**Council**

**CNL(05)19**

***Report of the Workshop on Marking of Farmed Atlantic Salmon***

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## *Report of the Workshop on Marking of Farmed Atlantic Salmon*

1. Under the Williamsburg Resolution it is stated that tagging or marking could be used in order to facilitate the identification of farmed salmon in the wild and the separation from wild fish, to determine the source escapes and to assess the interactions of escaped farmed salmon with the wild stocks. The need to evaluate the effectiveness of marking methods, their feasibility for large-scale marking and their costs was recognized. Last year the Council accepted an invitation from the European Union on behalf of the Scottish Executive to host a Workshop to assess the current and developing methods of marking farmed Atlantic salmon. This Workshop was held in Edinburgh during 6-8 December 2004 and the report of the meeting is attached.

2. The Workshop first reviewed presentations by three companies involved in the manufacture or marketing of systems for mass marking juvenile farmed salmon. Information was also presented on existing tagging programmes in Ireland and in Iceland (where 10% of farmed salmon are required to be tagged with coded wire tags and fin clipped). Reports were also made on evaluations of methods of marking farmed salmon which had been carried out in Norway and in Maine, USA. The Workshop developed a number of criteria and evaluated a number of marking methods (external tags, combination method, genetic and chemical methods, fin clipping, otolith marking, passive integrated transponders (PIT tags) and coded wire tags (CWTs)) against these criteria.

3. In short, the Workshop came to the view that while many possible methods are available for marking fish, some methods are not suitable for mass marking, some require further development and others can provide very limited discriminating power. Of the methods evaluated, CWTs and otolith marking are most suitable for mass marking while, at their present costs, PIT tags are more suitable for smaller-scale trials. Genetic identification methods have potential for marking farmed salmon but further development is needed. All methods involve significant costs and the greater the discrimination power that is required the higher the cost. The industry representatives expressed concern about any additional cost and, while the Workshop was not in a position to consider who should bear these costs, there are also clearly significant costs associated with damage to the wild stocks from interactions with escaped farmed salmon. Welfare and food safety concerns were also raised in relation to a considerable number of the possible methods for marking farmed salmon. The Workshop felt that it would be valuable if each NASCO Party with salmon farming interests obtained advice at an early opportunity from the appropriate authorities in relation to the food safety and welfare aspects associated with marking farmed salmon.

4. It is not a simple matter to ascertain how many fish are in a cage at any given time and therefore how many may have escaped. Moreover, although there are estimates of escapes following catastrophic events such as storm damage, there is no information on escapes due to handling errors, so-called trickle losses or leakage. It is entirely possible that such small-scale regular trickle losses might well, on an annual basis, amount to similar levels to, or even exceed, the catastrophic losses. The

Workshop recommended that further investigations should be carried out to improve the accuracy of estimates of the number of fish in cages and the extent of trickle losses during routine operations, and that the NASCO Parties cooperate so as to plan and undertake such assessments. The Workshop suggests that progress in relation to these further assessments should be reviewed through the reporting procedures under the Williamsburg Resolution at NASCO's Annual Meetings and at the Liaison Group meetings.

5. The report of the Workshop has been made available to the NASCO/North Atlantic salmon farming industry Liaison Group which will consider the findings at its meeting on 26 April 2005. Any feedback from the Liaison Group on the recommendations arising from the Workshop will be made available to the Council in the report of the Liaison Group meeting.

6. The Council is asked to consider the recommendations from the Workshop and to decide on appropriate action.

Secretary
Edinburgh
5 April, 2005

**WMFS(04)6**

***Report of the Workshop on Marking of Farmed Atlantic Salmon***
***Holyrood Suite, Balmoral Hotel, Edinburgh, Scotland***
***6-8 December 2004***

## 1. Opening of the Meeting

1.1 The Secretary of NASCO, Dr Malcolm Windsor, opened the meeting and welcomed Workshop participants to Edinburgh. He thanked the Scottish Executive for hosting the meeting, for developing the Terms of Reference and for the arrangements made. He indicated that under NASCO's Williamsburg Resolution to minimize impacts of salmon aquaculture on the wild salmon stocks it is recognized that tagging or marking could be used in order to facilitate the identification of farmed salmon in the wild and their separation from the wild fish, to determine the source of escapes and to assess the interactions of escaped farmed salmon with the wild stocks. This Resolution also recognizes that while tagging or marking is being used on a small scale for these purposes, there is a need to evaluate the effectiveness of these trials, the possibility of large-scale marking and the associated costs. Furthermore, NASCO and the North Atlantic salmon farming industry have developed Guidelines for Containment of Farm Salmon and there is a requirement to evaluate their effectiveness in minimizing escapes. He noted that the task before the Workshop was not to recommend to the Council whether or not farmed salmon should be marked or tagged but rather to evaluate the pros and cons of the various approaches, the results of which would then be available if a NASCO Party decided to proceed with a requirement to mark or tag farmed salmon. In this regard he particularly welcomed participation in the meeting from representatives of tagging companies and the salmon farming industry.

1.2 A list of participants is contained in Annex 1.

## 2. Appointment of a Chairman and a Rapporteur

2.1 The Workshop appointed Mr Gordon Brown (European Union) as its Chairman. He added his welcome to that of Dr Windsor and described the background to the Scottish Executive, on behalf of the European Union, proposing to the Council of NASCO that a workshop on marking of farmed salmon be held. He referred to the importance of both salmon farming and the wild stocks to the Scottish economy and described the Strategic Framework for Scottish Aquaculture, which had been developed through a Ministerial Working Group comprising public sector, industry, environmental NGOs, wild fish interests and scientific organizations. This framework includes a proposal that an international assessment of current and prospective techniques for marking farmed fish be conducted during 2004. He indicated that the recommendations arising from the Workshop would be presented to the Ministerial Working Group at its next meeting in March 2005 so that it could consider the case for marking farmed fish.

2.2 The Workshop appointed Dr Peter Hutchinson, Assistant Secretary of NASCO, as its Rapporteur.

## 3. Adoption of the Agenda

3.1 The Workshop adopted its agenda, WMFS(04)5 (Annex 2).

3.2 This report reflects the views of the Workshop. However, where there are differences in views these are clearly attributed.

## 4. Consideration of the Terms of Reference

4.1 The Workshop reviewed its Terms of Reference as agreed by the Council of NASCO. These are as follows:

- to evaluate the current and developing techniques available for marking large numbers (many millions each year) of juvenile salmon destined for sea cage operations;

- to develop protocols to ensure that smolts destined for different sea cage locations may be separately identified. (Each smolt-rearing station may supply smolts to a number of different fish farms, and each fish farm may receive smolts from a number of different smolt farms);

- to develop recommendations for screening techniques that may have to be used (often in remote fisheries) to identify marked fish farm escapees;

- to examine the compatibility of marking techniques with food safety requirements, and their consistency with the requirement not to devalue the fish farm product.

## 5. Presentations on current and developing technologies for mass-marking juvenile farmed salmon

5.1 Mr John Taylor (Fish Eagle Trading, UK) presented an overview of the development of methods for tagging fish from the earliest report in Sir Izaac Walton's book 'The Compleat Angler' published in 1653. He referred to the development of external tags, coded wire tags (CWTs), Passive Integrated Transponder (PIT) tags, radio and acoustic tags and visible implant tags. He indicated that given the wide array of tagging methods available today it is essential that care is taken to ensure that the appropriate tag is selected for the purposes of the study being undertaken. In this regard, he suggested that CWTs were the obvious candidate for tagging farmed salmon and noted that in addition to the environmental aspects of interest to NASCO, there may be advantages to the industry in terms of product traceability. In 1993, Fish Eagle had developed a proposal for marking farmed salmon (SALMARK) using CWTs in support of initiatives being considered at that time to address over-production in the industry and the consequent low market price of farmed salmon.

5.2 Dr David Solomon (Northwest Marine Technology, UK) made a presentation on the marking of farmed salmon with CWTs. He indicated that the CWT is a tiny, biologically inert tag with no adverse impact on the fish; is very rapidly, easily and

inexpensively applied; has huge coding capacity allowing batch or individual identification; represents no human health risk and is proven technology with 50 million juvenile salmon tagged annually with CWTs. Furthermore, automatic tagging equipment can sort, grade (by length), count and vaccinate fish cost-effectively and without the need for anaesthetic. As such, he believed that the CWT offers great potential advantages for monitoring escapes and for stock husbandry, product traceability, improved vaccination efficiency and precise grading. A summary of this presentation is contained in Annex 3.

5.3 Mr Jeroen Bolscher (Texas Instruments Holland BV) made a presentation on radio frequency identification (RFID) systems in which there is wireless radio communication between the transponder (tag) and a receiver. Texas Instruments has produced more than 400 million transponders (PIT tags) since 1990 for a wide range of applications, including livestock traceability and studies of fish passage at hydro-electric installations. With regard to tagging farmed salmon, he indicated that PIT tags were permanent (being retained in the body cavity), could be used on fish as small as 75mm in length, had no impact on survival, did not cause stress, would not interfere with vaccines, had no impact on marketability of the product if placed in the body cavity, had a high success rate of detection, and could be detected without handling of the fish. The cost of the tags would be below US$1 for quantities in excess of 1 million tags and receivers cost in the range US$ 300 – 5,000 depending on the unit chosen. He strongly recommended that the ISO Standard for Animal Identification (ISO11784 and ISO11785) be adopted in deciding on any PIT tagging system for farmed fish. A summary of this presentation is contained in Annex 4.

5.4 In addition to these presentations, information was made available to the Workshop by Trovan Ltd on its PIT tags. Trovan had indicated that tag costs could be in the region of Euro 0.35 – 0.45 depending on volume.

5.5 Information was presented on the CWT tagging programme in Ireland by Mr Tom McDermott. Since 1980 in excess of 6.5 million salmon have been tagged, of which approximately 121,000 have been recovered. The objective of the programme is to assess the exploitation rate of salmon in the Irish commercial and recreational fisheries, to assess the contribution of Irish-origin salmon to distant water fisheries at West Greenland and the Faroes, to assess the contribution of hatchery-reared salmon to the fisheries, and to assess marine survival of salmon. He indicated that while the cost of the CWTs is very low, there is a substantial effort and cost involved in obtaining the recapture data. The current retrieval cost of each tag in the Irish fishery is approximately Euro 6. In addition to the fishery assessments, tagging studies had also been conducted by the former Salmon Research Agency in order to assess theft of hatchery fish. He noted that production of farmed salmon in Ireland amounted to approximately 17,000 tonnes in 2003 and some escapees were evident in the fishery, although it was becoming increasingly difficult to distinguish these from wild and ranched salmon on the basis of external appearance. At present there is no problem of major escapes from farms in Ireland but on-going leakage is a significant issue. He referred to the possible mutual benefits and the opportunities for cooperation between wild and farmed salmon interests on any proposal to tag farmed salmon.

5.6 A document, WMFS(04)3 (Annex 4), describing the experience of using CWTs in Iceland, was tabled and introduced by Mr Summarlidi Oskarsson. Since 2001,

operators of marine salmon farms in Iceland have been required to tag and adipose fin clip 10% of hatchery smolts planted into sea cages. Icelandic salmon farmers had initially objected to this requirement claiming that it was too costly and distorted their competitive ability in international salmon markets. However, a compromise was found where the salmonid management agency donated the tags and funded the tag recovery programmes in rivers but the fish farmers paid for the application of the tags. Since the smolts are mostly tagged in large batches up to 6 months prior to stocking into cages, some difficulties had arisen related to hatchery practices (e.g. grading into size classes, transport of smolts between hatcheries before stocking to sea cages) and to the supply of cage sites from a number of hatcheries.

5.7 A summary of the findings of a Norwegian Committee established by the Directorate of Fisheries to review methods for identifying escaped farmed Atlantic salmon was presented by Dr Tor Heggberget. This Committee had reviewed a number of possible methods (morphological characters, external and internal physical tags, electronic tags, chemical methods and genetic methods) taking into consideration aspects such as animal welfare, public health, life stage at which the tag could be applied, current availability of the method for mass marking and costs. While morphological techniques are well developed they cannot give information on the origin of the fish. The Committee had concluded that external tags (Carlin, anchor and visible implant tags) were not appropriate because of their high cost, welfare issues, and their unsuitability for mass marking. Genetic and chemical methods (natural trace elements, fatty acid components, fish-feed components and vaccination markers) were considered to need further development before they could be utilized for mass marking farmed salmon. Electronic tags were not considered suitable for mass marking although the Committee felt that the μ chip (Hitachi) was a very promising development. Two approaches were considered most appropriate – CWTs and the 'combination method'. He indicated that while CWTs have been developed for mass marking, there are logistical problems to resolve, such as the fact that each marine cage site may receive smolts from a number of hatcheries and each smolt production facility may supply a number of marine sites. The 'combination method' does not involve marking but utilizes a variety of information about the escaped farmed fish (site of recapture, smolt characteristics, year stocked to sea, stomach contents, genetic and chemical profiles) to identify the site of escape. The Committee had concluded that this method was primarily appropriate in the case of large-scale escapes. In Norway there is probably a large difference between the number of reported escaped farmed salmon and the numbers estimated by monitoring, indicating significant unreporting of escapes (probably the result of small-scale but frequent 'leakage' of fish) and the Committee had recommended further scientific investigations to assess the magnitude of unreported escapes and enhancement of monitoring programmes in both the freshwater and marine environments.

5.8 A report on evaluations of marking methods carried out in Maine, USA, was presented by Mr Mike Pietrak (Maine Aquaculture Association). Sixteen methods were evaluated against 15 criteria (including fish health and welfare, economic implications, identification strategy, ease of readability and verification). Three marking techniques showed particular promise, including scale reading/otolith marking, microtaggets (microscopic multi-layered fragments of plastic combined with vaccines and injected into the body cavity of the fish) and genetic identification. In addition, CWTs were considered worthy of further consideration by the government

agencies. He indicated that concerns about scale reading relate to the accuracy of the reader in correctly identifying the origin of the fish but trials had indicated that 80% of samples could be accurately assigned. The highest misclassification occurred between hatchery-reared smolts released for restoration purposes and farmed fish. Concerns about thermal marking of otoliths are related to the possible increase in deformities. The cost of genetic analysis is high but costs are declining. In order to confirm that European strains are not being used by the salmon farming industry in Maine, samples are provided for analysis at seven loci and expert opinion suggests that these analyses may be capable of confirming the parentage of fish. He indicated that both mictotaggets and CWTs raise food safety and fish health (related to vaccine efficacy) issues. In particular, CWT tagged fish would need to be marketed without their heads which could not be used as by-products in producing pet food or fish meal. Field trials are now being undertaken with CWTs and otolith marking. The costs (both direct and indirect, although the latter are difficult to assess) of marking are considered a major obstacle by the industry and would have to be assessed in relation to the benefits in terms of preventing interactions with wild fish and traceability. The direct cost (excluding capital costs) of marking 1.5 million salmon has been estimated to be US$ 1,500 and US $223,000 for otolith marks and hand-applied CWTs respectively. It was noted that marking is ineffective if the marked fish are not recaptured, and in Maine only 2 of the 7 rivers with salmon populations listed under the Endangered Species Act have counting fences installed. He suggested that an alternative solution to marking would be to further enhance containment methods. This would benefit both wild fish and the farming industry while marking might offer benefits in protecting wild salmon from genetic impacts but would have a negative impact on the industry.

5.9 It was noted that any proposal to mark farmed salmon might be more acceptable to the industry if the costs were minimized and if there were associated benefits to the industry. The tagging companies suggested that these benefits might include enhanced traceability of product and prevention of theft. However, the industry representatives indicated that the existing system of record keeping is acceptable to the retail sector and allows individual fish to be traced back to the source of eggs from which they were derived through paper trails. Furthermore, while theft of farmed salmon is a concern to the industry in some locations in Maine, there is a concern that marking could encourage theft by those opposed to salmon farming with the intention of releasing the fish to the wild in an attempt to lead to closure of an aquaculture facility. It was recognized that while marking of fish will not stop escapes, it could allow better estimates of the scale of the problem and the source of the escapes. It was also recognized that escaped farmed salmon migrate over large distances and there is, therefore, a need for international cooperation in monitoring escaped farmed salmon in the wild. For example, there have been incidences of escaped farmed salmon in rivers in Denmark, which has no salmon farming industry. There may also be benefits from considering any proposal to mark farmed salmon internationally so as not to disadvantage the industry in any particular country. Reference was made to the situation in Maine where there is currently a requirement to mark farmed salmon, which will be introduced in 2006**.** The view was expressed that if there is no such requirement in the neighbouring Canadian province of New Brunswick, it could undermine the effectiveness of the marking programme.

# 6. Evaluation of current and developing technologies for mass-marking juvenile farmed salmon

***Introduction***

6.1 In this report where costs are mentioned they are generally in relation to the costs of applying a certain mark. The report also refers to the cost of mark recovery programmes and analysis costs. The farmers could also incur logistical costs associated with rearing marked fish. There is no doubt that all such costs can be significant and will increase as the discriminating power required increases, and the Workshop was made well aware by the salmon farming representatives that their industry would resist additional costs because their customers, the retail sector, would resist price increases. The other participants understood the industry's difficulty but it was not part of the remit to advise whether or not farmed salmon should be marked or to suggest who should bear the cost. They wished to emphasise that there are also significant environmental costs to allowing the present situation of escapes to continue because of the serious risk of changes in genetic diversity ('genetic pollution') to the wild salmon stocks. Such changes may be irreversible and contrary to the Precautionary Approach which had been adopted by NASCO and its Contracting Parties. Escapees also pose a risk to the wild stocks through transmission of disease and their presence in the wild can confound scientific assessments. It was stated that the salmon farming industry has a responsibility for stewardship of the environments it utilises. The environmental costs of existing practices could well exceed the cost of any marking programme. It was also recognized that there was a need for urgency in minimizing escapes. Marking would not itself solve the problem of escapes but could form one component of any integrated management programme to quantify the scale and causes of, and thus to minimize, escapes. However, the industry felt that third-party audited containment management systems to ensure high containment would be of more benefit than marking, which they perceived as an additional cost with little benefit to them. An example of such a system is the Maine Aquaculture Association's Generic Containment Management System introduced in 2002. The Workshop was not in a position to evaluate such procedures and welcomes any such measure to improve containment. The Workshop recommends that further information be obtained on the causes and scale of escapes, and commends further assessments as detailed in paragraph 6.14 below.

***Evaluation criteria***

6.2 The Workshop discussed the goals for mass marking juvenile farmed salmon and agreed that this might be undertaken for two principal management purposes as identified in the Williamsburg Resolution, i.e. to facilitate the identification of farmed salmon in the wild and to determine the source of escapes. Different marking methods might be required if the goal was to simply indicate that a fish was either farmed or wild, than if more detailed information was required on its origin. The Workshop considered the scale of resolution required in relation to the source of escapes and agreed that while it would probably not be feasible, or necessary, to use marking methods to identify a particular cage from which losses occurred, some marking methods could be used to allow identification of the site of escape, the hatchery of origin or the company whose fish had escaped. In the event that marking was introduced the Workshop felt that resolution to company level would be

appropriate and could allow representations to be made to, or sanctions to be taken against, any company shown to have a poor track record on containment. The Workshop evaluated seven marking methods (external tags, the 'combination method', fin clipping, genetic and chemical methods, otolith marking in conjunction with scale reading, PIT tags and CWTs) against the following criteria:

- permanency of mark
- applicability to early life-stages
- impacts on survival
- potential for interference with vaccines
- capital costs of marking
- operational and logistical costs of marking
- stress caused by detection
- costs and success rate of recovery and identification
- discrimination power
- marketability impacts and impacts on production cost
- the compatibility of marking techniques with food safety and welfare requirements
- the need to maintain farmed salmon product quality
- concerns of the retail sector

***External tags***

6.3 The Workshop considered that while external tags had the advantage of being readily identifiable without sacrificing the fish, there were concerns about their suitability for marking farmed salmon because they are time-consuming and therefore costly to apply, they have impacts on survival of the fish, there is a question mark over their retention, they cannot be applied to small fish and there may be welfare issues associated with their use. Batch marks such as pan jet marks, brands and tattoos may be problematic to detect and may also raise food safety and welfare issues.

***Combination method***

6.4 The combination method (see section 5.8 above for a description) is a low-cost method that does not involve application of a mark, but it cannot be used to obtain precise information about the location of the escape and is generally only applicable in the case of large-scale escapes (not leakage losses) and where a proportion of the escapees are recovered from around the vicinity of the farm site at the time of the escape.

***Genetic and chemical methods***

6.5 Genetic identification methods offer potential for marking farmed salmon and may be implemented in Maine from 2006/2007. Genetic stock identification methods are being used in the West Greenland fishery, in real-time management of the Foyle fishery in Northern Ireland, and have been proposed in relation to the SALSEA project in order to identify post-smolt origin. Part of this project will involve the development of an atlas of baseline genetic information on the wild stocks. In relation to marking farmed salmon, genetic identification fulfills a number of the criteria including permanency of mark, lack of impacts on survival, no interference

with vaccines, applicability to early life stages (all stages, including eggs), no marketability, welfare or food safety issues and no concerns for the retail sector. However, except in the case of Maine, where there is vertical integration in the industry production, there could be problems related to discrimination power, although the technique would be capable of distinguishing wild and farmed salmon, and there would be a need to establish baseline datasets.

6.6 The Workshop believes that this is a promising approach for the future. The Workshop also noted that chemical methods such as feed additives, analysis of the chemical composition of otoliths and fatty acid analysis also hold potential for future application but further development work is required. It was noted that there might be marketability issues, particularly in relation to using feed additives for marking.

***Fin clipping***

6.6 The Workshop recognized that fin clipping is a low-cost method of mass marking that could be used to differentiate between farmed and wild salmon, but not to finer scales. It fulfills a number of the criteria but there may be welfare issues associated with this method. Rayed fins regenerate after clipping, leading to difficulties in detection, so the only feasible method is to remove the adipose fin. Clipping of the adipose fin is currently used by the Icelandic salmon farming industry as a secondary mark when applying CWTs. However, the Group was advised of a draft recommendation concerning farmed fish which is being developed by the Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes. Under this draft recommendation, the mutilation of farmed fish, defined as any procedure carried out other than for therapeutic purposes and resulting in damage to or loss of a sensitive part of the body or alteration of the bone structure, would be prohibited. This recommendation also states that marking methods may be used for research purposes but only where they cause minimal damage to the fish. The Workshop also recognized that fin clipping is used as a secondary mark in relation to CWT tagging programmes and that adipose clipping of farmed salmon could adversely impact these research programmes.

***Otolith marking***

6.7 Thermal otolith marking of eggs or alevins can be used to batch mark large numbers of farmed fish at very low cost (see paragraph 5.8 above), for example through exposure to a rapid change in temperature ($4^{o}$C) over a period of 30 minutes. There is a limited number of marks that could be induced (a few hundred) so the technique would not be applicable for identification to an individual site but it could be used to identify farmed fish to a particular company. This approach is used for stock identification of hatchery-origin Pacific salmon. There are no food safety concerns and marks can be applied at the egg stage. Used in conjunction with scale reading, to first identify fish of farmed origin, this approach could be a possible method of marking farmed salmon but the welfare issues would need to be considered, particularly with regard to deformities associated with the process. The Workshop was advised that rapid changes in temperature for marking purposes may not be permitted under forthcoming EU legislation.

***PIT tags***

6.8 The Workshop considered that PIT tags fulfill many of the criteria including permanency, applicability to early life stages (fish of 75mm length or greater), lack of impact on survival, lack of interference with vaccines, and high discrimination power (identification of individual fish is possible at no additional cost). However, their cost (see paragraph 5.4 and Annex 4) and slow rate of application could, at present, preclude their use for mass marking purposes. There are food safety concerns associated with the use of glass casing for the tags, welfare issues associated with their application, and the industry expressed concerns about the stress imposed on the fish during a prolonged tagging operation. The Workshop recognized, however, that PIT tags could be a valuable research tool, for example in relation to assessing small-scale leakage from marine sites

**CWTs**

6.9 CWTs, particularly when applied automatically, fulfill many of the evaluation criteria, particularly with regard to permanency of the mark, applicability to early life stages (fish of >57mm in length), they have no impact on survival, have vast coding capacity, high discrimination power and do not affect product quality. The manufacturers indicated that the cost of tags and tagging are low (see Annex 3) and a system (AutoFish) has been developed which is capable of automatically tagging and vaccinating up to 8,000 fish per hour without the use of anaesthetic. There may, however, be food safety concerns although these have not been a problem in the Pacific where very large numbers of microtagged salmon are harvested for human consumption. Furthermore, it has not been identified as a problem in Iceland, where 10% of farmed salmon are tagged with CWTs, or in relation to the Irish fishery. In Canada, the food safety authorities had indicated that microtagged farmed fish could only be marketed 'head off' and there may be difficulties in utilizing the heads as by-products for pet food or fish meal.

***Summary of evaluation***

6.10 In short, the Workshop came to the view that while many possible methods are available for marking fish, some methods are not suitable for mass marking, some require further development and others can provide very limited discriminating power. Of the methods evaluated, CWTs and otolith marking are most suitable for mass marking while, at their present costs, PIT tags are more suitable for smaller-scale trials. Genetic identification methods have potential for marking farmed salmon but further development is needed. The major disadvantage with CWTs and otolith marking is that the fish must be sacrificed in order to obtain data to identify the location of escape, whereas the information from PIT tags can be obtained without sacrificing or stressing the fish. There is no doubt that the cost of marking farmed salmon, the associated mark recovery programmes, analysis of the information recovered, and the logistical costs in aquaculture facilities, are significant, and that these costs increase the greater the discrimination power that is required. All methods involve significant costs and the industry representatives expressed concern about any additional cost. The Workshop was not in a position to consider who should bear these costs but there are also clearly costs associated with damage to the wild stocks from interactions with escaped farmed salmon.

***Welfare and food safety issues***

6.11 It is clear from the evaluations above that welfare and food safety concerns have been raised in relation to a considerable number of the possible methods for marking farmed salmon. The Workshop felt that it would be valuable if each NASCO Party with salmon farming interests obtained advice at an early opportunity from the appropriate authorities in relation to the food safety and welfare aspects associated with marking farmed salmon.

***Protocols for the separate identification of smolts destined for different sea cage locations***

6.12 There were repeated references during the Workshop to the difficulties of marking farmed salmon arising from the practice of smolt-rearing stations supplying smolts to a number of marine sites, and marine sites receiving smolts from a number of smolt-rearing facilities. This aspect will require careful consideration in the event that the decision is taken to proceed with a marking programme for farmed salmon but the Workshop did not feel that it had the appropriate technical expertise to develop protocols or procedures during its meeting. This issue is not likely to arise where the industry is vertically integrated and where tagging is used to identify to company rather than individual site.

***Screening techniques to facilitate identification of marked escaped farmed salmon in the wild***

6.13 The Workshop noted that the feasibility of recovery of marked fish could prove more problematic than the marking because escapees are widely distributed throughout the ocean and in rivers over large geographical areas. With regard to recoveries in the ocean, the SALSEA project may offer opportunities for recovery of information from marked escapees. The Workshop also discussed the need to consider a secondary mark when using internal marking methods so as to facilitate identification of tagged fish in the wild. The absence of such a mark would lead to increased screening costs for marked farmed salmon, although it would not impact on existing screening for wild and hatchery-reared fish tagged as part of on-going assessment programmes.

***Further assessments***

6.14 The Workshop is aware that some basic information is not available. For example, it is not a simple matter to ascertain how many fish are in a cage at any given time and therefore how many may have escaped. Moreover, although there are estimates of escapes following catastrophic events such as storm damage, there is no information on escapes due to handling errors, so-called trickle losses or leakage. There is an obligation on salmon farmers to report the former to the authorities but not the latter. Furthermore, as cage technology continues to improve and be implemented in the industry, it is perhaps likely that the catastrophic losses may be reduced, whereas the trickle losses would not be and are essentially unknown even to the farmer. It is entirely possible that such small-scale regular trickle losses might well, on an annual basis, amount to similar levels or even exceed the catastrophic losses. The Workshop believes that further investigations should be carried out to improve the accuracy of

estimates of the number of fish in cages and the extent of trickle losses during routine operations. The Workshop recommends that the NASCO Parties cooperate so as to plan and undertake such assessments.

6.15 The Workshop had noted a number of possible benefits from international cooperation in relation to the containment of farmed salmon and evaluation of the scale and causes of escapes and the behaviour of escapees in the wild. The Member Parties of the North-East Atlantic Commission are undertaking a coordinated trial release of farmed salmon in 2005 in order to study the migration and distribution of escapees, and the Workshop believes that the results of this project will be of considerable interest to other NASCO Parties and to the NASCO/North Atlantic salmon farming industry Liaison Group. It believes that progress in relation to the further assessments detailed in paragraph 6.14 should be reviewed through the reporting procedures under the Williamsburg Resolution at NASCO's Annual Meetings and at the Liaison Group meetings.

## 7. Other Business

7.1 There was no other business.

7.2 Although the Workshop had no remit to consider species other than Atlantic salmon, some of the issues considered in this report may be of relevance to the farming of other fish species.

## 8. Report of the Meeting

8.1 The Workshop agreed a report of its meeting. This report will be presented for information to the NASCO/North Atlantic salmon farming industry Liaison Group at its meeting in May 2005 and the Council of NASCO in June 2005.

## 9. Close of the Meeting

9.1 The Chairman closed the meeting and thanked participants for their contributions.

Secretary
Edinburgh
8 December, 2004

**Annex 1**

## *List of Participants*

**CANADA**

| | |
|---|---|
| Mr Tim Young | Department of Fisheries and Oceans, Ottawa |

**EUROPEAN UNION**

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|---|---|
| Mr Gordon Brown – (Chairman) | SEERAD, Edinburgh, UK |
| Mr David Dunkley | SEERAD, Edinburgh, UK |
| Mr Gordon Jeffrey | Aqualife Services Ltd, Lasswade, UK |
| Mr Tom McDermott | The Marine Institute, Galway, Ireland |
| Mr Daniel Pendrey | Fisheries Research Services, Aberdeen, UK |
| Mr Paul Shave | SEERAD, Edinburgh, UK |
| Dr Joseph Thorley | Fisheries Research Services, Pitlochry, UK |
| Mr Andrew Wallace | Association of Scottish Fishery Boards, Edinburgh, UK |
| Dr John Webster | Scottish Quality Salmon, Perth, UK |
| Dr Ken Whelan | The Marine Institute, Newport, Ireland |

**ICELAND**

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| Mr Sumarlidi Oskarsson | Directorate of Freshwater Fisheries, Reykjavik |

**NORWAY**

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|---|---|
| Mr Arnfinn Aunsmo | VESO Trondheim, Trondheim |
| Mr Vidar Baarøy | Directorate of Fisheries, Rådal |
| Dr Tor G Heggberget | Norwegian Institute for Nature Research, Trondheim |
| Mr Arne Sivertsen | Directorate for Nature Management, Trondheim |

**USA**

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|---|---|
| Mr George Lapointe | Department of Marine Resources, Augusta, Maine |
| Dr Christopher Legault | National Marine Fisheries Service, Woods Hole, Massachusetts |
| Mr Mike Pietrak | Maine Aquaculture Association, Hallowell, Maine |

**TAGGING COMPANIES**

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| Mr Jeroen Bolscher | Texas Instruments Holland BV, Almelo, The Netherlands |
| Dr David Solomon | Northwest Marine Technology Limited, Salisbury, UK |
| Mr John Taylor | Fish Eagle, Gloucestershire, UK |

**SECRETARIAT**

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| Dr Malcolm Windsor | Secretary |
| Dr Peter Hutchinson | Assistant Secretary |

**Annex 2**

# WMFS(04)5

## *Workshop on Marking of Farmed Atlantic Salmon*
## *Holyrood Suite, Balmoral Hotel, Edinburgh, Scotland*
## *6-8 December 2004*

## *Agenda*

1. Opening of the Meeting

2. Appointment of a Chairman and a Rapporteur

3. Adoption of the Agenda

4. Consideration of the Terms of Reference

5. Presentations on current and developing technologies for mass-marking juvenile farmed salmon

6. Evaluation of current and developing technologies for mass-marking juvenile farmed salmon, including development of recommendations on:

   (a) protocols for the separate identification of smolts destined for different sea cage locations;

   (b) screening techniques to facilitate identification of marked escaped farmed salmon in the wild;

   (c) the compatibility of marking techniques with food safety requirements and the need to maintain farmed salmon product quality.

7. Other Business

8. Report of the Meeting

9. Close of the Meeting

**Annex 3**

# *Marking Farmed Salmon with Coded Wire Tags*

**D J Solomon, Northwest Marine Technology**

Full documentation was tabled at the meeting discussing the feasibility of tagging all farmed salmon using NMT coded wire tags (CWT) and AutoFish System. It had been prepared by NMT and its aim was to explain how such a tagging programme might be achieved and what the costs are likely to be. If such a scheme is to be introduced it is, of course, essential that maximum benefit accrues all round; therefore the potential benefits to wild salmon stock management, the salmon farming industry and to the consumer were also considered.

The CWT is a very small section of magnetised stainless steel wire (standard tag 1.1 mm in length) that is injected into suitable tissue. An area of connective tissue and cartilage in the snout is the usual location selected for juvenile salmonids, and fish as small as 50 mm can be tagged. The tag is marked with decimal numbers which allow batch or individual identification. Presence of the tag is determined using a magnetic detector but the tag must be recovered for decoding. Around 50 million CWT are currently put into hatchery-reared salmon each year, mostly on the US Pacific Coast. They have also been used extensively on Atlantic salmon, with more than 15 million being used since 1990 in 15 countries. The CWT has proven to be an extremely useful and inexpensive tool for salmon hatchery managers.

While hand-tagging using NMT Mark IV injectors has been used to tag of the order of 50 million juvenile salmon per year, using such an approach to tag 300 million fish in a matter of several months each year would pose major logistical problems. What makes this proposal viable is the availability of the NMT AutoFish System which automatically grades, sorts, counts, aligns, holds and coded-wire tags small fish. The AutoFish System can handle and tag fish at a rate of up to 8,000 per hour and requires one operator plus an assistant. No anaesthetic is required. The system can also locate and excise the adipose fin at the same time it is tagging if required. Development of a grading and vaccination version of AutoFish has recently been completed, and a grading/vaccination/tagging version could be produced if the application were to be developed.

The process is computer-controlled throughout and at no time are the fish touched by hand or anaesthetised. The machine uses a patented volitional entry device at two stages of the process. First, fish enter the sorter by swimming against the flow. This determines the length of the fish to within 1.0 mm using video imaging, and sorts them into one of eight size classes. Five of these are fed to individual tagging lines; the other three classes, (too small, too large, and "reject") are separated for later processing. The fish distributed to each line again pass through a volitional entry device into the clipping and tagging chamber. Here the fish is firmly but gently held. The adipose fin is removed (if required) using a robotic clipper guided to the correct location by automatic video imaging; the imaging system also acts as a quality control, to check that the fin has been effectively excised. A coded wire tag is injected into the snout at the same time. The fish then passes through a CWT quality control device which checks that it contains a properly magnetised tag; any that are not properly tagged are rejected and the system computer is informed. A five-line trailer is capable of clipping and tagging up to two fish per second, or 40,000 per eight hour shift; tagging alone is quicker, possibly as fast as 80,000 per hour.

It became apparent early on during development that this fish handling system could potentially be adapted to perform a range of tasks, including vaccination, in one pass. However, in order for the machine to overcome problems associated with other manufacturers' attempts to develop automatic and semi-automatic vaccination machines, significant development was required. This has recently been completed and includes achieving a very accurate location for needle penetration, accurate needle penetration depth, and carefully controlled dosing. These can be achieved as the equipment is capable of determining the length of the fish within close tolerances, and allocating them to different processing lines. Combining tagging and vaccination at a single pass offers significant cost savings and potentially a considerable reduction in handling of the fish with associated stress.

Detailed costings for programmes designed to tag different proportions of the total farmed stock are presented in the full documentation. Based upon experience of deploying the AutoFish System in North America we estimate that the cost per fish to tag all farmed fish is of the order of 6.5 cents US; this includes all capital and operational costs of a stand-alone tagging programme including the tag itself, but does not include the cost of the subsequent monitoring and tag recovery programme. If tagging were to be added to existing use of the AutoFish System for vaccination, the add-on cost per fish would be of the order of 3.5 cents US. Higher costs per fish would apply if only a proportion of production were to be marked.

It is essential that any marking system for widespread use in farmed fish must represent no hazard whatsoever for human health. The coded wire tag is a tiny, biologically inert section of stainless steel wire. It represents no hazard to humans if ingested, and in any case would be injected into tissue (the nasal cartilage) which is not commonly consumed in any country or culture. Up to 50 million CWT are put into Pacific salmon released to the wild each year in North America. The Japanese, who are fastidious over food hygiene and safety and consume most edible parts of fish, readily accept landings of salmon with CWT and are now using this marking system in their own investigation. We are confident that the CWT system will satisfy the most vigorous examination of human health concerns.

Further, in allowing individual fish traceability, the CWT system would make a contribution to the interests of consumer safety and reassurance. Thus routine checks, or special checks of batches or individual fish of concern, at any stage in the rearing and prior to filleting in the wholesaling or retailing process, would allow the rearing and husbandry history to be accessed.

The coded wire tag, being small, biologically inert, and completely enclosed in tissue represents the most benign of all existing fish tagging methods. Histological studies have demonstrated that there is no adverse tissue reaction to the presence of the tag, while other investigations have shown there is no effect upon survival, growth or behaviour. These observations contrast with those for some other marking methods, particularly those involving permanent penetration of the skin. We are confident that the CWT system will satisfy the most vigorous examination of animal welfare issues.

More information can be found on the NMT website at www.nmt.us. Copies of the feasibility study can be obtained from David Solomon; email djsolomon@nmt.us.

**Annex 4**


**Texas Instruments RFid Systems**

Texas Instruments Radio Frequency Identification (TI-RFid™) Systems is an industry leader in radio frequency identification (RFID) technology and the world's largest integrated manufacturer of RFID tags, smart labels and reader systems. With more than 400 million tags manufactured, TI-RFid technology is used in a broad range of applications worldwide including access control, automotive, document tracking, livestock, product authentication, retail, sports timing, supply chain, ticketing and wireless payment.

TI-RFid, as an industry leader, has been a driving force behind large-scale RFid implementations and ISO standardization for livestock identification programmes. The ISO 11784 and 5 standards published in 1996 are a result of that. These standards today are the basis for official regulations for national and international tracking and tracing schemes. Consumer concerns about food safety, diseases such as BSE and FMD, beef import regulations such as those in the EU and Japan have forced beef exporting countries to assure traceability of livestock. Major producers like Australia, Botswana, Uruguay, Canada and USA have or will have nationwide systems in place based on ISO RFid. The EU has published a sheep and goat regulation which envisages tagging of all sheep and goats in the EU with ISO RFid tags.

TI-RFid offers to share the wealth of experience with RFid applications, and animal tagging in particular, with other industries like salmon production. TI's standard technology and off-the-shelf components will allow systems integrators to easily set up systems with high performance. The high performance level of the TI HDX technology will assure error-free, hands-free data capture of animal movement registration. New industries can benefit from the high number of integrators offering solutions and back-up worldwide. Ready-to-go fish identification equipment is already on the market.

During the presentation, application examples in USA, Sweden, Australia and New Zealand were discussed. All examples provide low-cost solutions based on standard components, but allowing fully automatic fish detection at dams, fishways and culverts, and even in small open streams. Researchers so far are overwhelmed with the amount of fish behaviour and migration data being collected generating ground-breaking results. Studies have already led to improvements to barriers not previously imagined.

For more information about animal ID, contact Jeroen Bolscher, TI-RFid, at +31 546 879409 or visit the website site at www.ti-rfid.com. E-mail: j-bolscher@ti.com

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