklet or assistance with NAFTA related issues can be obtained from Agriculture and Agri-Food Canada: Food Marketing Industries and Seafood Division, Food Bureau, Market and Industry Services Branch, Room 5101, 930 Carling Avenue, Ottawa, Ontario K1A 0C5 (tel 613 995-9554 (ext. 3275); fax 613 954-0122).

A Status Report of the Seafood and Marine Products Section Campaign — November 1994, Agriculture and Agri-Food Canada. The report attempts to consolidate the outputs of all the initiatives under the Seafood and Marine Sector Campaign, and in some respects, is a "report card" on the campaign to date. The report was intended to focus on phase III, the

Upcoming Bulletin Issues

June 1995 — Proceedings of the Aquatech '95 Workshop *Pacific Rim Opportunities in Aquatic Biotechnology;*

September 1995 — Proceedings of the BCMAFF Furunculosis Workshop;

December 1995 — Contributed papers from AAC's 12th annual meeting held in Nanaimo, June 1995

action and implementation stage. The individual programs undertaken are summarized and the report offers some observations and analysis on this part of the campaign.

Five other reports have also been prepared:

A study of seafood industry associations in Canada,

Successful partnerships: the sector campaign experience,

Value added seafood and marine products: marketing research findings,

New horizons in trade show marketing, "Learning from the SIAL experience", and

The potential competitive effects and joint venture opportunities for the Canadian seafood industry with Chile's accession to the NAFTA.

The following videos have also been produced:

Seafood market in Mexico,

Trends in the North American food service markets, and

Competitiveness in the seafood industry.

For information on acquiring copies of these reports or videos contact: Nilo Cachero, Gordon Snow or Margaret Thibault at 613 995-9554.

Guide to Drug, Vaccine, and Pesticide Use in Aquaculture, Texas Agricultural Extension Service. The guide was developed through the cooperative efforts of groups associated with the Federal Joint Subcommittee on Aquaculture's Working Group on Quality Assurance in Aquaculture Production. Provides the US aquaculture community with the most accurate and complete information on compounds that legally may be used. Included are all federally regulated compounds approved for use in aquaculture and aquatic sites, information on the proper use of these compounds, a glossary of common terms and sources of additional information. The Food and Drug Administration, Environmental Protection Agency, and the USDA — Animal and Plant Health Inspection Service — have each reviewed and cleared it for publication. Copies of the guide are available free from the National Agricultural Library, Aquaculture Information Center, 10301 Baltimore Boulevard, Room 304, Beltsville, Maryland 20704 (tel 301 504-5558; Internet AIC@nalusda.gov). The guide is also available electronically via Internet — for access on how to access it, contact AquaNIC at telephone 317 494-6264 or via Internet at **lswann@hub.ansc.purdue.edu**

Fact Sheets — Martime Mariculture Series — on giant scallops, mussels, European oysters and haddock have been published by the Aquaculture Coordination Office, Scotia-Fundy Region, Department of Fisheries and Oceans. The fact sheets are brief, illustrated reports on marine species of fish and shellfish that are being cultured commercially or show promise for culture. The series is intended for a general audience and to provide basic information for people considering entering aquaculture. Each fact sheet describes the business opportunities for a species, as well as its biology and life history, and identifies constraints or problems that are yet to be overcome. For copies contact Jim Ross at the Aquaculture Coordination Office (telephone 902 426-1828).

B.C.'s Pulp Mills: Effluent Status Report, Ministry of Environment, Lands and Parks, Province of British Columbia, January 1994. This document provides a review of the current status and projected effects of pulp mill liquid waste discharges on the environment in British Columbia. Emphasis is placed on recent trends in liquid effluent contaminant discharges, and resulting environmental responses. Copies available from: Ministry of Environment, Lands and Parks, Industrial Waste and Hazardous Contaminants Branch, 777 Broughton Street, 4th Floor, Victoria, BC V8V 1X5.

Erratum

Dr. T.J. Davidson provided the following correction:

The paper *"An On Farm Management Programme for Mussels"* published in Edition 93-4 of the AAC Bulletin (p. 120) should have listed R.J. MacFarlane as the primary author. The correct citation is R.J. MacFarlane and T.J. Davidson. 1993. Bull. Aquacul. Assoc. Canada 93-4:120-122.