RESEARCH RESTORE SUSTAIN

JOURNAL 2011

The Atlantic Salmon Trust

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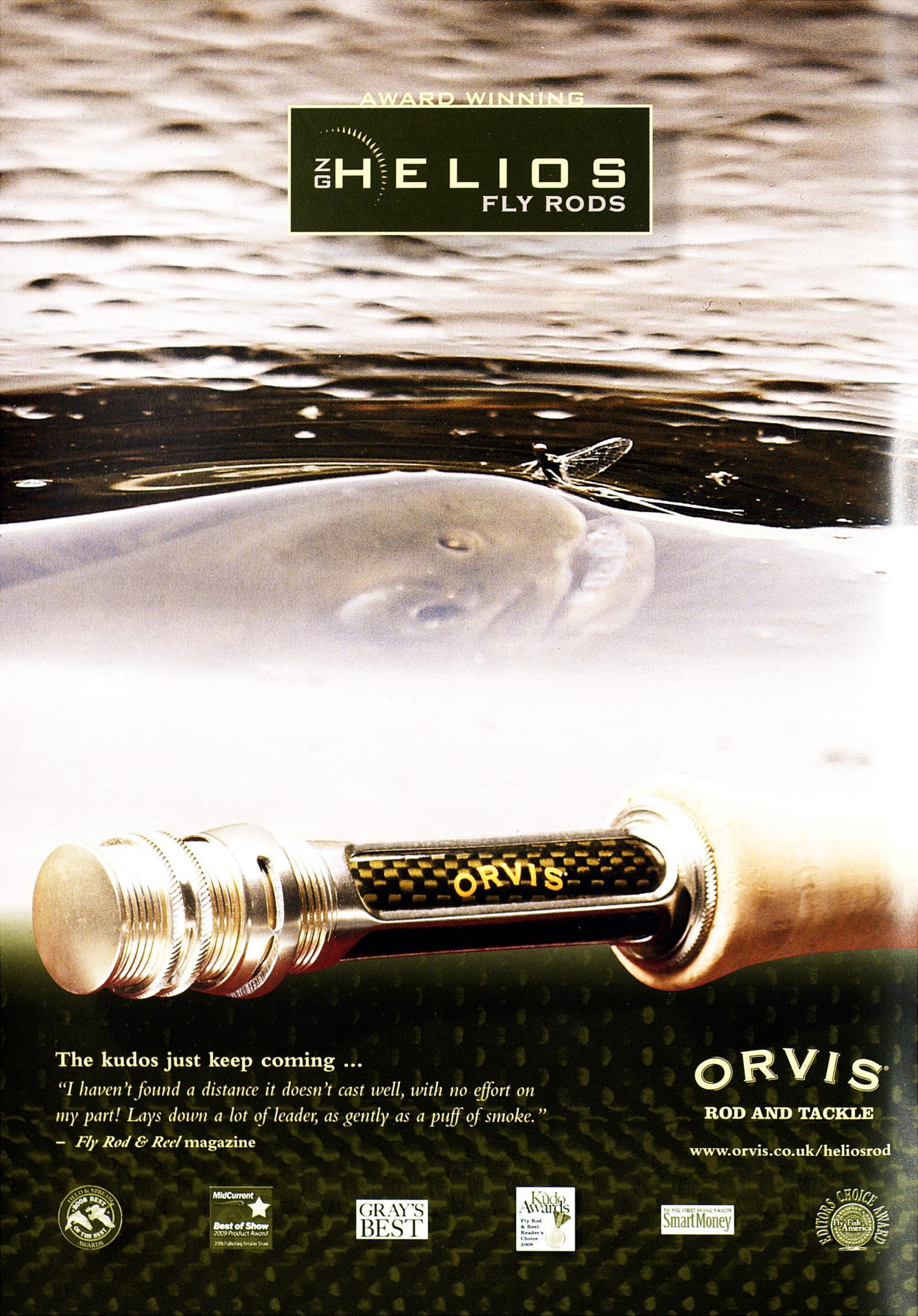
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ABOUT THE ATLANTIC SALMON TRUST

What is the Trust?

- Founded in 1967, the Trust is an international organisation, based in the UK and Ireland, which champions wild salmon and sea trout. It does not represent any person or commercial interest, only wild salmonids themselves
- The Trust, through good scientific data and other evidence, supports efforts to conserve and restore wild salmon and sea trout to a sustainable level
- The Trust is an independent, registered charity, with a small staff, which receives no Government funding

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What are the Trust's current activities and priorities?

Promoting, taking part in or supporting:

- Research into the survival of salmon at sea and in its freshwater habitats
- Conservation of wild salmon and sea trout, as an essential element of the biodiversity of the west coast of Scotland and the Isles
- Reduction of any form of unsustainable exploitation, including mixed stocks fisheries
- Minimisation of the negative impacts of salmon aquaculture on wild salmon and sea trout and their ecosystems
- Expansion of the AST's roles in education, information and communications
- Implementation of the AST's Fellowship scheme

Cover photograph
Loch Meadie and Ben Loyal, © Donald Rose.

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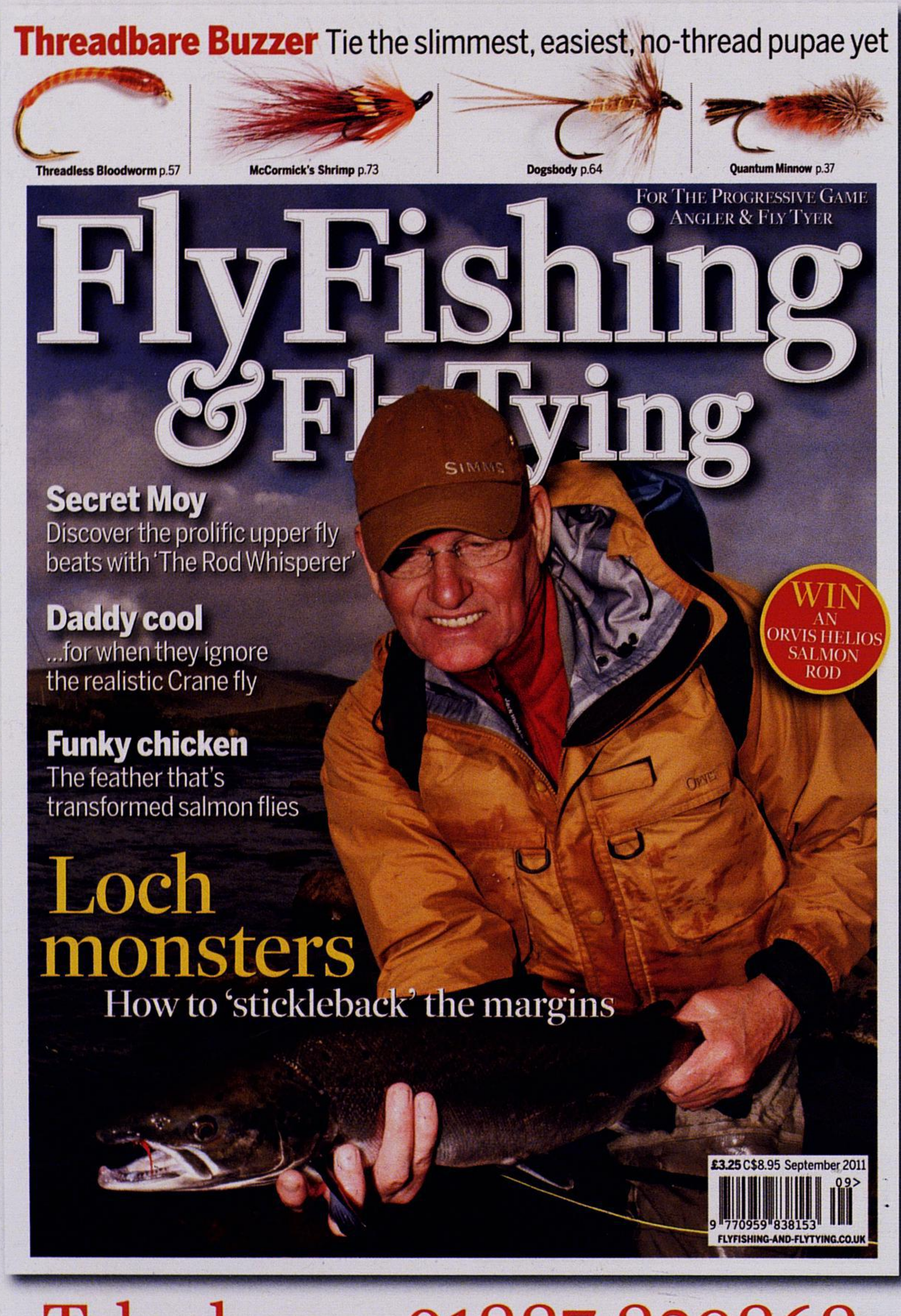
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Donald Rose's superb photograph of Loch Meadie and Ben Loyal, which features on the front cover of this Journal, encapsulates what we all care deeply about: the beautiful, precious and all-too-often fragile environments in which our wild salmonids live. A theme which stands out in the wide-ranging collection of articles we now bring you is the extent to which man's activities have impacted on these environments, and on the lives of the fish which live in them. From the development of agriculture and its impact on chalk streams to the use of rivers for hydro-power schemes, from the continued existence of Mixed Stock Fisheries to the risks from sea lice larvae bred on salmon farms, we are answerable for a great many of the trials and tribulations which affect fish.

We hope that you enjoy the 2011 AST Journal – and we particularly welcome your feedback on it. As always, we will be delighted to have contributions of photos of (live!) Atlantic salmon and sea trout, and their habitat, for use in future Journals, in our e-newsletter and on the AST website. We're already planning the 2012 Journal, and also welcome submission of articles for inclusion.

Fiona Cameron, Editor
fiona@atlanticsalmontrust.org

Please note that articles represent the views of their authors, and do not necessarily reflect the Trust's views.

CONTENTS

CHAIRMAN'S INTRODUCTION

HAVING TAKEN ON THE ROLE OF CHAIRMAN AT THE END OF 2010, MY FIRST THOUGHT IS TO ACKNOWLEDGE AND THANK ROBERT CLERK FOR HIS CONTRIBUTION DURING HIS SIX YEARS AS CHAIRMAN. THE TRUST HAS BEEN VERY FORTUNATE TO HAVE ROBERT AS CHAIR, LEADING THE BOARD AND STEERING THE ORGANISATION ON A RELEVANT AND EFFECTIVE COURSE DURING THESE HARSH TIMES.

Melfort Campbell, Chairman

On taking up the Chair, and coming from outwith the AST, or indeed any other body with salmonid interests, I have taken time to review what the Trust is doing and how it fits with the aspirations of and adds value to those that support us. In reading this Journal, it is very clear that whilst there is some progress in the work of ensuring our rivers are sustainably populated with salmon and sea trout as we would wish, it is still very much a case of one step forward and at least one and a half steps back.

On taking up the role I therefore started with the intention of reviewing what the Trust did and how it contributed to creating a better world for salmon and sea trout. It quickly became obvious that studying the AST in isolation would achieve little, and the need is to view the role of the Trust in the context of the other organisations with similar interests. With such a cluttered landscape of various bodies it is almost impossible to map all the other organisations with an interest in Salmonids, let alone what each is doing. Gaining cohesion and clarity from this cluttered landscape must be the priority.

The aim has therefore been to commence a dialogue with as many bodies with salmon and sea trout interests as possible – a process which is started but by no means complete - with the aim of arriving at a clear picture of our common interests, common objectives and how we should work together and co-operate to achieve them. We all need to make better use of our limited resources. We therefore need a real focus on jointly ensuring we are neither wasting resource and energy on duplication, nor missing out important areas where action is needed.

Internally, working with Tony Andrews, Ken Whelan and Ivor Llewelyn, we have set ourselves two tasks. First is to review what we are doing and find better ways of communicating so that our outputs can clearly be understood and seen by our stakeholders as adding value. The second task is foresighting, looking at what we need to be doing now that will better enable us achieve our objectives in the future. Whilst this may be a bit less incisive than some would like, I expect to write to all our key stakeholders shortly outlining how we are re-defining our role and how this will allow us to build on the excellent work the AST has done in the past and is currently doing, and the leadership we are providing in the sector.

Our aim is to give all those who have a part to play in the conservation, exploitation and promotion of salmon and sea trout a better knowledge and understanding of what is happening, why it is happening and what needs to be done to build the sustainability and therefore the value of the species to us all.

Our dependence on our supporters has never been greater, at a time when attracting funding for our activities is ever more difficult. Our aim is to give clarity to our stakeholders to enable them to see how a small commitment from a large number of people can allow us to be effective in helping create the situation where their aspirations for salmon and sea trout can be more achievable?

In the case of some of the issues raised in this publication it is plain to see that there is much to be done. With the work we have done in SALSEA Merge, and the potential of our Fellowships, and the other work we are supporting, the AST can and will take the lead in the thinking and procedures needed to ensure we have now, and in the future, the ability to aspire to returning the salmon and sea trout stocks in our rivers, on a sustainable basis to where they were in years past and should be in the future.

“ Our dependence on our supporters has never been greater, at a time when attracting funding for our activities is ever more difficult. ”

THE ATLANTIC SALMON TRUST TODAY

Tony Andrews, Chief Executive

To some people the world of migratory salmonids management and science may seem complicated and confusing. Perhaps that is because wild salmon and sea trout have complex life histories and studying their lives, especially in salt water, requires a multi-disciplinary approach. Nowhere is that point better illustrated than by the work of the Institute of Marine Research in Bergen, Norway, whose integrated approach to marine fisheries research and management is an intrinsic and definitive part of the SALSEA (salmon at sea) project. Of course, interactions between species - ranging from benign symbiosis to predation – are a vital part of this integrated approach, as well as inter-dependencies of physical aspects of the environment, especially the effects of climate change on ocean temperatures. Getting our minds around the extraordinarily complex lives of animals that move freely between the freshwater and saltwater environments, demands breaking the mould of silo-thinking about the fresh and salt water environments and adopting an ecosystem-based approach.

The relationship of migratory salmonids with the human species is multi faceted. While we are as much part of the natural world as the fish, we also find ourselves in the 'driving seat' at certain stages of their life cycle in opportunities to exploit or conserve them. If you include the unintended impacts of our actions, such as diffuse pollution from agriculture, impacts from aquaculture, renewable energy generation and distribution, introductions of non native species etc, it becomes fairly obvious that there is and can be no 'one coat fits all' strategy for research and management of wild Atlantic salmon and sea trout. Hence, what may appear to some as confusing is actually a necessary reflection of the reality of the natural complexities of the lives of these fish, and the ways we humans address them.

" interactions between species - ranging from benign symbiosis to predation – are a vital part of this integrated approach "

Pentland Firth: beyond management control? (Photo APHA)

THE ATLANTIC SALMON TRUST TODAY

As a small charity working to conserve wild salmon and sea trout, AST defines its own contribution in ways that we hope are achievable and understood by our supporters. AST's main focus is on brokering research that has a direct influence on the quality of fisheries management. By promoting better understanding of the lives of salmon and sea trout in the marine, coastal and freshwater environment AST supports fishery management and scientific research, but does not practise either of them. By communicating new data on the whole lives of both species in their ecological context, AST acts as conduit from science to practical actions on the riverbank.

We recognise that the world into which the AST was born in 1967 no longer exists. Increased awareness of the importance of migratory salmonids and action plans to conserve them at international, national, regional and local levels have meant that much of the work traditionally done by the AST, for example the advisory work provided by our biologist, is no longer needed. These developments are most welcome and timely, and it is reassuring to witness the increasing professionalism of fishery management throughout the North Atlantic salmon-owning countries. If you then consider how advances in science have provided the analytical tools to give management a solid scientific baseline on physiology, habitat requirements and threats to survival, there is good cause for believing that the accuracy of management interventions can only improve further.

In this new operating context it is important for the AST to focus on areas of work that add value to the efforts of others in the sector, and it is important that our work is seen to do so by working with our UK and international partners in areas agreed with them, and which avoid duplication of effort. While AST is perhaps freer to develop policies than some of its analogues, who are to some extent constrained by the wishes of their subscribing members, we should use that freedom to plug the gaps in knowledge, thereby adding real value to the combined effort.

“ These developments are most welcome and timely, and it is reassuring to witness the increasing professionalism of fishery management throughout the North Atlantic salmon-owning countries ”

Juvenile habitat on the river Prosen: where we can manage effectively Photo - APHA

THE ATLANTIC SALMON TRUST TODAY

Our international work is best demonstrated by our close involvement in the SALSEA (salmon at sea) project, as well as our longstanding connections with the Atlantic salmon Federation in the USA and Canada, and its equivalents in France, Norway and Russia. The emergence of EU bioregional projects (INTEREG), such as Living North Sea and the Celtic Sea Trout Project, confirms that cooperation across political borders to maximise conservation and collaborative management is now recognised as an effective way forward. AST, as an NGO networking within the N Atlantic region, can therefore continue to fulfil a valuable role as an independent instrument for international cooperation.

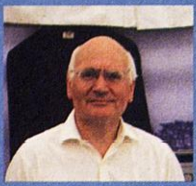
Following a thorough review of our role we will focus on the lives of salmon at sea and analysis of data gleaned from SALSEA samples and historical records. We will also follow up our recent workshops on sea trout by initiating projects designed to improve understanding and management of these polymorphic fish, including where damage to stocks from salmon aquaculture is acute. We will also explore ways of improving the ability of owners, managers, and anglers to assess salmon and sea trout stocks, by developing a user-friendly 'toolkit' and methodology. Through workshops, conferences, publications and presentations at home and abroad we will continue to raise awareness of the importance of wild salmon and sea trout as indicator species, as well as cultural icons and economic assets. We will also continue to use scientific evidence in our efforts to influence decision makers on issues such as mixed stocks exploitation and salmon aquaculture.

The AST's work has one clear ultimate goal, which we share with every other organisation in the sector, namely an abundance of naturally regenerated wild salmon and sea trout to levels that allow for a harvestable surplus. For that to happen we need to know more about these fish and apply the knowledge gleaned from research to taking the right actions on their behalf.

A lethal load of juvenile sea lice on a finnock caught in a fyke net in Little Loch Broom summer 2011 Photo - APHA

ENGLAND AND WALES

Ivor Llewelyn, Deputy Director England & Wales



So far as salmon and sea trout are concerned, the coalition Government has had a reasonably encouraging first year. It has certainly said the right things, although on most issues we are still waiting for action.

The Minister responsible for salmon and freshwater fisheries, Richard Benyon (himself a keen salmon angler), has made it clear that he recognises the contribution that fisheries and angling make to the natural environment and to people's wellbeing. He has convened two 'angling and fisheries summits'; the first attended by the main NGOs (including the Trust) and the second by a wider range of people involved in fisheries and angling. They discussed a range of issues, including the future management of fisheries, hydropower and predation. We expect further meetings of this kind to be arranged.

At the second of these meetings the Minister made the welcome announcement that new legislation on fish passage, for which we have been pressing for some time, would be brought forward.

The Government's overriding concern, of course, has been to reduce the budgetary deficit. Overall, fisheries has escaped the worst consequences of the cuts. Although the Environment Agency's funding has been reduced substantially, it is slightly increasing the amount of its grant that it spends on salmon and sea trout. This is very welcome, and follows joint lobbying of both the Government and the Agency by the Trust and the S&TA.

We are also very pleased that the Government has announced that it will spend an additional £92 million over the next few years on improving the state of our rivers. The money will be spent on removing weirs and improving fish passage, habitat restoration, dealing with pollution and removing invasive alien plants and animals. Part of the money will be spent through rivers trusts, and other fisheries and river restoration organisations will be able to obtain funding through a new Rivers Restoration Fund.

Environment White Paper

The government announced last year that it intended to issue a white paper on the natural environment, and published a discussion document on the topics it thought should be covered. The Trust worked closely with the other main fisheries and angling organisations to produce a comprehensive response; this emphasised the importance of rivers, lakes and streams to the wider environment, the need to improve conservation of the aquatic environment and the positive contribution made towards this by fisheries and angling. It also supported the retention of a single body responsible for the regulation and management of all aspects of the freshwater environment, but suggested improvements in the way that the Environment Agency exercised its responsibilities for salmon and freshwater fisheries. The Trust and the S&TA also produced a separate, further response focusing on salmon and sea trout. Both responses can be read on the Trusts website **(http://www.atlanticsalmontrust.org/concerns/white-paper-on-the-natural-environment-uk.html)**.

The Government has now published the White Paper. While this contains welcome commitments to improve rivers and streams, which will undoubtedly benefit salmon and sea trout, it does not address many of our specific concerns. We will be meeting the fisheries minister to discuss these.

2010 England and Wales Salmon Catches and Stock Assessment

The Environment Agency and Cefas have released provisional figures for rod and net catches last year. These show:

- The salmon catch by nets was 22,634 fish; this was almost double the average of the last five years, and the highest catch since 2002. 88% was taken in the north east coast fisheries, with more than half the total catch taken in T and J nets.
- The rod catch was 23,763 fish, which was over 50% higher than in 2009; 14,103 of these salmon (59% of the catch) were released. Catches of both grilse and MSW salmon were well above the previous 5-year average.

These figures are contained in the CEFAS and the Environment Agency's Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2010 **(http://www.cefas.defra.gov.uk/media/483458/salmonreport2010-web-version.pdf)**. This provides a wealth of information about all aspects of salmon fisheries, including catches, fishing effort, rod licence sales and the methods used and number of licensed netsmen in the various net fisheries. This Assessment is produced annually; this year, as an economy measure, it is available only as a web document.

The Assessment report warns that care is needed in drawing conclusions about the state of the stock from catches alone. The actual relationship between catch and stock abundance depends upon exploitation rates (i.e. the proportion of the salmon population taken in the catch - both retained fish and those released). Exploitation rates can be calculated on those rivers where there is a reliable fish counter that can establish

ENGLAND AND WALES

the size of the run. Counts and stock estimates of returning adult fish entering freshwater were better than those in 2009 in all but one of the 12 rivers for which data are available; in 7 of the catchments the runs were also above the recent 5-year average. Exploitation rates were more variable (suggesting that angling conditions varied between rivers), but were generally below the average for the last five years. These estimates confirm that the improved catches last year did indeed reflect an improved run.

The Assessment report also looks at the overall state of salmon stocks in England and Wales, Stocks on 64 individual rivers are assessed by the Environment Agency against **conservation limits**, which define the minimum number of spawning adults needed to ensure the conservation of salmon stocks; they therefore set thresholds below which the number of returning adults that survive to spawn should not fall. In 2010, 59% of rivers were assessed as meeting their conservation limits, up from 34% in 2009.

Numbers of spawners, and hence compliance with conservation limits, can vary significantly from year to year, so the Agency seeks to manage stocks at a level well above the conservation limit. To do this, a **management target** is also set for each river; this represents the average number of spawners required to ensure that stocks remain at or above their conservation limit for at least 4 years out of 5 (the **management objective**). On average, across all rivers in England and Wales, the management target is 35% higher than the conservation limit.

The Agency classifies salmon rivers in four categories, according to the likelihood that they will meet the management objective of complying with conservation limits in 4 years out of 5. The categories, numbers of rivers in each category in 2010, and forecasts for 2015, are shown in the table below (comparable figures from last year's Assessment are shown in brackets):

While there is a welcome increase in the number of rivers in the highest (Not at Risk) category, in both 2010 and 2015, this is largely due to movements up from the next highest category. There is no change in the number of rivers estimated as being in the two lowest categories (having less than a 50 % probability of meeting the management objective) in 2010, and only a slight reduction in the numbers forecast to be in these categories in 2015. However, the report continues to forecast a substantial reduction in the number of rivers in the lowest (At Risk) category.

The report also assesses the total number of salmon returning to England and Wales (before exploitation) and the total number of spawners. These have shown a steady decline over the past forty years, with total returns falling by some 55% since the early 1970s and spawners by around 35% (the difference in the two percentages reflects the effect of lower levels of exploitation by both nets and, via catch and release, rods). The figures for 2010 show a sharp upturn following those for 2009, which were the lowest on record.

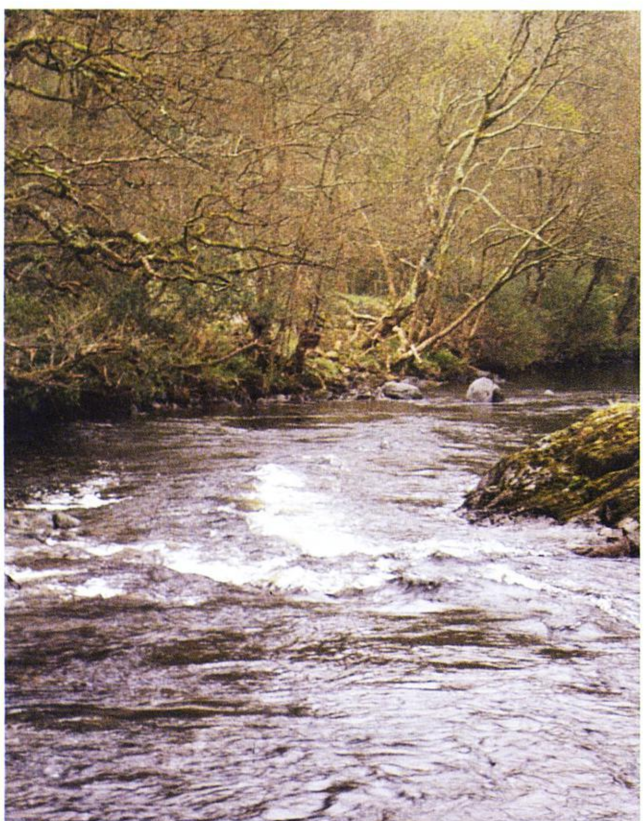
Category	Probability of meeting the management objective	2010 (2009)		2015 (2014)	
		Number of rivers	%	Number of rivers	%
Not at Risk	>95%	13 (7)	20	12 (6)	19
Probably not at risk	50%-95%	12 (18)	19	20 (23)	31
Probably at risk	5%-50%	16 (17)	25	22 (25)	34
At risk	5%	23 (22)	36	10 (10)	16

THE RESEARCH ROLE OF THE ATLANTIC SALMON TRUST

THE ATLANTIC SALMON TRUST'S MISSION IS TO FACILITATE SCIENTIFIC RESEARCH FOR THE CONSERVATION OF WILD MIGRATORY SALMONIDS. IN AN EVER CHANGING AND FAST MOVING WORLD IT IS IMPORTANT THAT THE TRUST CHALLENGES ITS RESEARCH ROLE AND LOOKS AFRESH AT HOW BEST TO SUPPORT THE URGENT MANAGEMENT ISSUES FACING OUR WILD SALMON AND SEA TROUT STOCKS. PROFESSOR KEN WHELAN CHARTS THE AST'S NEW COURSE AND DESCRIBES HOW THE TRUST IS PREPARING TO MEET THE CHALLENGES AHEAD.

Background

Since its formation in the late 60s the Atlantic Salmon Trust has championed the welfare of wild salmon and sea trout stocks, which it clearly sees as an essential component of aquatic biodiversity, both freshwater and marine. The main objective of AST is to promote scientific research which can lead to the conservation and improved management of wild migratory salmonid stocks and to disseminate the information derived from that research to inform and influence fishery managers, anglers, conservation groups, government and all who by their actions may have an impact upon wild salmonids.



The R Duddon, Cumbria

In summary the Trust aims to:

- Support marine and freshwater research
- Give independent research-based advice to a wide range of interest groups including: sister conservation organisations, governments, international and national authorities, to commercial and angling interests.
- Co-ordinate activities with other conservation, environmental, fishery, heritage and wildlife agencies and organisations
- Hold and support seminars and workshops to investigate specific issues
- Publish high quality reports and booklets to inform and to educate
- Influence governments and their agencies to adopt evidence –based policies for the conservation of wild salmon and sea trout and their habitats
- Work generally for the conservation and improvement of wild salmon and sea trout stocks to a level which allows sustainable exploitation

Concerns

Increasingly over the past decade the AST has focused its attention on issues relating to the welfare and survival of migratory salmonid stocks at sea. Therefore the current focus of the Trust's work encompasses not alone the more traditional areas of concern in freshwater but also threats from aspects of their life at sea. There is also an increasing awareness of the need to understand their role in the underlying marine and freshwater ecosystems which regulate their overall survival. The main concerns which the Trust seeks to address can be summarised as follows:

THE RESEARCH ROLE OF THE ATLANTIC SALMON TRUST

At Sea

- Changes in migration, distribution, feeding and survival patterns of migratory salmonids
- Fishing – bye catch in pelagic commercial fisheries and excessive harvest of fodder fish species
- Degraded marine habitats and pollution
- Predation – marine mammals

On the Coast

- Mixed Stock Fisheries and bye catch
- Aquaculture Impacts – sea lice infestation, escapees, genetic introgression and disease
- Degraded estuarine and bay habitats and pollution
- Predation – marine mammals and cormorants
- Poaching

In Rivers and Lakes

- Climate Change – impact on rainfall patterns, temperature, flow, discharge patterns, water resources and water resource management
- Pollution and poor habitat
- Aquaculture Impacts – cage rearing of juvenile salmon, leakage of juvenile salmon from land based rearing units, genetic introgression
- Abstraction
- Obstructions – dams, weirs and culverts
- Impacts of existing and new hydropower developments
- Predation – cormorants, sawbill ducks, mink and assessing the potential impacts of recovering otter populations
- Disease
- Impacts of poor angling practices on fish survival

The AST's Research Role

Traditionally the AST's role in research was quite broad ranging. In addition to its core programme of seed funding new or innovative research the Trust in recent years provided river bank advice on a wide range of areas such as stock management, habitat management, impacts from aquaculture and stock restoration. The AST was also central to many major research initiatives including for example the SALSEA Merge FP7 research programme and the SALGEN genetics programme. The Trust initiated and ran a wide range of seminars, workshops and scientific conferences. It published the Blue Books series which in addition to recording the proceedings of these events covered a wide range of management and environmental issues.

Over recent years new organisations, based on the very successful Rivers Trust model, have been established throughout the British Isles; these provide practical assistance and advice on such matters as fisheries management and habitat restoration. Trusts have largely replaced the river bank service provided by AST. In addition the work of the Wild Trout Trust provides river surveys and advice to angling clubs and angling interests and they are particularly successful in urban areas. Their work includes the rehabilitation of derelict sea trout fisheries which very much complements that of the AST in these degraded habitats.

For the future, AST will concentrate its efforts on identifying and supporting research gaps and practical research needs. The Trust will act as a research broker to advise on and where necessary establish partnerships with sister bodies, both national and international, and seek funding for key research areas. With its partners the AST will seek to establish a funding mechanism that is both pliable and reactive and will complement on-going research in Government agencies and in third level institutes.

Management of migratory fish stocks will in the future require a far greater emphasis on adaptive management and the need to integrate new and emerging research results into the day to day management of migratory fisheries. New integrated approaches to the use of Information and Communications Technologies (ICT) will facilitate a modern ecosystem approach to management of our aquatic resources and the Trust sees a clear role in facilitating access to new and innovative solutions to present challenges through its highly regarded workshop and seminar programme.

THE RESEARCH ROLE OF THE ATLANTIC SALMON TRUST

The AST will continue to run and organise meetings on major topics of interest and act as a focal point for the development of new and innovative research initiatives.

Central to the future work of the AST will be the recently established Fellowship Scheme. The scheme is designed so that it can support, as funding allows, not alone traditional post graduate and post doctoral research but also advanced training, upskilling and the appointment of Fellows to act as Research Officers and carry out discrete research projects over a twelve to twenty four month period. This type of Fellowship could prove particularly useful in the collation and publication of existing data from grey literature or the cataloguing of historical reports and papers.

AST Research Themes

The AST is currently developing and refining a set of research themes and key research topic areas – see below. These will comprise the research topics of key importance to AST and will be used as a basis for deciding on which research initiatives will be prioritised by the Trust. The themes and research areas will be kept under review and it is envisaged that a formal review of these will be carried out every 5 years to ensure that they accommodate new and emerging areas of concern or interest.

Theme 1:

The Marine life of Salmon and Sea trout

- Monitoring of juvenile salmon migration routes in estuaries and near shore locations
- Development of methodologies to monitor the abundance of juvenile salmon stocks in the marine pelagic zone
- Addressing priorities which emerge from the completion of SALSEA Merge – e.g. analysis of stored samples from the surveys, such as isotopes, lipids & plankton
- Movements and ecology of juvenile sea trout in the inshore zone, use of estuaries by sea trout, including for over-wintering

Theme 2:

Managing Salmon & Sea Trout in a Changing Climate

- Assess the impacts of climate change on in-river habitats and migratory salmonid populations
- Identification of key populations at risk
- Assess impacts of changes in flow, discharge patterns and changing temperatures on geomorphology, juvenile survival and migration patterns
- Mitigating the effects of barriers to fish passage, including in-river hydropower schemes
- Excessive abstraction and water quality
- Drivers for Anadromy - what factors influence levels of anadromy in trout populations (genetic, food availability, physical habitat changes etc) and how climate change may affect these
- The role of small streams in the ecology of juvenile salmon and sea trout
- To assess habitat loss and support the development of novel conservation techniques

Theme 3

Impacts of Aquaculture

- Assess the status of migratory salmonid stocks in fish farming areas
- Assess the level of introgression between wild and farmed Atlantic salmon in selected salmon rivers and lakes
- Restoration of damaged migratory stocks

Theme 4

Social and economic importance of salmon and sea trout

- Assess the wider economic and social importance of salmon and sea trout and their fisheries, using both traditional and ecosystem service payment models - see **(http://www.teebweb.org/) and (http://bankofnaturalcapital.com/)**

THE RESEARCH ROLE OF THE ATLANTIC SALMON TRUST

Role of the HSAP

The Honorary Scientific Advisory Panel has played a pivotal role in the success of the Atlantic Salmon Trust research initiatives. It comprises a group of eminent scientists who meet annually and provide advice and support to the Trust in all facets of its research work. Their guidance on the quality of the science undertaken in AST funded programmes and their advice on new and emerging areas of science in which the Trust might consider becoming involved, has ensured that the work of the AST is both current and relevant to the management and conservation of salmon and sea trout stocks.

In the light of the changes outlined above we envisage that the future work of the HSAP will largely focus on the following:

- Commenting on the research themes and research areas identified as priorities by AST
- Advising on possible synergies with existing or planned programmes
- Advising on possible partnerships and funding opportunities
- Advising on the structure and potential outcomes from identified fellowship programmes, in terms of their relevance and the quality of the science likely to emerge from the study
- Suggestions with regard to third level institutes who would be willing to host Fellowships and the identification of possible Fellowship supervisors
- Comment on the research reports received form AST Fellows or other AST research initiatives
- Advise on themes for seminars conferences and workshops

The AST is fundamentally a research support organisation which was established to ensure that the best objective scientific advice is available to those involved with the management and conservation of our valuable migratory salmonid stocks. Where technical or scientific evidence is lacking or where advice is unclear or technical issues remain unresolved, the Trust will work with a wide range of partners to tackle such impediments. Armed with the best available science it is the Trust's mission to interact with Government, advisory and management bodies to ensure that decisions relating to the welfare of salmon and sea trout stocks take full cognisance of best advice and the latest technical results. Where such advice is lacking the Trust will, as in the past, push relentlessly for adoption of the precautionary approach, based on the international protocols agreed through NASCO.

It is the Trust's view that lack of scientific evidence should never be seen a reason to delay or prevaricate over critical management decisions but equally management decisions and management structures should be subject to refinement and change in a proactive and creative manner.

OCEAN SILVER

THE LAST FOUR DECADES HAVE SEEN A MASSIVE DECLINE IN MARINE SURVIVAL OF SALMON, WITH THE DROP IN RETURNING MULTI-SEA-WINTER FISH A PARTICULAR CAUSE FOR CONCERN. ALTHOUGH THE PROBLEM WAS OBVIOUS, THE REASONS HAVE BEEN LESS SO. RECENT RESEARCH – IN PARTICULAR THE SALSEA PROGRAMME – IS STARTING TO BRING ANSWERS TO THE QUESTION OF WHY FEWER FISH ARE SURVIVING TO RETURN TO OUR RIVERS. IN THIS ARTICLE, PROFESSOR KEN WHELAN SUMMARISES WHAT WE CAN HOPE TO LEARN FROM SALSEA, IN TERMS OF WHERE OUR FISH GO AT SEA, AND WHAT CONDITIONS THEY FIND ON THEIR JOURNEY.

SEVENTH FRAMEWORK PROGRAMME

The Atlantic Salmon's Ocean Odyssey

Stocks of salmon first showed signs of a serious decline in marine survival in the late 1960s and 70s, when catches of 2-sea-winter spring salmon and the giant 3 and 4-sea-winter fish dropped sharply. Only the Norwegian and Russian rivers of the far north seemed to be immune from these trends. As the decades wore on it became obvious that these very large fish were quickly becoming a rarity and the early spring run was apparently becoming later and later. Finding a cause was particularly difficult as the salmon was assaulted on all fronts by a wide array of pernicious and damaging catastrophes.

The deadly salmon disease, UDN, first made its appearance in the mid 60s against a back-drop of increasing levels of domestic, industrial and aerial pollution. Habitat loss, due to river impoundments and arterial drainage schemes, was widespread and industrial development seemed destined to move inexorably forward, accompanied by a serious degradation in water quality and the aquatic environment. The discovery of the salmon's feeding grounds in the north Atlantic and the sudden and very dramatic appearance of major high seas fisheries off the Faroe Islands and Greenland seemed to sound the death knell for the salmon. Every commentator appeared to have a favourite singular cause for the decline in stocks but nobody seemed to appreciate that the deadly cocktail of impacts was potentially far more serious than any individual issue. Even more surprisingly, little if any research was carried out on the role of marine survival and how this decline in stock abundance might be linked to or regulated by, natural cyclical changes at sea.

By the early 1990s it was clear that grilse stocks were also showing evidence of poor marine survival. This was particularly true in the case of more southerly stocks stretching from the Iberian Peninsula to the Northern Isles of Scotland.

However, by this time, great advances had been made by NASCO and the North Atlantic Salmon Fund in tackling the management of the high seas fisheries off Faroe Islands and Greenland and all that remained of the original 3,000 tonne commercial fishery was a subsistence fishery along the west coast of Greenland. Pollution was under increasing control, salmon loss was slowly stemmed and there was a far greater awareness of the long-term impacts of barriers, barrages and hydro electric dams and turbines. Despite all of this progress some of the long term index systems showed a steady decline in smolt-to-adult return rates, and in many cases a drop of one third or more in survival rates was recorded. In the 70s a smolt-to-adult return rate of 15% plus had been apparent but by the mid-90s survival rates of 10% or less were consistently recorded. It had been assumed that once the high seas fisheries had been eliminated stocks of salmon would rebound but this was far from the case and it became increasingly obvious just how little we knew about the travels of salmon at sea and the challenges they faced. It was also obvious that tackling these major research questions was beyond the resources of any single jurisdiction and that a well planned cooperative approach was called for.

“The deadly salmon disease, UDN, first made its appearance in the mid 60s against a back-drop of increasing levels of domestic, industrial and aerial pollution.”

OCEAN SILVER

The breakthrough came in the late 90s when Jens Christian Holst of the Institute of Marine Research in Bergen and Dick Shelton of the Fisheries Research Services in Scotland, in a project part-funded by the Atlantic Salmon Trust, joined forces to test the feasibility of designing a pelagic trawl that would consistently capture post smolt salmon at sea. The challenge was immense: to find and capture relatively small numbers of tiny silver fish (8cm to 20cm in length) in the vastness of the North East Atlantic. Despite the frustrations and initial disappointments that inevitably accompany such research, Dick and Jens Christian succeeded in locating smolts, pinpointing their pattern of movement along the edge of the giant north Atlantic currents and refining the trawl so that it consistently sampled the top two to three metres of the ocean's surface layers, where the salmon smolts are to be found. This seminal work was fundamental to the design and implementation of future marine programmes.

As mentioned earlier, NASCO's original brief was the regulation and management of the high seas fisheries, which were all but eliminated by the late 80s. In the following years NASCO turned its attention to the conservation of the species and the improvement of management systems in home waters, the eradication of a broad range of threats relating to habitat, water quality and the potential impacts of aquaculture. Advice from ICES in the early years of this decade consistently drew attention to the serious marine survival issues affecting salmon at sea and the need to learn more about the salmon's role in the overall ecology of the pelagic zone of the north east Atlantic.

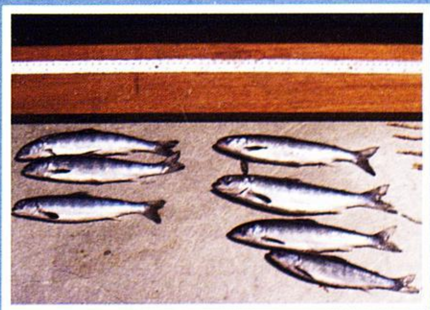
It became obvious that the only way forward was to encourage NASCO parties to pool resources; to draw together existing work in the marine area and to compile a comprehensive over-arching research proposal. To coordinate this process and to ensure a clear focus on marine survival issues by both the parties themselves and the home water Governments, NASCO established, in 2001, the International Atlantic Salmon Research Board IASRB (see **www.nasco.int/researchboard.html**), which compiled a costed inventory of marine research and set about assembling a research plan.

SALSEA Merge

The three year SALSEA Merge programme was the most extensive of the marine initiatives and comprised over 50 scientists from ten nations across Europe. It was designed to deliver novel, regional and stock-specific, migration and distribution models merging hydrographic, oceanographic, genetic and ecological data. It included six 15 to 20 day marine surveys, stretching from the west coast of Ireland to areas deep into the Greenland Sea. In essence, the initiative set out to compile a series of complex maps showing where individual stocks of salmon or regional groupings are located at sea, the pathways they use to locate these feeding areas and the parts of the ocean where stocks of salmon are found during their first summer at sea.

On each research cruise every salmon post-smolt was examined in great detail. The fish were photographed, measured, weighed, sexed, scale loss was estimated, number of lice counted and stored, and a visual inspection of cataracts, external tags, fin clip for internal tags, deteriorated fins/escapee, scars etc, was carried out. The biological samples taken included: scale sample, pectoral fin for DNA sample, disease sample (gill filament, pyloric caeca, spleen, and kidney), ISA disease sample (gill filament and kidney), Isotope sample (liver, dorsal muscle, adipose fin, heart, and tip of caudal fin), lipid sample (dorsal muscle), stomach sample, and otolith sample. The carcass was labelled and stored. Full details of the SALSEA-Merge programme are available on **www.salmonatsea.com**.

In addition to the results themselves the programme has also provided novel genetic, scale reading and marine sampling techniques which hopefully will become standard tools for managers into the future. The extensive databases of biological information emerging from SALSEA Merge will be made publicly available over the next year and will provide a unique resource for those working on the marine life of the salmon well into the future.



Photos - Deirdre Brennan

OCEAN SILVER

Examining the results

The scientific results from SALSEA Merge, in conjunction with data from a wider range of sister programmes from both the Atlantic and the Pacific, will be presented at the Salmon Summit planned for La Rochelle, France in October 2011 – (**www.nasco.int/sas/salmonsummit.htm**).

The salmon summit will be complemented by a major dialogue meeting, organised by the AST at Fishmongers Hall, London (**www.atlanticsalmontrust.org/oceansilver/**) on the 13th December 2011. The conference, Ocean Silver- the Atlantic salmon's ocean odyssey: implications for fishery managers, will concentrate on results from the North East Atlantic. A panel of well known and expert scientists will present the results of the SALSEA Merge programme, in ways which are accessible to the non-scientist.

As mentioned above, AST was a major sponsor of SALSEA - Merge and one of only two non-government financial contributors. We would encourage you to attend and make your voice heard at this unique and important gathering of scientists, managers and anglers. The SALSEA programme will provide the basis for advancing our understanding of oceanic-scale, ecological and ecosystem processes needed for implementing, in the future, sustainable management of this key marine species.

It is our hope that the conference will give fishery managers, anglers and others involved in the welfare of wild Atlantic salmon the opportunity to see these remarkable animals in a wider context and to find implications and some applications for managing them better on the riverbank and along our coasts. Delegates will also learn about the extraordinary role of the wild salmon in bringing back home information about the oceanic environment, and how those data, analysed by novel scientific methods in genetics and scale reading, can contribute to a fuller understanding of the life of salmon at sea.

Photo - Deirdre Brennan

MIXED STOCK FISHERIES – THE AST POSITION

IVOR LLEWELYN EXPLAINS WHY THE AST WANTS TO SEE AN END TO MIXED STOCK FISHERIES, AND ARGUES THAT IT IS NOW TIME FOR GOVERNMENTS THROUGHOUT THE UK TO ACT.

The AST, in common with NASCO and ICES, is opposed to fisheries which exploit stocks from more than one river – mixed stock fisheries. The reasons for this are clearly set out by Andrew Wallace in his article on Scottish mixed stock fisheries; in essence, unless salmon are managed according to their river of origin it is impossible to assess the impact of a fishery on a particular stock. The only exception is fisheries which exploit stocks from a strictly limited number of rivers, typically flowing into a common estuary, where the impacts on each stock can be accurately assessed.

As Andrew Wallace says, this is not simply a Scottish problem. It has an English dimension as well, in particular the net fisheries off Northumbria and Yorkshire. It has been Government policy in England and Wales since 1991 to phase out mixed stock fisheries, a policy strongly supported by the AST. This has brought results. Over twenty years, and with the assistance of a buy-out scheme in 2003, the number of net licences on the North-East coast drift net fishery has fallen from 142 to 14. There has been a significant fall in licence numbers in the Anglian coastal drift net fishery, which exploits mainly sea trout, and smaller coastal net fisheries, such as those off South- West Wales and South-West Cumbria, have been closed. The effect of this very significant reduction in netting effort was described in last year's journal, with English and Welsh net catches falling from a five year annual average before the NE coast buy-out of 38,000 salmon to one of 10,000 salmon for the five years after the buy-out.

Averages, though, can hide significant variations from year to year. In 2010 the total net catch in England and Wales was 22,000 salmon; around three times higher than the catch in 2009, almost double the average of the last five years and the highest declared catch since 2002. Almost 90% of this was accounted for by the North East coast net fisheries.
These catches reflect a much better run of salmon last year than in 2009, with rod catches also doubling, but they do send a warning signal. North-East coast fixed nets (T and J nets), are not being phased out. This is because when this policy was introduced it was thought that they mainly targeted salmon returning to local rivers, and sea trout. But last year they took well over half the total catch. The potential of the North-East coast (and other) net fisheries to catch large numbers of fish if conditions are right has been clearly demonstrated.

In these circumstance, the AST, together with the Salmon and Trout Association, wrote to Richard Benyon, the UK fisheries minister, urging him to take action to phase out T and J nets. These are classified, by ICES and the EU, as coastal mixed stock fisheries, and we believe that the failure to treat them as such is no longer acceptable. We are also seeking the

> “ The time has surely come for the UK and Scottish Governments to deal decisively with the issue of mixed stock fisheries; voluntary schemes, even when encouraged by buy-outs, are no longer sufficient ”

A Northumbrian salmon netting boat prepares to sail
Photo - Fiona Cameron

MIXED STOCK FISHERIES – THE AST POSITION

introduction of an overall quota to ensure that catches are kept within agreed limits – something that is also relevant to other net fisheries.

As Andrew explains, this is not purely a UK issue. If we do nothing about our own mixed stock fisheries, North and South of the Border, the Greenland and Faroese governments, which are already under pressure from their fishermen to resume commercial salmon fishing, will be increasingly reluctant to resist this pressure. Concern on this point led six fisheries organisations, including the AST, to send a joint letter to the UK and Scottish governments. The letter concluded:

'There is a very real risk that unless the UK and Scottish governments are seen to be taking more effective action to control catches [in mixed stock fisheries], there will be a resumption of distant water fishing for salmon on a significant scale, and this could have significant impact on stocks within UK rivers which are struggling to reach conservation limits. This would undo the progress that has been made over the last twenty years to reduce the exploitation of salmon, which in turn has been critical in limiting the impact of lower levels of survival at sea on the number of salmon that survive to spawn.'

While the changes we are seeking in England and Scotland will help, the time has surely come for the UK and Scottish Governments to deal decisively with the issue of mixed stock fisheries; voluntary schemes, even when encouraged by buy-outs, are no longer sufficient. Ireland has shown us the way forward. There, the coastal drift net fishery was closed by Government action, with proper compensation paid to netsmen. The AST believes that similar action must be taken throughout the UK.

Tending salmon stake nets at Blackdog, Aberdeenshire. Photo - Fiona Cameron

ENOUGH SALMON PIE FOR ALL? NO FUTURE FOR SCOTTISH MIXED STOCK SALMON FISHERIES

ANDREW WALLACE – CHAIRMAN, RIVERS AND FISHERIES TRUSTS OF SCOTLAND (RAFTS), DISCUSSES THE PAST, PRESENT AND FUTURE OF SCOTLAND'S MIXED STOCK SALMON FISHERIES.

There have been few more vexatious subjects in the annals of Scottish salmon fisheries management than the long history of disagreement between rod and net fisheries. There are parts of Scotland where these two forms of exploitation co-exist quite happily but, as a general rule, they don't and the reason for this is obvious. The "salmon pie" is finite and just as net fisherman wish to see as many fish as possible on ice and off to market, so rod fishermen want to see them on the end of their lines. These two aspirations were never going to be easy to reconcile.

It is getting increasingly hard to understand now, as the perspective changes with time, but Scottish salmon was, until the late 70's and early 80's, largely viewed from a business perspective as a highly prized and economically valuable commodity. The management of the resource was heavily dominated by those with an interest in commercial fisheries and many of the salmon fishing luminaries of that time had considerable interests in net fisheries. Most major Scottish fishery boards were dominated by lower proprietors whose net fishing rights were economically far more important than the recreational fishery which tended to be a low-key gentlemanly pursuit, often very much playing second fiddle to the economically muscular net fisheries. Salmon, as a commodity, was big business.

Such was salmon abundance at the time that huge commercial fisheries were being sustained at every point in the salmon's migration at sea. At Greenland and Faroe, over 3000 tons of fish were caught at the peak of that fishery. From 1960, briefly but devastatingly, a major drift net fishery for salmon existed off the Scottish coast. Along the coast itself were serried ranks of fixed engines, and in estuaries and lower rivers net and coble fisheries operated in considerable numbers. Only after having run this gauntlet, often waiting until the start of the netting close season at the end of August, did rod fisheries get much of a look in. This was purely a reflection of what part of the business was paying the bills.

As salmon abundance fell away in the 70s and 80s, there was a growing realization that such extensive exploitation was simply not sustainable. In an early moment of enlightenment, the short-lived drift-net fishery for salmon was banned in Scotland in 1962, something that took English and Irish salmon administrators a further 40 years to address. The North Atlantic Salmon Conservation Organisation (NASCO) was formed in 1983, resulting in the control, almost down to zero, of all exploitation at Greenland and Faroe, where it remains to this day. And many coastal net fisheries were acquired for conservation purposes throughout the 80s and 90s by Fishery Boards and organisations like the Atlantic Salmon Conservation Trust. The high days of salmon abundance and the businesses it supported, when over half a million fish were caught in the Scottish net fishery alone, were now well and truly over. In 2009, just over 8000 fish were reported caught in Scottish nets (10% of the all methods catch).

The primary driver of the decline of the net fishing industry was a marked decline in marine survival of salmon, resulting in fewer numbers of fish returning to the Scottish coast. There is a prevailing view that the number of smolts leaving Scotland each year has probably not declined substantially over the last sixty years. Indeed, in many rivers it may have increased as a result of large areas of river having been opened up to fish, accompanied by a considerable improvement in both water and habitat quality.

" Such was salmon abundance at the time that huge commercial fisheries were being sustained at every point in the salmon's migration at sea. At Greenland and Faroe, over 3000 tons of fish were caught at the peak of that fishery. "

ENOUGH SALMON PIE FOR ALL?

It is said that for every 100 smolts going to sea in the 1960's, about 20-30% would return to natal rivers. In 2011 few rivers will exceed a 5% return rate. This in effect means there are four to six times fewer fish around now than then. The impact of these diminished returns on the sort of abundances of fish available to support commercial fisheries has been obvious. A further factor in the 1980s and 1990s was the depression of salmon prices as a result of the emergence of large quantities of cheap farmed salmon further undermining the competitiveness of netting businesses. That singular collateral benefit of salmon farming was short lived as wild salmon now commands a vast premium (up to £30/kg in the spring), creating further pressure on a resource that can ill afford the motivations associated with such seductive prices.

Finally, there was a growing understanding, driven by these serious declines, that the only sensible way to manage salmon stocks - which due to their biology are always a product of their natal river - was to ensure that each catchment had sufficient information on the numbers of smolts leaving the system, the numbers of adults returning and the exploitation of those stocks at all points (by nets, rods and predators) such that managers could make sensible decisions about what was an appropriate level of exploitation at each stage.

Salmon management is an imprecise art and such data is hard and expensive to come by. The story is further complicated by the fact that each river has more than one population of fish (spring / grilse / autumn etc) the exploitation of which should logically be assessed and managed separately. But managers have to make decisions based on the evidence they have, not necessarily on that which they might want. The crude but practical end result of this logical train of thought was: net buy outs and regulations (particularly to control exploitation on vulnerable stocks); precautionary catch and release measures, which in Scotland now have resulted in over 70% of all rod caught fish being returned (and over 80% of all rod caught spring fish); predator control as and where possible; effective anti-poaching measures and a general focus on improving, as far as is possible, the in-river environment. These measures are increasingly evidence-based and are paid for out of the resources raised from fishery boards.

Therefore in any given catchment, and with sufficient information, it should be possible (at least in theory) to agree how the finite "salmon pie" is sliced up between rods, nets and even predators! This can and in some cases has led to a truce between those competing for the resource, based on a better understanding of what that resource will sustain.

Tending salmon stake nets at Blackdog, Aberdeenshire. Photo - Fiona Cameron

In such places agreement is reached whereby a local single-stock, in-river net fishery can continue sustainably harvesting commercially viable numbers of fish without notably compromising either the fish stock or the upstream rod fishery. Such a solution is also equitable, as those who pay for the management of the resource through the fishery board levy system within the catchment (including the netsmen), then reap the rewards of effective local management.

However, this system relies entirely on two principles. First, that a precautionary approach to stock management is maintained and, second, that harvesting is confined to single-stock fisheries. These principles are enshrined in all conventional, internationally accepted salmon management wisdom and are hard-wired into the advice given by the International Council for the Exploration of the Sea (ICES) and its annual recommendations to NASCO. It is adherence to these principles that supports the logic of keeping the Greenland and Faroese fisheries closed, and which underwrote the eventual decommissioning of the Irish Drift Net Fishery and most of the North East Drift Net Fishery. It is widely accepted, in one of those rare moments of convergence of thinking in the fisheries world, that exploitation of salmon stocks should occur as close as possible to the river of origin of the fish being exploited for the simple, startlingly logical reason, that unless you do so, you have no idea whether that exploitation is sustainable.

So what is the problem? The problem is that despite this consensus several countries, Scotland included, continue to allow mixed stock net fisheries to continue. These fisheries fly in the face of all the logic listed above and undermine the common-sense principles of salmon stock management by exploiting significant numbers of fish at gathering points on the coast that are destined for any number of rivers. This is an

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affront to sound salmon management at many levels. We don't know where these fish are destined for or whether the stocks in these systems are capable of exploitation. Many of the rivers which they are destined for are Special Areas of Conservation (SACs) which under European Law require us to manage on a highly precautionary basis. Furthermore exploitation of large numbers of fish from adjacent catchments by a net fishery that makes no contribution to or has no locus in the management of those stocks, is inequitable. And the final paradox is that every year, through the advocacy of NASCO, we demand that hard-pressed Greenland and Faroese fishermen desist from catching our fish in their own mixed stock fisheries, only to summarily go on catching them in our own.

At the NASCO Conference in Greenland in June 2011 international salmon managers, for the first time, witnessed directly the strength of feeling about this lack of 'weight pulling' by the developed nations in the NASCO family. A large delegation of Greenland fishermen protested that the bays in West Greenland were currently full of salmon and that it was unacceptable that they should not be allowed to catch these fish when mixed-stock net fisheries were still being operated in the home waters of rich Western nations. Their case is hard to argue against.

The prospect of the big commercial fisheries in Greenland and Faroe reopening, both of which have desisted until now purely because they have been requested to do their bit for salmon conservation, should fill all salmon managers around the North Atlantic with dread.

It is all too easy to conflate the two arguments about the generalities of net fisheries and the specifics of mixed-stock fisheries and portray these views as some form of anti-netting fundamentalism. It is not. Most salmon managers are perfectly content to take a sensible approach to managing in-river nets and to reap the benefits, where possible, of a sustainable harvest.

What has always been and will remain unacceptable until it is dealt with, is the continued harvest of substantial numbers of salmon in the few remaining indiscriminate and indefensible mixed-stock fisheries in Scotland and elsewhere. We have all worked hard to establish sound principles of salmon management based on arguments of equity, the precautionary approach, shared burden, sound and logical conservation arguments and the rule of European law. If these principles are to be maintained, then the remaining mixed stock net fisheries in Europe and North America, must be decommissioned and quickly.

Salmon was an important export for Scotland from the Middle Ages onwards. Indeed, it was classed as one of the 'staples' of trade with Europe.

This importance lasted until well into recent times, as is well illustrated by the history of the Salmon House at Portsoy, on the Banffshire coast. This was built in 1834 by the Seafield Estate, which then owned the salmon fishing rights along the coast, where both stake nets and bag nets were used. The three story building provided an office, a bothy, an ice house, a fish preparation area, workshop and storage accommodation. The Salmon House continued in use until 1990, when salmon netting was stopped at the Portsoy Station.

Portsoy salmon house Photo - Clare Tierney

Portsoy salmon house Photo - Clare Tierney

IRELAND'S NET FISHERIES: THE VEXED QUESTION OF CASTLEMAINE

NIALL GREENE, CHAIR OF THE BOARD OF DIRECTORS, SALMON WATCH IRELAND

There is a good deal of consternation and not a little bewilderment in Ireland about the decision of the Minister for Natural Resources to establish a quota for mixed stock draft net fishing in Castlemaine Harbour for July 2011. A draft statutory instrument had been published for consultation by the Minister in mid- May at which time Inland Fisheries Ireland (the state agency responsible for the conservation and protection of inland fisheries and wild salmonids) published the text of the management advice they had given the Minister and the scientific analysis behind it.

Castlemaine is a contentious area with two rivers which are above their conservation limits and two which are well below running into it and a fifth river which exceeds its conservation limit running into Dingle Bay which is seaward of Castlemaine. It is an SAC within which the local fishing community has been faced with struggles with the Habitats Directive to maintain their traditional mussel and salmon fisheries. After mixed stock fishing was abolished in 2007 the local fisheries board (since subsumed into IFI) attempted to licence a fishery in the harbour, ostensibly on the basis that there was sufficient spatial and temporal separation between healthy and threatened stocks to limit collateral damage. Salmon Watch Ireland and the Kerry Angling Federation obtained an interlocutory injunction in the High Court to prevent the initiative going ahead but the substantive case was never heard because the Government stepped in with new secondary legislation to enforce the mixed stock ban.

Then out of the blue in 2010 the then Minister of State for inland fisheries requested the Central Fisheries Board to advise him 'on how a commercial fishery could be operated on salmon stocks in Castlemaine Special Area of Conservation in a sustainable manner, maximizing the opportunities for commercial fishing while ensuring that stocks are not over-exploited'. A protocol was developed for the operation of a tightly defined and controlled pilot fishery in the harbour and this was conducted in June, July and August 2010 with a limit of 808 fish. In addition to collecting data on the location, timing and characteristics of each fish caught two biological samples of each were taken. The outcome comprised two scientific reports: one dealing with the distribution of the catch over five defined areas in Castlemaine and the timing of the catches; the other dealt with the genetic stock identification of the fish taken in the pilot fishery and the mixed stock characteristics of the 785 fish actually taken during the trial. The genetic analysis suggested that some 12% of the fish taken were from rivers other than the three 'healthy' ones. Both reports were reviewed by the Standing Scientific Committee of IFI.

The SSC response was cautious but concluded that 'fisheries should take place only on single stocks which are meeting their conservation limits and that 'fishing inside [the three healthy rivers] is advised as this will reduce the possibility of intercepting fish from other rivers'. Finally, they stated: 'if it is not possible to operate the fisheries within these rivers, then the fisheries should take place as close as possible to the rivers (i.e. the river mouths) or the estuaries of the individual rivers in order to reduce the possibility of intercepting fish from neighbouring and other rivers'. While acknowledging that more research needed to be done the SSC decided 'not to consider [the populations of the two rivers that are below their conservation limits] as discrete populations for the purposes of catch advice in 2012 (sic)' given the evidence from the genetic study 'of a high degree of temporal instability suggesting that these rivers may have low population integrity'. Finally, the SSC drew attention to the fact that two of the five areas studied in Castlemaine 'were more likely to take salmon from mixed stocks'.

Faced with all this carefully assembled and balanced advice, IFI in their submission to the Minister threw all the toys out of the pram and advised the provision of a quota (of 1,162 salmon) for Castlemaine in all five areas of the study, including the two that had been identified by the SSC as being particularly problematic from a mixed stock perspective. On that basis the Minister published a draft order on 19 May with a 30-day consultation period.

“Castlemaine is a contentious area with two rivers which are above their conservation limits and two which are well below”

IRELAND'S NET FISHERIES

In their lengthy submission to the Minister, Salmon Watch Ireland argued that the draft regulations constituted a departure from Government policy established in 2006; that the entire research exercise and the advice derived therefrom resulted from an inappropriate and skewed question posed by the then Minister in 2010 and that the processes required by the Habitats Directive (which was the measure which effectively brought an end to Irish mixed stock fishery for salmon) were not followed in that no appropriate assessment of the plan to reintroduce mixed stock fishing in Castlemaine had been carried out.

On 28 June the Minister signed secondary legislation permitting 11 public draft net licences to be issued for Castlemaine with a quota of 1,162 for the period 5 to 31 July, 2011.

Is this a major setback to the policy of ending mixed stock fishing for salmon in Ireland? Probably not – there are a number of other mixed stock estuaries being fished by draft nets around the coast albeit that in all of them the rivers are above their conservation limits – but it is an unfortunate precedent. In particular, the affair is a major setback to the credibility of the newly established Inland Fisheries Ireland which, when faced with finely balanced evidence about the state of stocks in Castlemaine and the damaging effect of the draft net fishing in the harbour, failed to take a precautionary approach and failed to obey the requirements of the Habitats Directive. What is also clear is that, with the dismantling of the Salmon Commission in which all stakeholders were represented, there is an inadequate degree of transparency in how these matters are being managed.

Salmon Watch Ireland is preparing a complaint to the DG Environment of the EU Commission about the affair.

Traditional draft netting in an Irish estuary Photo - P Gargan

THE IMPACT OF COMMERCIAL SALMON NETS ON NORTHERN IRELAND'S DIMINISHING WILD SALMON RESOURCE

THE DEPARTMENT OF CULTURE ARTS AND LEISURE (DCAL) HAS RESPONSIBILITY FOR CONSERVATION AND PROTECTION OF WILD SALMON FISHERIES IN NORTHERN IRELAND, EXCEPT FOR THE FOYLE AND CARLINGFORD CATCHMENTS THAT ARE THE RESPONSIBILITY OF THE LOUGHS AGENCY (WWW.LOUGHS-AGENCY.ORG). COMMERCIAL NETS, INCLUDING DRIFT NETS, MAY STILL BE LICENSED WITHIN THE INNER FOYLE BUT CURRENTLY ALL NETTING IS SUSPENDED PENDING RECOVERY OF THE SALMON STOCK IN THE RIVER FINN. WITHIN THE DCAL JURISDICTION A VOLUNTARY BUY-OUT HAS RESULTED IN A REDUCTION IN THE NUMBER OF COMMERCIAL LICENCES FROM 27 IN 2000 TO SIX IN 2004. THERE ARE CURRENTLY TWO DRIFT NETS AND TWO FIXED NETS OPERATING IN COASTAL WATERS WHICH ARE CONSIDERED MIXED STOCK FISHERIES. HERE MICHAEL SHORTT EXPLAINS WHY ANGLERS IN NORTHERN IRELAND ARE URGENTLY SEEKING THE REMOVAL OF THESE REMAINING COASTAL NETS.

Some years ago, in 2003/2004, DCAL accepted that action should be taken in respect of the commercial salmon fisheries licensed to operate in Northern Ireland. Eventually compensation was offered, in return for a voluntary cessation of commercial salmon fishing, to those still licensed to operate in the province. However, being voluntary, not all accepted the offer. This exercise resulted in a reduction in the number of commercial licences from 27 in 2000 to six in 2004. However, since then little has changed and, despite pressure from anglers and their representatives, these remaining commercial nets continue to fish.

DCAL Fisheries annual reports clearly state, under the heading Salmon Conservation, that... *"International scientific monitoring programmes have shown that Atlantic salmon populations are currently low and many are below safe biological limits.* ***Numbers of salmon returning to many Northern Ireland rivers are too low to be sustainable****... DCAL has a responsibility to conserve salmon by managing impacts, including angling and commercial fisheries. Work to manage these impacts is given high priority and is on-going... The strategy is based on NASCO resolutions and agreements founded on the precautionary approach and principles of sustainability."* However, some three years after Northern Ireland presented its first Focus Area Report to NASCO, indicating these weaknesses in the salmon management structure, nothing has been done to address the serious issues involved.

The DCAL Salmon and Inland Fisheries Annual Report 2008 states that there were two drift nets, two fixed nets and one tidal drift net operating in Northern Ireland and that the commercial salmon catch was 1,817 (3,834kg) compared with 2,647 (6,178kg) in 2007. The verified total salmon catch for all DCAL licensed coastal fishing engines in 2008 came to 1935 and in 2009 totalled 1537. Significant figures in that they illustrate an annual decline in catch numbers. As a footnote the value of salmon caught commercially in Northern Ireland from 2004 to 2006 had an estimated annual value of just £61,565.

This season, 2011, the Department has re-issued six commercial licences located off the coast of Northern Ireland. These have all been licensed in previous years and the Department state that they are required to issue a licence to any person who has held one in the previous year. This despite the fact that such a licence may not have been used. In fact the Department state that one has not been fished for a number of years. While no new licences may be issued it seems strange to renew inoperative licenses? Anglers must limit their catch – and practice 'catch and release' - according to the licence regulations but for the commercial nets no set number of tags is issued per licence and holders can request additional tags and these will be provided. The more fish they can catch the more they seem to be allowed to catch. In addition the relevant legislation does not refer to the length of nets and the Department holds no information on this.

Much to the frustration of those concerned with the conservation and management of wild salmon stocks in Northern Ireland little has changed since 2004 despite increasing problems and serious threats to local and specific river stocks. As a result the Ulster Anglers Federation has decided to make a formal complaint to DG Environment of the EU Commission on the basis that such indiscriminate mixed stock netting contravenes the EU Habitats Directive (92/43/EEC).

To manage the fisheries in a rational manner and to avoid any further damage to the weaker stocks it is imperative that DCAL must implement a programme utilising the latest genetic stock identification methods. This will identify what stocks are represented in the commercial catches and the risk posed to the weaker stocks impacted by these nets. Funds better utilised than fighting legal battles?

FRY SURVEYS

CONSERVATION LIMITS HAVE BEEN SET FOR ALL 148 IRISH SALMON RIVERS AND RECREATIONAL AND COMMERCIAL INSHORE FISHERIES ARE NOW REGULATED RELATIVE TO THESE CONSERVATION LIMITS BEING MET ON A RIVER-SPECIFIC BASIS ANNUALLY. EACH YEAR THE STANDING SCIENTIFIC COMMITTEE (SSC) OF INLAND FISHERIES IRELAND REVIEWS ALL DATA FOR SALMON RIVERS TO PROVIDE SCIENTIFIC ADVICE FOR MANAGERS ON THE ATTAINMENT LEVELS OF SALMON CONSERVATION LIMITS ON EACH RIVER. ANNUAL COMMERCIAL AND ROD CATCH DATA AND COUNTER DATA ARE ANALYSED TO DETERMINE IF RIVERS ARE MEETING THEIR SPAWNING TARGETS. A HARVEST FISHERY IS PERMITTED ONLY WHERE THE CL IS EXCEEDED. IN THIS ARTICLE PADDY GARGAN AND WILLIAM ROCHE OF INLAND FISHERIES IRELAND OUTLINE NEW DEVELOPMENTS IN STOCK ASSESSMENT.

Catchment-Wide Electrofishing as a means of salmon stock assessment in Ireland

For many rivers, the attainment of Conservation Limit (CL) is assessed by direct measures (e.g. counter data or rod catch based estimates to calculate total numbers returning to the river). However, since the new management regime was introduced in 2007 many small rivers or rivers deemed not to be meeting their conservation limit are closed to angling and commercial exploitation. Therefore no direct measures of salmon runs are available to advise on stock status for management.

It will not be possible to install fish counters in all rivers to assess stock status and many rivers (up to 107 in 2007) were closed and could remain so unless other measures of stock strength can be found. An indirect measure of salmon abundance, catchment wide electro-fishing of 0+ salmon fry, is being developed in Ireland to provide a means of assessing salmon abundance on rivers which have no direct means of assessment. In rivers without a counter, which are closed to angling and have unreliable salmon redd count data, this juvenile salmon index may be the only potential/practical measure of salmon abundance.

Juvenile Salmon Index

The abundance of salmon fry close to salmon redds in riffle areas has been used previously (Kennedy & Crozier, 1994) as an index of site-specific salmon abundance on the River Bush in Northern Ireland. This technique is now being developed for Irish salmon rivers to provide an index of juvenile salmon abundance on a catchment-wide basis. The objective of the catchment-wide electro-fishing programme is to attempt to develop an index of juvenile salmon abundance which could be used to assess attainment of salmon conservation limit. Electro-fishing is being undertaken in catchments above and below conservation limit and unassessed rivers. Some have counters which allow for investigation of the relationship between upstream adult runs and juvenile fry abundance.

Catchment-wide electrofishing is a semi-quantitative technique used to assess salmon fry (0+) distribution & abundance in a system. The technique is a rapid assessment method compared to the more labour-intensive quantitative electrofishing. It provides for the same effort an approximate estimate of salmon fry abundance at a much greater number of sites than would otherwise be possible. Crozier & Kennedy (1994) calibrated the technique against quantitative 3 catch depletion fishing and results indicated that electrofishing for a period of 5 minutes in a suitable habitat gave statistically acceptable estimates of actual salmon fry population density. They recommend that constant calibration is required in each catchment.

Site Selection & Time of Sampling

For the current long-term study sampling is undertaken at sites throughout each catchment to ensure coverage of all likely salmon-bearing or potential juvenile habitat. This provides data on the distribution and numbers of juveniles, identifies sections where barriers may be present downstream (i.e. by identifying sites where juvenile salmon are absent) and general habitat quality. Particular attention is given to known salmon spawning areas as adults stocks would be closely linked to spawning activity at these locations in the previous winter.

Sites are generally selected at riffles every 500m to 1000m apart throughout a catchment. Factors affecting site selection include accessibility for the survey team, depth and flow of river (a stretch of river may be unsuitable for the electrofishing method i.e. too fast or too deep) and presence/absence of riffles. In larger, well studied catchments sites are often located within known spawning locations; however the sampling effort is consistent throughout the catchment to ensure a comprehensive assessment is made. Catchment size sampled varies considerably (depending on the need to undertake catchment wide electro-fishing in the absence of a direct means of salmon stock assessment) but the majority of rivers are in the small to medium category.

FRY SURVEYS

Sampling is confined to the July to September period when salmon fry are large enough to capture and identify correctly, and are unlikely to have migrated significantly from spawning areas. Migration of adult salmon into spawning areas, which occurs in the autumn/winter period, will result in fry emigration and could lead to bias in the results.

The sampling approach used is a modification of the semi-quantitative electrofishing method developed by Crozier & Kennedy (1994). The modified technique involves one fishing operative fishing a riffle area continuously upstream under low water conditions, as opposed to downstream (Crozier and Kennedy, 1994), for a standard 5 minutes. All fish captured are removed using a battery powered backpack electrofishing apparatus. No stop nets are used and as many salmon fry (0+) as possible were caught by the operative and passed to a bucket carried by the second operative. A count of all fry missed is taken by both operatives during the 5 min sampling and the mean of these two counts is noted on the standard data recording sheet used. Forklengths (cm) of all (0+) fry captured are measured. All fish are returned alive after measuring. At individual sites the total number of salmon fry captured is calculated as:

Total catch of salmon fry per site = total count of captured salmon fry + number of salmon fry missed

The number of salmon fry missed is estimated by multiplying the total number of all fry missed by the proportion of salmon fry: trout fry in the captured fry sample. Only sites with a capture efficiency exceeding 60% are used. Various factors including depth, flow, substrate type, water colour, in-stream access and conductivity may have influenced capture efficiency. Results are expressed by individual site and by mean catchment value. The mean value is the primary statistic derived from the overall analysis of catchment-wide salmon fry abundance.

Bio-Security Considerations

With the introduction of a range of macrophyte (e.g. the curly waterweed Lagarosiphon major) and invertebrate (e.g. Zebra mussels Dreissena polymorpha) invasive species to Ireland in recent years, it is critical to ensure that the practice of catchment wide electro-fishing adheres to strict bio-security protocols to prevent potentially devastating inter-catchment or within-catchment transfers. All personal equipment (waders, coats etc.) and electro-fishing equipment are thoroughly disinfected by IFI staff according to the IFI field survey biosecurity protocol.

Scientific Committee Analysis of Catchment-wide Electrofishing Dataset

The Standing Scientific Committee undertook an analysis of catchment wide electro-fishing data over the three year period 2007 - 2009. The analysis showed that the majority of the rivers known to be meeting and exceeding salmon conservation limits have a catchment-wide salmon fry index of 17 or higher which represents the 75%tile of salmon fry values. The SSC therefore advised an index value of 17 fry (average catchment wide 5 minute electro-fishing) as the threshold value for identifying rivers which could be considered for catch and release angling. Apart from opening the river to angling, the rod catch returns generated by catch & release, (in conjunction with a rod exploitation rate for the river) provide an additional index of adult salmon abundance which can be used to assess if the salmon conservation limit is met. A number of rivers have been open for a harvest fishery (commercial and rod) in the following year as a result of this process.

Eight rivers without a robust means of salmon stock assessment in 2011 were found to have in a salmon fry index ≥ 17 (based on electro-fishing in 2010) and these rivers were opened for catch & release in 2011.

The sampling approach used is a modification of the semi-quantitative electrofishing method developed by Crozier & Kennedy (1994).

FRY SURVEYS

		Electro-fishing	Salmon fry	Average salmon
District	River	Year	Mean / Site	Fry density
Dundalk	Glyde	2009	17	24.5
		2010	32	
Drogheda	Boyne	2008	21	19.0
		2009	17	
		2010	19	
Wexford	Slaney	2007	19	17.7
		2009	16	
		2010	18	
Lismore	Bride	2008	10	17.0
		2010	24	
Lismore	Glenshelane	2007	23	17.0
		2008	11	
Kerry	Owenascaul	2007	24	23
		2009	22	
Kerry	Inney	2007	25	22.5
		2009	20	
Kerry	Kerry Blackwater	2009	13	19.7
		2007	31	
		2008	15	

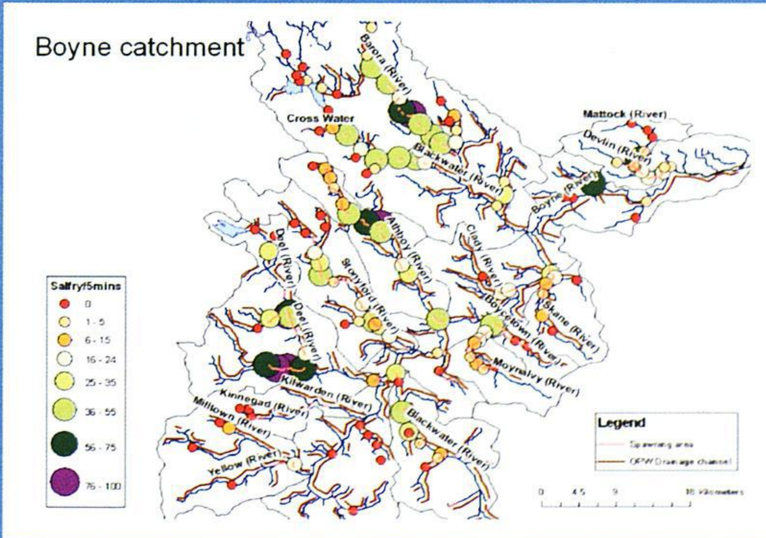
Since 2007, over 3,000 sites in 80 rivers have been electro-fished during the catchment wide electro-fishing programme. As part of the ongoing improvement to salmon data the threshold will be reviewed using the additional annual datasets.

Management Implications

Data from the catchment-wide electro-fishing survey programme, initiated in 2007, indicates that the technique is very valuable in assessing the status of juvenile salmon stocks in catchments nationally. As the abundance of salmon fry during the summer period is an index of salmon spawning in the previous winter, the technique has potential to assess salmon stock status.

Catchment-wide electro-fishing is also important in providing managers with information on the distribution and abundance of salmon fry and to identify management issues in a catchment or tributary. The absence or low density of salmon fry may be related to water quality issues, obstructions, or habitat damage and areas of low abundance can be investigated.

Over a number of years, it is expected that the catchment-wide electro-fishing technique will develop into a robust scientific assessment to determine attainment of salmon conservation limit in individual rivers. Further scientific assessment of the technique is required to develop a standard methodology which is likely to require a number of years of additional data.



Abundance of salmon fry (0+) in the Boyne catchment in 2009.

SALWRD

FISHERY MANAGERS RECOGNISE THAT RELIABLE TOOLS FOR STOCK ASSESSMENT ARE KEY TO ENSURING THE FUTURE OF OUR SALMON RIVERS. THEY ALSO UNDERSTAND THE VALUE OF KNOWING WHAT PROPORTION OF THEIR STOCK CONSISTS OF MULTI SEA-WINTER FISH. IN THIS ARTICLE, PHIL BACON AND HIS COLLEAGUES DESCRIBE RECENT RESEARCH AND A WEBSITE WHICH WILL PROVIDE AN EXCEPTIONALLY USEFUL ITEM IN THE MANAGER'S TOOL-KIT.

SALWRD: Determining Scottish Salmon Sea-Ages from Length or Weight and Return-Date

Managers of Scotland's salmon stocks have for many years recognised the important biological and economic differences between the multi sea-winter (MSW) stock component and grilse, or one sea-winter (1SW) salmon. There is indeed a statutory requirement to report salmon catches separately by sea-age, but the designations reported by rod fishers appear to have shown considerable 'grilse bias'.

Recent research, based on over 186,000 scale-read Scottish salmon ages, now allows grilse to be separated from MSW salmon very confidently (97%), if just the size and date of capture of the fish are known. Importantly, these predictions can be made with high confidence for much of Scotland using the same simple rule.

Details of the research establishing this approach can be found by linking to **http://www.mathstat.strath.ac.uk/outreach/salwrd/**. The publically available portion of this website gives access to: a Marine Scotland Science leaflet describing the approach; free copies of the scientific paper published in the 'ICES Journal of Marine Science'; a calculator to determine (on provision of the size and dates of capture) the probabilities that a salmon is 1SW, 2SW or 3+SW; tables showing the monthly discriminating size values between those different sea-age classes.

The public pages of the website also allow fishery professionals to request a privileged 'user account' on the website. These additional facilities, still undergoing collaborative development, allow registered users to: down-load large amounts of data; curate it; obtain sea-age predictions from the authoritative Scottish data-lists. Users with sufficient amounts of data will also be able to fit new sets of predictive equations to their own data, and hence determine if there are local deviations from the general Scottish picture. The website is configured so that it will also cope with more widespread information, such as salmon from the rest of the UK, Europe or North America.

Why might managers of Scottish salmon find this facility useful? There is growing evidence that knowing the sea-age composition of a river's salmon stocks is important for its proper management. There is also much historical information to show that the ratio of grilse to MSW salmon can change, within rivers, over a few decades. It is therefore important to know the present value and the recent trend. The bulk of the reliable data establishing this information used to come from Scottish net-fisheries. However, as these no longer operate on most Scottish rivers, and as the classical rod-reported subjective designations are known to be unreliable, an alternative is needed.

The SALWRD website not only provides a reliable alternative approach, but one which facilitates the development of common standards, tuned to local details if appropriate, which can be used by fishery managers amongst themselves. Indeed, the website could develop into a vehicle to record both 'stock composition by sea-age' and 'fishing effort' (as advocated by the Strategic Framework, Priority For Action 6.1). Such an initiative by owners of rod-fisheries would help plug the developing gap in knowledge of sea-age composition that is opening up as the nets continue to decline.

SALWRD

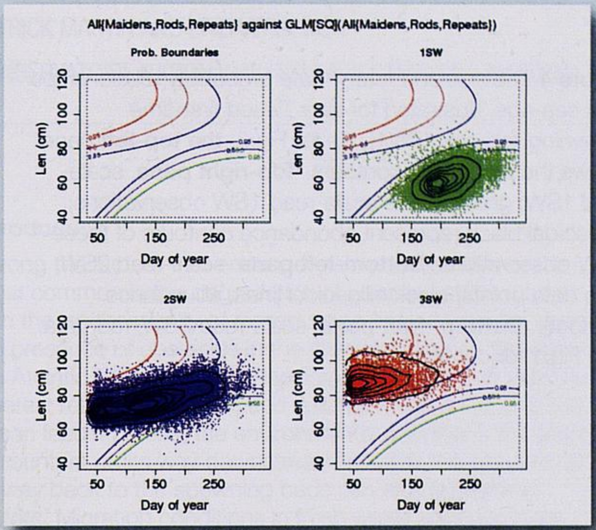


Figure 1 The size and return-date probability relationships with sea-age, illustrated by the overall {allSA} data-set, for all fish (including repeat-spawners).

The top-left pane shows the probability contours. In the bottom-right corner, (s,d) points are 1SW with p >0.95 Moving diagonally towards the top-left, the first three lines illustrate a narrow (s,d) transition zone where the probabilities change rapidly from 1SW to 2SW, with the line's respective probabilities (1SW:2SW) being: heavy green, (0.95:0.05); light blue, (0.50:0.50); heavy blue (0.05:0.95). The region between the two sets of three probability contours has (s,d) points that are 2SW with p >0.95. The next transition zone, for (2SW:3SW), is somewhat broader, with illustrated probability contours: blue, (0.95:0.05; light red, (0.50:0.50); heavy red, (0.05:0.95).

The next three panes show these same probability contours over-lain with data points for observations of different sea-age fishes, as determined by scale-readings. The continuous black lines show data-density contours at 5,20,35,50, 65 and 80 % of the maximum density. **Top-right pane**, scale-read 1SW: green points are individual scale-read observations. Note that the great majority are below-right of the (0.50:0.50) 1SW:2SW sea-age probability contour (triad probability (0.50:0.50:0.00)), as are the ellipsoidal black lines that represent the abundance contours of those 1SW observations. **Bottom-left pane**: scale-read 2SW, blue data points and black abundance contours. Again, the ellipsoidal contours are largely within the two (0.50:0.50) probability contours. **Bottom-right pane**: scale-read 3SW,red data, black contours. Here the ellipsoidal contours overlap the (0,.50:0.50) (2SW:3SW) probability contour by an appreciable degree.

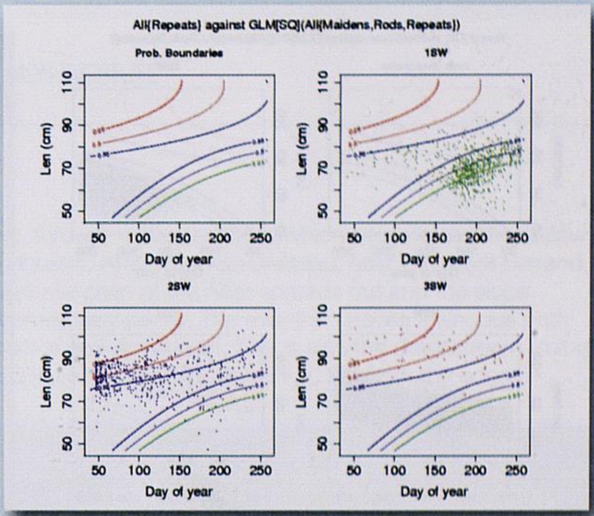


Figure 2 The size and return-date probability relationships with sea-age, illustrated for repeat-spawning fish only {allSA_Repeat}. The **top-left pane** shows the probability contours. **Top-right pane,** scale-read 1SW: green points are individual scale-read observations; the majority are still below-right of the critical (0.50:0.50, 1SW:2SW) probability contour, but note the horizontal scatter to the left, which represents a majority of the mis-assigned 1SW points evident in Fig.1, which includes these data. **Bottom-left pane:** scale-read 2SW, blue data points. **Bottom-right pane:** scale-read 3SW,red data. See Fig.1 for details.

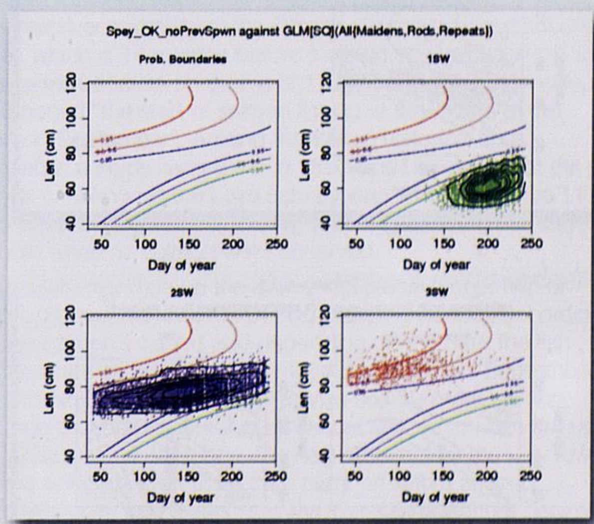


Figure 3 The size and return-date probability relationships with sea-age, illustrated for river Spey first-time spawning fish only {SP1}. **The top-left** pane shows the probability contours. **Top-right pane,** scale-read 1SW: green points scale-read 1SW observations; ellipsoidal black represent abundance contours of those 1SW observations. **Bottom-left pane:** scale-read 2SW, blue data points; black ellipsoidal lines, abundance contours. **Bottom-right pane:** scale-read 3SW, red data. See Fig.1 for details.

SALWRD

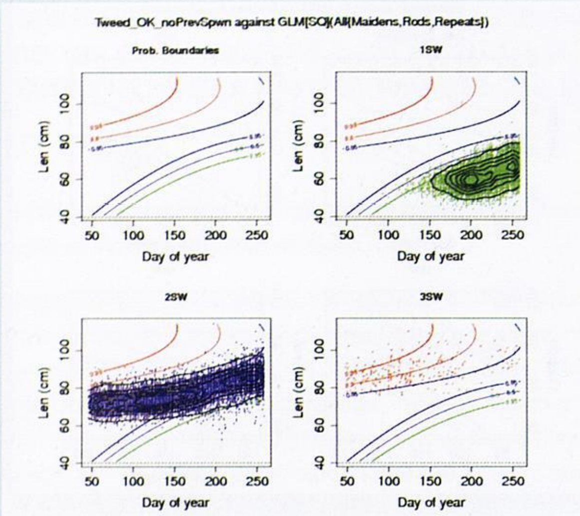


Figure 4 The size and return-date probability relationships with sea-age, illustrated for river Tweed first-time spawning fish only {TW1}. As for Fig.3, **the top-left** pane shows the probability contours. **Top-right pane**, scale-read 1SW: green points scale-read 1SW observations; ellipsoidal black represent abundance contours of those 1SW observations. **Bottom-left pane**: scale-read 2SW, blue data points; black ellipsoidal lines, abundance contours. **Bottom-right pane**: scale-read 3SW, red data. See Fig.1 for details.

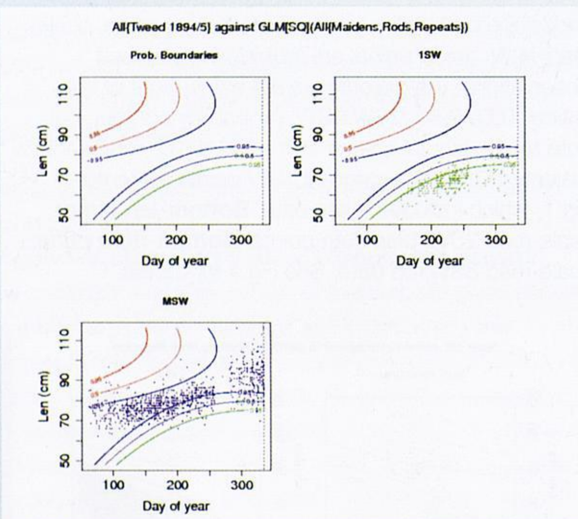


Figure 5 The size and return-date probability relationships with sea-age, illustrated for river Tweed historical sample {Tweed_1894-5}. Note that these fish were not aged by scale-reading but visually assessed as 1SW or MSW salmon, hence the **bottom left pane** is here MSW (2SW & 3SW). As for Fig.1, **the top-left pane** shows the probability contours. **Top-right pane**, 1SW: green points observer-assigned 1SW observations; ellipsoidal black lines represent abundance contours of those 1SW observations. **Bottom-left pane**: observer-assigned MSW, blue data points. See Fig.1 for details.

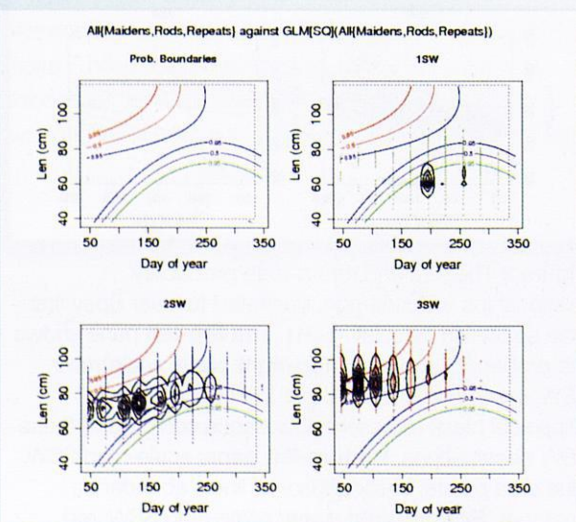


Figure 6 The size and return-date probability relationships with sea-age, illustrated when dates and sizes are only approximately known (see text for details). Dates are monthly-mid points, sizes are in the length-equivalent of half-pound (Imperial units) weights. Data are shown by sea-age, for the overall set of fish with lengths and weights {allSA_W}. As for Fig.1, **the top-left pane** shows shows the probability contours. **Top-right pane**, scale-read 1SW: green points scale-read 1SW observations; ellipsoidal black represent abundance contours of those 1SW observations. **Bottom-left pane**: scale-read 2SW, blue data points, black ellipsoidal abundance contours. **Bottom-right pane**: scale-read 3SW,red data, black ellipsoidal abundance contours. See Fig.1 for details.

LOIRE/ALLIER

THE LONG-DISTANCE MIGRATION OF THE SALMON OF THE LOIRE AND ALLIER: A CLOSING WINDOW OF OPPORTUNITY

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Introduction

Among the factors that endanger salmon populations, the most common is the degradation of juvenile habitat along with the inaccessibility of reproduction areas to adults, due to the presence of obstacles in the river. However, in the case of the Atlantic salmon which shares its life between its natal river, where it returns to spawn, and spends its early life, and the ocean feeding areas, the environmental conditions the salmon encounters on its way downstream towards the sea and on its way back to the spawning beds can also be limiting factors. Migration conditions in fresh water are even more crucial for salmon that from long rivers in the southern distribution zone of the species where any alteration to the timing or environment of the period of downstream or upstream travel may lead to increased mortality. The increase is expected due either to a reduced ability to adapt to salt water outside the heritably determined "physiological window" or to encountering unfavourable environmental conditions and missing the "ecological window" (e.g. too high a temperature). It is essential that the two are matched and the "global window" of migration is such that the smolts reach the estuary at the time they are ready to move into the sea and at a suitable time for them to reach their marine feeding areas at the appropriate time for optimal growth. The same applies to adult fish on their return migration, when they have to ensure they encounter favourable environmental conditions in the river so they can return to their natal tributaries and reach the right areas of the river to spawn and successfully produce the next generation.

The Loire-Allier system: a journey of nearly 1000km for the salmon

The Allier rises in Lozère, in the north of the Languedoc-Roussillon region, to the south of the Auvergne, at an altitude of 1485 metres. While its source is only 110 km from the Mediterranean as the crow flies, this mountain river sets off northwards for 421 km before it joins the Loire, which takes it to the Atlantic Ocean, 975 km from its source. In its upper reaches, known as the "Haut-Allier", the river has gouged out a deep steep-sided valley between a volcanic plateau to the east and the granite massif to the west (photo 1). Here the river flows like a torrent, alternating between flats and rapids, through a landscape of rocks, moors and forests (photo 2). This is where we find the furthest upstream spawning grounds of the river, about 950 km from the ocean, making the Loire-Allier system the longest run for Atlantic salmon in the whole of mainland Europe. This part is very sparsely populated, and there are only a few villages perched on either side of the valley to remind us of the presence of man. Lower down, the villages gradually come closer to the river (photo 3). Steep-sided meanders and widening stretches follow one another before the river arrives at its first sedimentary area, 150 km from the source. Here it snakes its way across the plain, through cultivated fields which alternate with meadows and forests. After Pont-du-Château, near Clermont Ferrand, the alluvial plain of the Allier spreads out and the slope becomes very gentle. The river then traces a sinuous path across a vast flood plain. This is also the downstream limit of the spawning grounds, about 730 km from the ocean.

A meander in the plain close to Jose;
Photo - LN_CEPA_J.SAILLARD

A migration lasting nearly 14 months, very much dependent on environmental conditions

One of the special characteristics of Allier salmon is that the earliest maturing adults can enter into the estuary and set off on their river migration in the October before their reproductive year, which is 14 months before the next spawning period. In his general treatise on fishing of 1769, Duhamel du Monceau mentioned "the start of salmon fishing at the mouth of the Loire in September". Among the limited historical data available, a study carried out in 1890-1891 showed that the arrival of salmon in the Loire estuary was spread over the 11 months from September to July, with August being the only month when no salmon were observed.

The adult migration up the river takes place in one, two or three phases, punctuated by two stopping periods according to the salmon's cohort and depending on the date the fish arrive in the estuary. The first migration, from mid-September to mid-November, involves big three-sea-summer salmon, salmon that have spent 3 summers at sea, which can get up to 500km upstream before they are stopped by the very low winter temperatures. They then carry on with a second migration in spring as soon as the water temperature begins to rise, in other words from mid-March to mid-June, before being halted again by the high summer temperatures (more than 23°C.) Finally, according to autumn conditions and notably when there is a flood, one can see a third period of migration of variable size which will bring the fish that have not reached the spawning areas into the furthest upstream parts of the catchment.

We therefore see that these successive journeys, and success in reaching the spawning beds, depend heavily on the conditions the fish meet, and the date they enter the

LOIRE/ALLIER

1 Marius Delmas's catch

2 The Haut Allier at Alleyras, 43
Photo: LN-CEPA-MC

estuary. Thanks to the Vichy counting station, which is 650 km from the estuary and has been in operation since 1996, we observe that 90% of the migration takes place between 1st March and 31st May, matching the second period of migration, before the summer heat. In the upper part of the system, a counting station at Langeac (855km from the estuary) in the heart of the spawning area allows us to observe two periods of migration: one from 15th April to 15th June, with about 1/3 of the total fish, and a second wave in autumn between 15th September and 15th December. (Fig 1)

The Allier has always been regarded as a "big salmon" river. In fact the composition of the populations coming into the estuary (estimated according to the average weight from the 1890 data) used to be distributed as follows: 40% 3-sea-summer fish, 50% 2-sea-summer fish and only 10% one-sea-summer fish. However, at Vichy and Langeac we are now seeing very few one-sea-summer fish. The low return rate of these fish to the upper part of the system can be directly attributed to excessively high temperatures which slow down the migration and then stop it altogether, before the grilse reach the spawning areas.

Later and later migration, with dramatic consequences

Only two indicators are available and interpretable, to measure how early the salmon migration happens and how it evolves. These are: catch data (professional, leisure, or for scientific purposes), and the figures from the counting stations. While catch figures are difficult to obtain, there is some historical information published in the fishing press mentioning catches very early in the season in the Haute-Loire department (780 km from the estuary). 15th January 1913: "numerous 'silver' salmon have arrived at the Bageasse dam at Brioude". 1914: Brioude, "the salmon season is drawing to an end, it was fruitful from February to the end of April, about 250 salmon were caught on rod and line, the biggest were 22 and 23 pounds." These fish were therefore the first to come through the estuary and they managed to reach the spawning areas at the beginning of winter.

Seventy-five years later, rod catches of the first salmon in Haute-Loire reported by members of the Salmon Protection Association between 1982 and 1993 took place on average on 12th April, getting later by approximately 1.5 days a year. Since sport fishing for salmon was prohibited in the whole Loire-Allier system in 1994, as a conservation measure, we can no longer get this information. However, the Vichy counting station has been operational since 1996 and it confirms the tendency. Thus, recorded passages of salmon at Vichy (650 km from the estuary) between 1997 and 2009 also point to an average shift of 14 days over 10 years, with the average of passages of the first quartile of the migrating contingent falling on 2nd April (fig. 2).

Impacts of delay in migration

Delay in migration can not only endanger a fish's survival if it does not reach the upstream areas before the summer periods when temperatures are too high (over 26°C); it can also determine its reproductive effectiveness by restricting it to the least favourable spawning areas.

Historical data backed up by radio tracking point to a speed of upstream progress in the estuarial part of the river of 15 to 35 km per day. However, the speed of migration is heavily dependent on water conditions and temperature. Speed is poor at temperatures below 4 to 5°C, optimal at around 11-12°C, but seriously reduced when the water temperature approaches 20°C; it stops completely beyond that point. The comparison of the cumulative passage data (fig.3) shows that, whatever its position on the axis, migration stops from the beginning of June and does not start again until the beginning of autumn. This situation is particularly worrying because the temperature of the Loire has risen 2°C on average in 24 years. Thus, individual fish arriving late in the Loire estuary may have their migration arrested by high temperatures and never reach Vichy or the spawning grounds. Those that reach Vichy late and halt their migration between Vichy and Langeac may make a second migration in the autumn, if the summer environmental conditions are favourable to their survival.

The later migration can threaten the survival of the fish but it can also adversely affect the success of reproduction by limiting access to the best spawning grounds. Historically, the spawning area was described as reaching from Pont-du-Château to Laveyrune in Ardèche, i.e. covering a distance of nearly 220 km. Occupation of this potential spawning area varies from year to year depending on the environmental conditions the fish meet. When there is a hot spring and an autumn without floods, the fish mostly occupy the downstream area. For several decades now, the areas downstream of Langeac have been regarded as more unfavourable, in terms of survival from egg to alevin, and they have been mediocre downstream of Brioude due to pollution from the main towns along the river.

The "belated" fish therefore have less chance of reaching the good spawning areas, all the more so if climatic conditions are gradually becoming warmer, which halts migrations earlier and earlier, and if the autumn floods that encourage a second migration are unreliable.

Probable causes of this development

Changes in run timing have been observed in numerous North Atlantic rivers. Alterations in sea conditions (changes in feeding areas, quantity of food, speed of ocean currents ...) may influence run timing and these factors are under investigation by NASCO's collaborative SALSEA programme **(www.salmonatsea.com)**. We can, however, speculate about the impact of certain freshwater activities which might have contributed indirectly to this delay by selecting "belated" individuals.

Pressure of fishing

Every year, under the law of 15th April 1829, known as the "River Fishing Code", royal regulations determined the times, seasons and hours of the day when fishing was prohibited in rivers and watercourses. Much later, by a decree in 21st October 1863, fishing for salmon in salt water as well as fresh water was uniformly prohibited from 20th October until 31st January. At that time, however, the Loire fishermen asserted that the salmon was exclusively a sea fish which only very

LOIRE/ALLIER

accidentally strayed into fresh water and, consequently, they claimed the absolute freedom to fish all year round. The opening of the salmon fishing season was later authorised from 15th January onwards, then put back to the first week in March.

While these measures certainly limited the catches of big salmon by professional fishermen in the lower Loire, they did not prevent sport fishermen from focussing their efforts on catching these salmon, especially in the upper system. Fishermen have always been in search of the biggest fish, always those that have spent several summers at sea. These "record" salmon, proudly displayed and immortalised in many photos (photo 5) are among the earliest to arrive. Once news of the arrival of the first salmon very low down in the basin was given, the whole fishing community would follow the vanguard of the migration. During the 1960s, the Salmon Protection Association for the Allier and Loire Basin organised a championship to reward the best fishers of big salmon in the administrative regions of the Nièvre, the Allier, Puy-de-Dôme and the Haute-Loire. While rod fishing on the Allier, which began in 1909 and closed in 1994, only represented a minor pressure on the salmon of the Loire-Allier system, it strongly targeted the first individuals to arrive in the spawning area, thus allowing a greater proportion of "later" individuals to reproduce.

Restoration and selection activity

The history of efforts aimed at the restoration of the Allier population can properly be regarded as having started in 1923. In the early days, the eggs used were collected from Allier fish, but these were later imported from many and varied sources. This practice continued until 1985. However, it is now recognized that building a breeding stock from a native strain to produce eggs for restocking is vital to the success of a restoration programme in an atypical system such as the Loire. So, to make up for the deficit in eggs while still using the local salmon stock, attempts began in 1973 to use first-generation salmon which had been kept entirely in fresh water. To ensure production of these future "captive" brood fish, "wild" salmon were initially caught close to the spawning areas shortly before spawning took place; from 1975 onwards, the brood fish were generally taken from among those that were latest to arrive. However, as discussed, the timing of the migration, crucial to the survival and return of adult fish, is the result of adaptation to local environmental conditions. Unfortunately, if the trait of "earliness" is heritable, we may have been selecting "late" individuals over the past 40 years and may thus have encouraged the drift away from early migration behaviour.

The salmon population of the Allier has managed to adapt to changing environmental conditions for tens of thousands of years. It is still capable of surviving in extreme conditions, well beyond what more recently evolved North European populations could cope with. But everything is a matter of time. Will the changes we are witnessing stay within the adaptive capacity of our population? Will our conservation programme be able to help this exceptional population cope with future changes? It is in trying to answer these questions, in particular, that all of us involved draw the energy we require to safeguard the mysterious Atlantic salmon of our rivers.

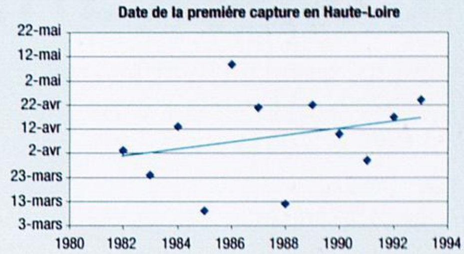

Figure 1 Estimate of the cumulative distribution and the proportion of different cohorts (---- 3SW, ----2SW, --- 1SW) in different sectors of the migratory axis. A: In the Loire estuary (km 0) (according to the daily catches from Paimboeuf and Nantes in 1890-1891); B to the metering station of Vichy (650 km) from 1997 to 2008 (source LOGRAMI), C: at the counting station at Langeac (855 km), from 2004 to 2008.

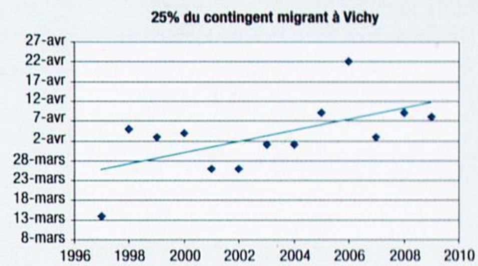

Figure 2 Date when the first salmon of the season was captured in the department of Haute Loire for the period 1980-1994 and the passage of the first quartile of salmon at Vichy, from 1997 to 2009.

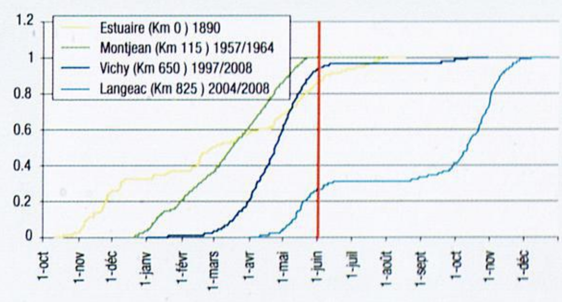

Figure 3 Cumulative passage of salmon at different points on the Loire-Allier axis.

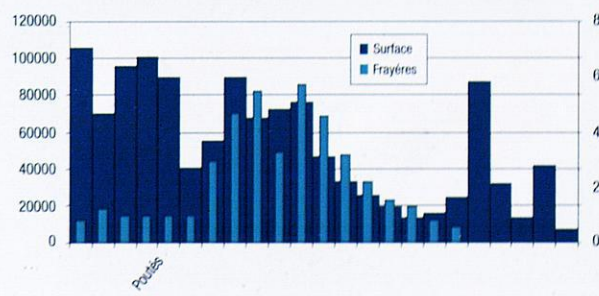

Figure 4 Distribution of spawning grounds from Luc (km 914) (γ) based on potential suitable habitat)(γ). (CSP-Logrami data).

MAN, CHALK STREAMS, AND SALMON

IN THIS ARTICLE, DAVID SOLOMON CHARTS THE LONG-STANDING AND COMPLEX IMPACTS MAN HAS HAD ON CHALK STREAMS AND THEIR FISH STOCKS – AND HOW WE HAVE ATTEMPTED TO ADDRESS THE PROBLEMS FROM THE EARLY 18TH CENTURY ONWARDS.

Although perhaps best known for their wonderful trout fishing, the chalk streams entering the sea between Southampton and Poole Harbour are something of a stronghold for salmon in the south of England. Given the present depleted state of the stocks in this region you may challenge the use of the word "stronghold" but the species does seem remarkably resilient to most things we can throw at it – so far at least.

However, concerns over the state of chalkstream stocks are not a recent development; an Act of Parliament introducing measures to protect stocks in the year 1705 opens with the preamble: "Whereas the salmon and the salmon-kind of fish resorting to spawn within the rivers in the County of Southampton, and the Southern parts of Wiltshire, are in danger of utter decay, to the great loss of the Kingdom, and the royalties and fisheries are in great measure consumed and destroyed..."

Other reports of stock deterioration through the centuries include:-

"This river (the Avon) formerly abounded with salmon, the number of which is very considerably diminished within the memory of persons now living." (Lt Gen. Henry Fane, minutes of evidence before the Select Committee on Salmon Fisheries, 1825).

"Few today realise that once this sporting water (the Avon) with its salmon and coarse fish, ranked second to none of our southern streams. Its all-round gradual deterioration is unaccountable". (J. Turner-Turner, "British sports and sportsmen", 1914).

"That a woeful decrease in the catches of salmon has been taking place for a number of years is evident from the published reports, and this is more distressing as there seems no rational obstacle to prevent this river from being, for its size, one of the finest salmon rivers of its type in the country". (Dr John Berry, Avon Biological Research, 1933).

Beautiful – but man-made

Although considered by country lovers a most attractive natural feature (Figure 1), the classic chalk stream surrounded by chalk downland is in fact a man-made and highly-managed environment. Man first appeared in Southern Britain about 700,000 years ago, but our ancestors probably made little impression on the scenery until Neolithic times (4500 – 2600 BC) when the hunter-gatherer lifestyle began to give way to agriculture. Fields were cleared in the natural forest of oak, elm, lime, ash, field maple, hazel and alder. However, limited tools meant that this process was slow until the Iron Age (750 BC-43 AD). The Romans introduced towns to the landscape and virtually completed the clearance of the natural woodland; however, some remnants of woodland remained and were managed for production of fuel and building materials. Since that time the chalk catchments have been managed for agriculture, milling, sport and landscape, and hardly a vestige of the pre-historic natural environment remains. Williams-Freeman (1915) describes the pre-historic status of the Hampshire chalk streams:-

"Two points (the reader) must thoroughly grasp – the impenetrable character of the natural forests, and the swampy, impassable nature of the river valleys. There was in the old days no tidy undergrowth of the ten-year-old hazel, but a tangled mass of every shrub that is native to a wet climate, with fallen trees and decaying branches all bound together, living and dead, by brambles, woodbine and wild clematis – a jungle so thick that only along the tracks made by wild beasts, or up the narrow gravelly beds of the higher reaches of the streams, could it be pierced by man..."

There a few places where unmanaged stretches of chalk stream have reverted to this situation – one such is shown in Figure 2.

Figure 1. A typical chalk stream, with tidy banks and abundant submerged macrophytes – a beautiful habitat, but a largely artificial one.

Impacts of agriculture

Control of the river and its riparian vegetation would have started with the dawn of agriculture in the area, as the valley floors would have represented the most fertile land. The Romans had water mills, and many mills were recorded on the chalk streams in the Domesday Book (1086). Although the buildings associated with these mills have long gone, many recent mills are built on the same sites, which were in continuous use for at least a thousand years. There are of more than a hundred existing and recently abandoned mill sites in the Avon catchment alone.

Development of milling would have involved extensive channelisation work to concentrate the river into a single channel, generally along one side of the floodplain so that the head could be retained and exploited. Further channelisation would have been involved in the development of agriculture, to help drain swampy areas. Development of water meadows arrived on the chalk streams during the 17th century, and these dominated the valley floors for the next three hundred years. Water meadows spread to cover about 20,000 acres on the Avon and its tributaries in Wiltshire alone. At first they were operated as part of a complex cycle of sheep grazing and hay production, and flooding took place primarily in the spring and autumn. However, by the middle of the 19th century they were being used mainly for cattle, and flooding took place on a discontinuous basis throughout much of the year.

MAN, CHALK STREAMS, AND SALMON

Traditional flooding of water meadows involved large volumes of water being spread over considerable areas of land, and was a major hazard for downstream migrant fish, including salmon parr and smolts, and juvenile coarse fish. Berry (1933) describes how fish may become stranded among the grass of the meadow, "a deservedly popular resort for several herons as well as a host of other feathered foe". Even those fish that managed to survive to pass on down the drawns (drainage channels) would be caught in special traps set there by the drowners (as the workmen who operated the meadows were called); the fish so caught were considered a perk of the job. As long ago as Victorian times angling interests on the Test paid £75 to two water meadow operators to limit watering to three days a week during the smolt migration.

Figure 2. An un-managed reach of chalk stream in Dorset. This picture was taken in January. In summer, the river is effectively completely overgrown, but aquatic macrophyte growth is minimal.

Water meadow operation involved retaining structures to create the head for flooding of fields a little further downstream. A head of water was such a valuable asset for milling and water meadows that virtually the whole fall of the river was exploited and many disputes broke out between neighbours. Many of these head-retaining structures still exist and much of the natural head of the chalk streams is lost in sharp steps at these places. This has played a fundamental part in destroying the natural features of the rivers.

More recent developments such as dredging of long reaches for land drainage and flood defence have completed the metamorphosis from natural river systems to highly artificial and managed ones.

Effects on fish stocks

So just how good would the chalk streams have been for salmon before man started imposing inexorable changes on the environment? There must be some doubt about that. The lack of obstructions would have been a great benefit, both in allowing unfettered access for upstream migrants and in optimising the riffle habitat through the distribution of natural head loss; when electric fishing on chalk streams the discontinuous distribution of juvenile salmon is very stark, with the fish being virtually restricted to the infrequent stretches with a good gradient. On the other hand, if most of the habitat was as in Figure 2, this might not have been so good for the species, favouring trout rather than salmon. Pike too would have thrived with all that cover and no gamekeepers to control them. But no doubt salmon did well enough without human interference.

But what of the future? Will salmon stocks survive in the chalk streams for another thousand years, with populations ebbing and flowing as man continues to place new challenges in their life cycle? Or will one of our challenges prove to be the last straw and relegate salmon to the growing list of species that we have managed to extirpate from the south of Britain? We might hope that, having learned so much about their requirements and the impacts of human activities upon them, we have also learned how to coexist, and let them thrive.

Impacts of climate change

But there are two very real risks looming, again both anthropogenic. The first is climate change. Recent studies have indicated that chalkstream salmon are on the edge of the thermal tolerance range for the species, and that an increase of a couple of degrees C throughout the year could well tip the balance – and the same applies to brown trout too. I was recently involved with Graham Lightfoot in an analysis of the factors affecting salmon populations in the Hampshire Avon. We were able to explain most of the variation in rod catch in the past 35 years (as an index of stock abundance) with a model based on climatic factors. Two of the strongest links are with August flow in the parr year (low flows poor, high flows good), and inshore sea temperature in April of the smolt year (high temperature poor, low temperature good). These are both factors that are likely to change for the worse with continuing climate change.

Hydro schemes

The second threat is that of low-head HEP, which is presently being encouraged by the generous tariffs on offer for "green" energy generation, and by the curiously supportive policy of the Environment Agency. I fear that we are about to see a new era of "milling wars" with different interests striving to capture as much of the potential energy of river fall as they possibly can. The prospect of extensive "depleted reaches" and the challenge of fish passage through turbines, and the complications of trying to prevent it, are issues that concern me greatly. We are certainly not through with the continuing saga of man, chalk streams and salmon.

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SEA TROUT WORKSHOP

SEA TROUT ARE PERHAPS THE MOST FASCINATING OF OUR NATIVE FISH. ALTHOUGH THEY DO NOT MIGRATE AS FAR AS SALMON, THE SHEER VARIETY OF THE RIVERS AND STREAMS THEY SPAWN IN AND COMPLEXITY OF THEIR BEHAVIOUR IS UNRIVALLED. IT IS A TRUISM, THOUGH, THAT THERE HAS BEEN FAR LESS RESEARCH INTO SEA TROUT THAN INTO SALMON, AND THAT WE KNOW LESS ABOUT THEM. IN AN ATTEMPT TO START TO ADDRESS THIS LACK OF KNOWLEDGE, THE TRUST CONVENED A SEA TROUT WORKSHOP IN BANGOR, NORTH WALES, ON 9 AND 10 FEBRUARY 2011.

The objectives of the Workshop, which was supported financially by the Environment Agency and attended by invited participants from Britain and Ireland, were to consider what progress had been made recently in sea trout research and to identify continuing gaps in our knowledge. The Workshop concentrated on what managers and regulators need to know in order to manage sea trout stocks and on the research needed to meet their requirements.

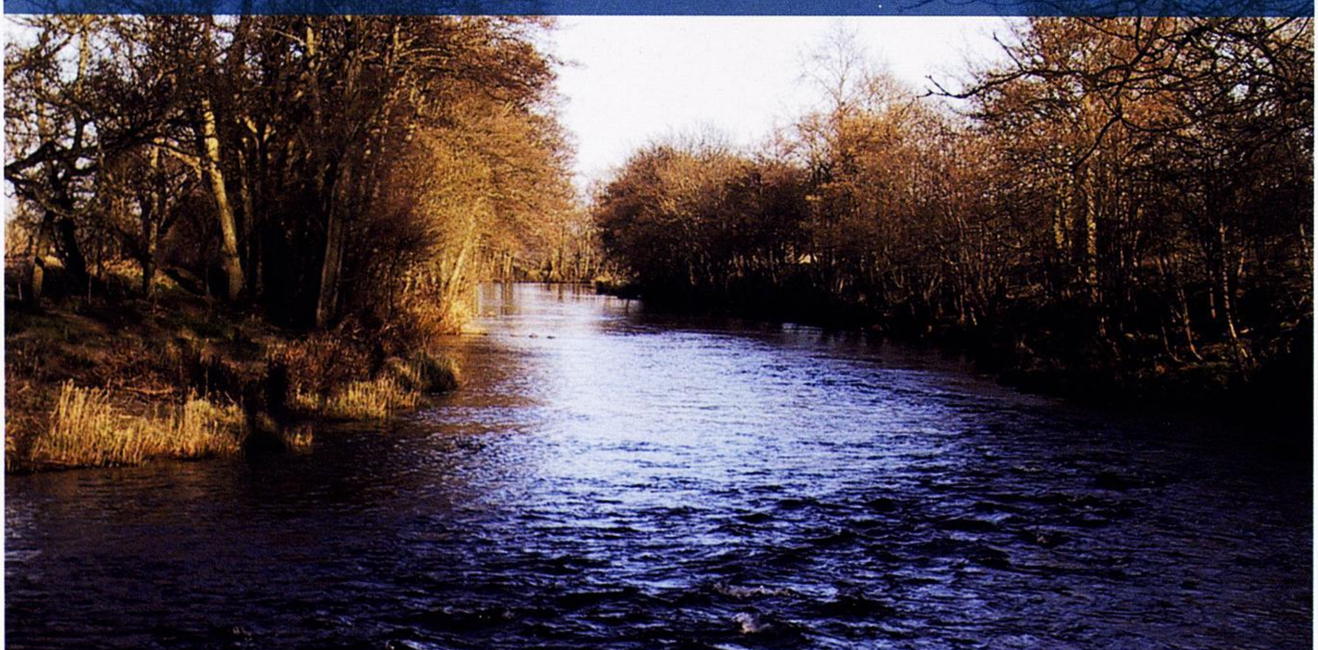
The Workshop did not attempt to review the whole range of existing work. Instead, it concentrated on a limited number of key topics; in considering these, the Workshop focused on issues that are specific to sea trout rather than generic issues that affect all species including sea trout.

There have, of course, been previous conferences and workshops on sea trout, in particular the 2004 International Sea Trout Symposium in Cardiff. This identified major strategic priorities for further research and investigation, but while a good deal of work is being done, progress on many of these has been limited. One important advance has been the development of the three EU funded programmes to look at the genetics of sea trout and their distribution at sea. When these are completed we should have baseline genetic data on sea trout stocks covering most of England and Wales and the east coasts of Scotland and Ireland. The outstanding gaps in this coverage are the west coasts of Scotland and Ireland.

The Workshop's primary aim was to produce advice to research funders, scientists and managers on research and monitoring priorities and it identified five key areas for future work, as well as and recommending further research/action on a range of specific topics.

The Workshop agreed that the greatest area of uncertainty so far as sea trout, and indeed trout generally, are concerned is our understanding of the factors (genetics, food availability, physical habitat characteristics etc) that influence the **life history strategies** that they adopt. Going to sea is the defining characteristic of sea trout, but this is only one life history strategy that trout can adopt. Trout may remain resident close to their spawning areas or migrate within rivers

Tyndals, S Esk, Angus Photo - APH Andrews



SEA TROUT WORKSHOP

or large lake systems (croneen and dollaghan) lakes or brackish estuaries (slob trout). The Workshop concluded that it would be pointless to look at sea trout in isolation; future research on this topic needs to cover all varieties of Salmo trutta. Indeed, given that the British Isles must originally have been colonised after the ice age by sea trout, the key question should perhaps be not why some trout go to sea, but why some do not! The Workshop therefore recommended that one of the principal focuses of future work should be the development of a comprehensive programme, provisionally called **Life History Optimisation in Trout in a Changing Environment**, to explore the factors that influence these choices, together with the ways that climate change might affect them.

The Workshop agreed that another significant area of uncertainty was the **role that estuaries and coastal habitats** played in sea trout life cycles. Estuaries, in particular, are complex, and varied, environments which appear to be of importance in several different life stages. It recommended the development of another work programme to address these uncertainties.

So far as freshwater habitats are concerned, the Workshop concluded that a greater focus was needed on the **significance of small streams for sea trout production**; these provide important spawning habitat, but are easily blocked by impassable culverts, farm crossings and minor land use changes. Research is needed to quantify the contribution small streams make to sea trout recruitment. There is also a need to identify both actual and potential sea trout spawning streams, and to draw attention to the need to protect them.

Monitoring and assessment, of stocks, habitats and fisheries, play an essential role in identifying potential threats and assessing the effectiveness of management measures; monitoring data is currently a limiting factor in stock model development.

The Estuary of the R Blackwater, Essex Photo © image-2-photography

SEA TROUT WORKSHOP

The Workshop agreed that there are significant shortcomings in the monitoring and assessment of sea trout stocks. Remedying these is a priority

The Workshop agreed that more should be done to establish **the social and economic importance of sea trout and sea trout fisheries**. In particular, more work is needed on the ecosystem services value of these fisheries. It recommended that a seminar or workshop, attended by the appropriate experts, should be organised to take this forward.

Finally, the Workshop considered **Threats to Sea Trout**, focusing on threats that it identified as being particular issues for sea trout. These include stocking, net fisheries, predation, aquaculture and renewable energy projects.

The report of the Workshop, including a full list of all the recommendations, has been produced as a pdf document, and can be downloaded from the AST's website, on **http://www.atlanticsalmontrust.org/assets/ast-sea-trout-workshop-feb-2011.pdf**

All those attending the Workshop were aware that similar recommendations had been made in the past and many of the points and specific recommendations made by the Workshop echoed those made by the 2004 Symposium, which in turn deplored the fact that these largely repeated recommendations which had been made by workshops in 1984 and 1994.

In the hope of breaking this pattern, the Workshop agreed to establish a small steering committee to ensure that the work it recommended is taken forward. Much will, of course, depend on the availability of funding, but the first step will be to develop projects, in collaboration with potential funders, for which funding can be sought. It is intended that these should be part of a comprehensive programme of future research and monitoring on sea trout that will guide government departments and agencies, research councils, fisheries managers, rivers trusts and associations, fisheries and angling NGOs and universities in reaching decisions on funding.

Bay of Kentra, Ardnamurchan, at high tide Photo - APH Andrews

SOUTH COAST SEA TROUT ACTION PLAN

THIS ACTION PLAN, WHICH WAS DEVELOPED JOINTLY BY THE AST, THE ENVIRONMENT AGENCY AND THE WILD TROUT TRUST, IS INTENDED TO IDENTIFY AND PROMOTE KEY ACTIONS TO PROTECT AND IMPROVE SEA TROUT POPULATIONS IN HAMPSHIRE, SUSSEX AND KENT.

Sea trout are the mystery fish of the South Coast. Many people are not aware that they spawn in many South coast rivers, and attempt to enter more. Few are targeted by anglers and angling is often not a realistic option, given the small size of many spawning streams and the limited time that fish spend in freshwater. But they are a critically important component of the regions biodiversity and are responsible for sustaining many wild trout populations in numerous headwaters, side-streams and tributaries. They are also notable fish in their own right; the average size of sea trout caught in the Sussex Ouse in recent years is over 5lbs.

The Action Plan concentrates on the main problems sea trout face along the South Coast: the many barriers that can prevent them entering rivers and that then limit their access to spawning areas, and the degraded condition of many spawning areas. The actions it advocates fall into two groups: relatively low cost improvements that can be led by the WTT, rivers trusts and other voluntary organisations and larger scale actions to deal with major obstructions, improve water quality, improve habitat and limit abstraction which are likely to fall to the Environment Agency. Shaun Leonard's article on the activities of the WTT gives some examples of what can be achieved in the first category.

The Action Plan also identifies the topics on which further research is needed. These tie in well with the recommendations made by the AST's Sea Trout Workshop, in particular the need to find out more about the contribution made by small and ephemeral streams to sea trout recruitment and the role and significance of estuaries.

The Action Plan was launched on 24 June in Arundel, and can be read in full on the AST website.

> "The Action Plan concentrates on the main problems sea trout face along the South Coast: the many barriers that can prevent them entering rivers and that then limit their access to spawning areas, and the degraded condition of many spawning areas."

R Arun at Stopham, West Sussex Photo - © Nickos

WILD SEA TROUT: HELPING THEM ACCESS HABITAT

THE WILD TROUT TRUST IS HIGHLY REGARDED FOR ITS CONSERVATION WORK AIMED AT RIVER HABITAT RESTORATION FOR BROWN TROUT. IN THIS ARTICLE, WTT DIRECTOR, SHAUN LEONARD DESCRIBES TWO OF THE TRUST'S PROJECTS WHERE SEA-GOING TROUT TAKE A LEADING ROLE.

The bread-and-butter work of the Wild Trout Trust (WTT) is practical advice and hands-on help to improve habitat for trout. That work has seen WTT help fishery and conservation interests across the British Isles, from Orkney to Cornwall, Norfolk to Connemara. In many of those rivers, there are sea-run components to the trout stock. However, WTT is heavily involved with two projects whose focus is very much on migratory sea trout.

Norfolk rivers

In 1996, former WTT Director, Simon Johnson, encountered some big sea trout during a fishery survey in north Norfolk's River Burn. He vowed then that something needed to be done to help those fish not only negotiate the tidal defences of these East Anglian rivers but also to improve spawning and nursery habitat in their heavily engineered channels. So, the seed was sown for an East Anglian Sea Trout Project, which today sees work ongoing or planned on rivers such as the Burn, Glaven, Nar, Stiffkey, Welland and Witham, funded in large part through the Interreg IVB Living North Sea Project. A truly impressive (and extremely topical) feature of this East Anglian work has been collaboration between a host of partners including the Association of Rivers Trusts, Atlantic Salmon Trust, Cefas, Environment Agency, National Trust, Natural England, Norfolk Wildlife Trust, local landowners and fishing clubs, several universities and WTT.

The first Norfolk river to receive WTT attention in this project was the Stiffkey, a chalk stream with a long history of land drainage works. The channel has been straightened and dredged over many years, resulting in accumulations of fine sediment and colonisation by reeds and rushes. So, work on the river through the Holkham Estate involved the creation of eleven trout-spawning riffles utilising around 650 tonnes of gravel, and the reprofiling of the river banks to create low shelves (berms) alongside the river; the latter to improve bankside habitats for water voles and retain the flood conveyance capacity of the river. These spawning riffles were used by trout in the very first winter they went in; monitoring work is ongoing to see the longer-term effect on trout recruitment.

Figure 1: New spawning riffles go into Norfolk's river Stiffkey

But the Stiffkey also had one very tricky access point for sea trout: a tidal gate at its mouth that forms part of the coastal flood defences. Close work between the Environment Agency, hydrogeomorphological specialists and WTT staff modelled flows and designed a cat-flap type fish pass to be built into the tidal gate, improving access between salt and freshwater not only for sea trout, but also eel, flounder and mullet. For the sea trout, this cat-flap pass should allow access to the lovely new, upstream riffles as spawning ground. Again, monitoring work is ongoing (via a PhD student) to assess the value of the cat-flap pass for fish passage.

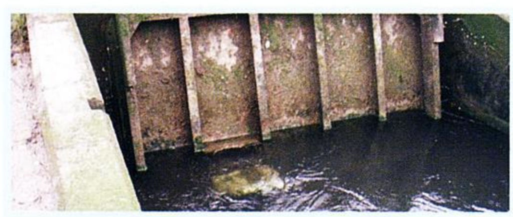


Figure 2: the impenetrable-looking tidal gate at the mouth of the Stiffkey; the silver structure in the middle of the picture is a cat-flap fish pass

The river Glaven is another Norfolk river that has been massively over-engineered, making for some biologically compromised habitat. In late summer 2010, the river was tackled with a major restoration project, yet again a real partnership effort, this time between the landowners, Stody Estate, and Wild Trout Trust, Environment Agency, Norfolk Wildlife Trust, River Glaven Conservation Group, Professor Richard Hey, University College of London and the Centre for Environment Fisheries and Aquaculture Science (CEFAS).

The project took a 400-metre reach which, at some time in the distant past, had been straightened and moved to the edge of the floodplain, and recreated the river's natural form by putting back pools, riffles, and meanders, narrowing the river and reconnecting it with its flood plain. The restoration was designed and closely supervised by Professor Richard Hey, a professional fluvial geomorphologist recently retired from the University of East Anglia.

Figure 3: Remeandering Norfolk's river Glaven

WILD SEA TROUT: HELPING THEM ACCESS HABITAT

WTT is now turning its attention to other projects and other reaches on Norfolk's rivers, with some very demanding access and habitat enhancement challenges, including culverted river sections several hundred metres long!

Southern English coast

In a series of separate projects along the southern English coast, WTT is involved in improving life for some little-known sea trout populations in some of the rivers of Sussex: the Adur, the Arun, the Ouse and the Rother. Like the Stiffkey, these rivers have been very heavily modified and running sea trout not only face challenges getting into the river but also working their way upstream over any number of obstacles such as weirs and road culverts. Again, here is a really good example of partnership working as WTT teams up with Environment Agency, County Council staff and the local rivers trust movement, delivering work funded through Defra to help deliver Water Framework Directive improvements.

These projects have required very different approaches, but the principles of reducing the head loss (upstream and downstream water level difference) and water velocities through in-river structures are broadly similar. Instead of installing full-blown fish passes, these sites have benefitted from easements which simply increase the opportunities for fish to be able to pass much more easily over a weir or through a culvert. The legislation regarding the construction and maintenance of formal fish passes is tricky stuff and often results in large scale engineering works, maintenance agreements and a raft of health and safety measures, all of which demand big budgets. On the other hand, installing easements can be a job for individuals and fishing clubs, as well as the larger rivers trusts and Environment Agency.

One method, applied on a Sussex Ouse tributary, was to bolt timber baulks onto the downstream concrete apron of a road culvert, creating a series of pools on the apron and increasing water depth through the culvert. This allows sea trout to burst through the culvert and access several kilometres of upstream spawning territory.

Figure 4: The impassable culvert on the Sussex Ouse tributary, before the easement went in.

Figure 5: The timber baulks bolted to the road culvert apron create a series of pools and increase water depth through the culvert.

Another method, carried out on an Adur tributary, was much more conventional. Here, the solution was to introduce 30 tonnes of block stone (for stability) and flint reject gravels in two steps to enable seat trout to push upstream over a weir under a semi-derelict farm bridge. Knocking the bridge down and removing the weir would have been the preferred method, but was not an option we could pursue! With this type of "pre-barrage" of stone and gravels, there is always the concern that, in low flows, water will flow "through" the structure rather than raising water levels. This is invariably the case on small spate streams where base flows can be extremely low. The gravels locked between the stones will seal after a spate or two and allow the water levels to rise. Other important aspects to remember are to avoid marginal erosion issues by creating a low, dish- shaped section in the centre of the pre-barrage.

Figure 6: Local block stones being lowered into the channel ready to form the core of the pre-barrage on the Adur tributary.

The Wild Trout Trust is carrying on its work, not only in Norfolk and Sussex, but across the British Isles, improving habitat for stay-at-home and sea-going trout. The Trust is a registered charity, always keen for further support; so, for more information, visit the Trust website at **www.wildtrout.org** or contact Shaun Leonard through **director@wildtrout.org**.

SEA LICE MODELLING

THE SEA LOUSE LEPEOPHTHEIRUS SALMONIS, WHILE BEING A NATURAL PART OF THE MARINE ENVIRONMENT, CAN ALL TOO QUICKLY BECOME A THREAT TO MIGRATING SALMON AND SEA TROUT SMOLTS, AS WELL AS FARMED FISH. IN THIS ARTICLE THE AUTHORS, FROM MARINE SCOTLAND SCIENCE, OUTLINE WAYS IN WHICH WE ARE LEARNING ABOUT HOW SEA LICE LARVAE ARE DISPERSED. THIS KNOWLEDGE WILL CONTRIBUTE TO BETTER UNDERSTANDING OF DISTRIBUTION PATTERNS AND INTERACTION BETWEEN LARVAL LICE AND FISH.

A multidisciplinary approach to the development of sea lice dispersal models in Scotland

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[2]Marine Scotland Science, Freshwater Laboratory, Faskally, Pitlochry, PH16 5LB.

Sea lice are naturally occurring parasites that feed on the mucus, skin and blood of fish, which can result in lesions leading to poor condition and potentially death. Salmon and sea trout in Scotland are infected by two species of sea lice: Caligus elongatus, which can also be found on a range of other fish species, and the salmonid specialist, Lepeophtheirus salmonis which can be a serious pest to both wild and farmed salmonids.

Although the life-cycle of sea lice is complicated, for the purpose of pest management it is possible to consider lice in terms of being infectious or non-infectious. Sea lice have three planktonic stages in their life cycle. These consist of two non-infectious nauplii stages and a copepodid stage which is the first stage during which they can attach to fish. Although the planktonic copepodids can undertake short-burst swims allowing them to move between fish in close conditions, these life stages can be considered as buoyant particles which are transported in the water by environmental forces such as tide, currents and wind. Therefore, an understanding of the environmental transmission of lice is required in order to identify the possible risks posed by sea lice to wild and farmed fish.

Previous work by epidemiologists and oceanographers at Marine Scotland Science (MSS), formerly the Fisheries Research Service (FRS), developed a bio-physical model of sea lice dispersal in Loch Torridon. The model predictions of sea lice distribution were assessed by zooplankton biologists using net sampling of nauplii, and parasitologists using sentinel cages to measure relative lice levels in different locations within the loch, whilst fish biologists monitored the lice burdens of local sea trout. In order to help classify the species of larval sea lice stages, molecular biologists developed DNA based identification techniques. The results of the study demonstrated that the majority of lice in Loch Shieldaig were L. salmonis and that wind has a strong influence in transporting lice over several kilometres from a source. Although salmon farms were shown to be a source of lice within Loch Torridon, it is important to note that lice were still recorded on wild fish and on salmon in sentinel cages at times when local farms were free of lice, indicating that wild salmonids are also an important source of infection.

The Loch Torridon study involved the development of techniques designed to predict and measure sea lice dispersal. The success of this work has enabled MSS to move on to investigate the dispersal of sea lice in the larger and more complex system of Loch Linnhe.

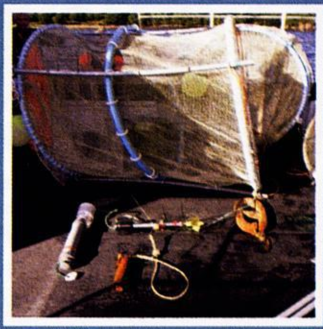
The starting point of the project was to obtain an inshore coastal model for Loch Linnhe which predicts water movements for the area. Such a model was provided by The Scottish Association for Marine Science (SAMS) based at the Dunstaffnage marine laboratory. The model takes into account many of the key physical features of the system and covers an area stretching some 60km from the Firth of Lorne in the south and the Isle of Mull in the west, up to the opening of Loch Eil near Corpach in the north of the system.

The model was passed to epidemiologists at MSS to include information on sea lice biological characteristics of maturation and mortality. Recent work conducted off the southwest coast of Shetland by MSS researchers, with help from staff at the North Atlantic Fisheries College, demonstrated that the majority of sea lice are found in the top layer of the water column. This meant the model could be restricted to the top few metres of the loch to account for the largest component of the lice population and, while lice at greater depth may play a role in dispersal (especially if a surface freshwater layer is present) the surface currents allow us to identify the most important routes of dispersal. The top few metres is also the region where wind- driven transmission has the most influence. A range of locations were defined as sea lice input sources in Loch Linnhe and used to predict the transmission distributions of lice within the loch system and predict where lice were more or less likely to be found. The distribution maps generated by the model were overlaid with geographical maps to identify sampling locations where it may be possible to observe the predicted patterns and verify the robustness of the model.

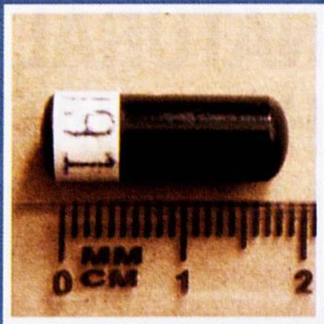
SEA LICE MODELLING

Plankton net sampling

The sentinel cage and monitoring equipment



An acoustic tag used to track the movements of migratory fish



To validate the model predictions, MSS parasitologists use sentinel cages. To undertake this work requires a substantial amount of administration. Permission is needed from the Crown Estate to establish moorings for cage attachment; approval from the Fish Health Inspectorate is obtained to ensure good fish welfare during the study and check that the cages and mooring follow industry best practices in line with the Code of Good Practice with regard to containment; healthy, disease-free fish for the cages are acquired from the aquaculture industry, whilst they are also informed about the research procedures; the Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH) are consulted to minimise the potential environmental impact of the cages; a range of organisations in the system are informed, such as fishery trusts and boards as well as marina organisations to minimise any impacts on their use of the loch.

The fish are stocked into 10 sentinel cage sites across the system predicted by the model as being potential areas for a range of lice densities. These fish act as samplers for infectious lice surrounding the cages over the course of a week. After this time in the cage, the fish are inspected for lice, the species are identified and numbers recorded to provide a measure of lice levels. The relative difference in the number of copepodid lice between sites will provide information to assess the accuracy of the predictions of the model.

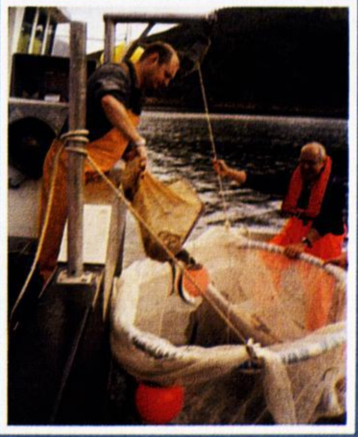
To measure the levels of non-infectious nauplii lice stages in the loch, as well as unattached copepodids, zooplankton biologists also undertake plankton tows using fine-mesh nets at some 30 sampling stations. The samples are screened for sea lice, species identified and numbers counted. Although planktonic naupliar larvae do not cause any harm to the fish, this sampling method gives information on the levels of lice in different areas of the loch, providing a source of validation of the model predictions. The Lochaber Fisheries Trust also conducts shoreline plankton net sampling to provide additional data for model assessment.

The model's validity is further measured by undertaking readings of the characteristics of the loch such as water temperature, salinity and current flow as well as wind direction and speed. To do this, oceanographers are placing recording stations on fish farms and on land at locations around the loch, and deploying current meters with the help of fish farm personnel. An additional measure of the model is undertaken by deployment of drogues which will be passively transported by the loch currents. The recorded position of the drogues allows comparisons between actual and modelled passive transmission in the loch.

In order to identify areas where lice and migratory fish are found together, MSS fish biologists in association with the Lochaber Fisheries Trust are attempting to record the movements of wild fish using acoustic tags and a network of listening stations. The combination of fish movements and lice dispersal predictions help to provide an estimate of interaction.

This project is only possible through the contributions of a range of organisations with the joint aim of developing tools and furthering knowledge which will lead to better control of sea lice infestation on farmed and wild salmonids. The project will help provide advice on the suitability of aquaculture management areas, improve our understanding of the effect of farm location and different management scenarios within such areas, and provide an insight on the risk of interaction between sea lice and wild fish. The exercise will also optimise model development and validation that could be applied in other parts of Scotland.

MSS would like to thank SAMS for allowing the use of their model of Loch Linnhe, members of the Linnhe/Lorne Area management group and in particular the Lochaber Fisheries Trust and District Salmon Fishery Board, Marine Harvest and Scottish Sea Farms for their extensive help, support and provision of fish, boats and personnel time. Additional thanks to all colleagues at the Marine Laboratory in Aberdeen, and the Freshwater Laboratory in Pitlochry who have helped plan and carry out work described above during the initial year of the project 2010-2011. The project is principally funded by the Scottish Government. Additional financial support was received during 2010 from the Crown Estate.



Stocking a sentinel cage in Loch Shieldaig

NATURAL OBSTRUCTIONS: HOW NATURE MAKES SALMON LEAP FOR THEIR LIVES

THE ROMANS GAVE THE ATLANTIC SALMON THE NAME WE KNOW IT BY TODAY – SALMO SALAR: THE LEAPER. AND ALTHOUGH MANY OF THE 'SALMON LEAPS' WHICH GIVE SUCH GOOD OPPORTUNITIES FOR OBSERVING THE FISH NOWADAYS ARE MAN-MADE, MOTHER NATURE HAS CREATED THE TRULY DRAMATIC SALMON LEAPS. IN THIS ARTICLE, COLIN CARNIE LOOKS AT HOW SCOTLAND'S MOST FAMOUS GEOLOGICAL FEATURE, THE HIGHLAND BOUNDARY FAULT, INFLUENCES THE SALMON'S JOURNEY – IN MANY CASES STOPPING IT AT IMPASSABLE BARRIERS.

The Highland Boundary Fault is best observed as one motors north or south through the wide gorge at Dunkeld which carries the A9, the railway line and the River Tay. Travelling north, one crosses the river and the mountains of Highland Perthshire open out in from of you, displaying the 1000m peaks of Schiehallion, Ben Lawers and Meall Garbh to the north west. Travel south, and after the top of the dual carriageway above Bankfoot, the lowland plains of the Earn valley extend towards the Central Lowlands.

The Fault, the result of two tectonic plates coming together some 500 million years ago, welds the harder metamorphic rocks in the north and west to the softer sedimentary rocks to the south and east. The rivers that cross this line break out of the confines of the harder rocks to the softer rocks in the south. At Dunkeld the River Braan demonstrates the power such geology can give a small river with the wonderful spectacle at The Hermitage, a series of falls which are a complete barrier to upstream migration - and there is good reason why they ought to remain so. Three streams, the Ballinloan, Tombane and Cochill Burns, which are the main tributaries of the Braan, all are very similar in size, similar in geology and similarly drain the south facing side of the valley. If ever one wanted to conduct relative experiments on the growth of parr, on the survival of smolts and on the many aspects of salmon which modern genetic capabilities have uncovered then the similarities of these three streams offer as good a field laboratory as one could wish for.

The East coast

The line of the Fault is also particularly noticeable when motoring on the A90 between Brechin and Stonehaven. Look to the north west, and the Angus hills rise in a remarkably straight line from the more benign arable land of the Mearns. A number of important rivers cross the line at this topographical junction. The most northerly is the North Esk, where The Loups of the Burn show where the harder grey rock mixes with the softer red sandstone. The Loups were not a total barrier to upstream migration but they were a serious hindrance, especially in the colder water of the Spring. In 1950 the Loups were eased by blasting and a pass was cut into the rock structure adjacent to the river which has improved the runs of salmon, especially the early running fish.

The next river to cross the Fault is the South Esk, a more gentle river than its neighbour, but it is not surprising that one of the pools on the charming beat at Inshewan is called The Dardanelles, as the river rushes between steep rock faces cut into the sandstone on the south side of the Fault. The salmon have no difficulty in migrating through this so it doesn't form an obstruction to migration, but it fits the pattern of rivers having to carve their course through these ancient rock masses which were forced into dramatic formations by tectonic movement.

The R Carnaig, Sutherland

NATURAL OBSTRUCTIONS:
HOW NATURE MAKES SALMON LEAP FOR THEIR LIVES

The Isla is quite different. The falls at Reekie Linn and the Slug of Auchrannie at Craigisla are spectacular and a total barrier to upstream migration. When the Isla is in flood the spectacle can only be described as frightening - made more so by the geology of the Fault. The grey metamorphic rock forms the cill of Reekie Linn but it overlies sandstone which is gradually being eroded so that eventually the cill will collapse and the falls may become a cataract. Should this barrier be breached? Various studies have been made of the practicability of doing so and people have ventured in towards the bottom of Reekie Linn in canoes to try to determine the scale of the task. It seems highly unlikely that upstream access would be a viable proposition on its own but if a fish lift could be incorporated into a hydro-electric scheme it might just be achieved. But this does not answer the question – should it be done? The quality of the water in the upper Isla is excellent, creating very good feeding for trout, and no doubt juvenile salmon if they were there, but there is a risk of salmo-centric ambitions wanting to encourage populations of salmon where none have existed for millions of years.

The author fishing the S Esk Photo - APH Andrews

Hydro Board intervention

The next river in this group is the Ericht where on the south side of the Fault is Craighall Gorge. This provides the appropriate and symbolic setting for the gathering of the Highlanders and their meeting with Edward Waverley in Sir Walter Scott's novel of that name, the first of his series of historic novels. It is an awe inspiring place where vertical cliffs drop from the general adjoining ground level to the course of the river some 70m below. It was a barrier to upstream migration, but in the late 1950s the North of Scotland Hydro Electric Board investigated the possibility of easing the falls to allow salmon to access the excellent spawning and juvenile streams in the catchments of the River Ardle and the Blackwater of Glen Shee.

This initiative was taken by the Board in recognition of the loss of access and spawning areas caused by their major developments in the western parts of the Tay system. The cataract was inspected in 1959 by an intrepid group including W J M Menzies, the fisheries advisor to the Board, and J K Woodrow, the owner of a small civil engineering company which undertook a number of rather specialised contracts for the Board. The word 'intrepid' is used with some justification as Lt. Cmdr. J K Woodrow RNR had the unusual decoration of a George Medal and Bar, awarded for his work on bomb disposal during the war, and interestingly his foreman 'Woody' Speirs, who in due course carried out the work, was a young sapper at Monte Casino where he was awarded the Military Medal for bravery. They were not going to be daunted by the physical challenges of working in the Craighall Gorge. The work involved difficult access down a steep scree wall where heavy items and equipment had to be lowered down by hand, and later pulled back up, again by hand. Two footbridges were built (and washed away in the winter) across the river to give access for the necessary drilling and blasting.

The work was done over the course of two summers and traces of a footbridge can still be seen. It was clearly a very special job, but all of the people involved were special. That opening up the Ericht was successful is perhaps best demonstrated by two facts. Firstly, the Crown Estate started leasing salmon fishing rights on the Ardle and Blackwater in 1962 and secondly, the number of salmon ascending the Ericht and counted at Blairgowrie is typically twice as many as the number counted in the fish pass at Pitlochry on the much bigger catchment of the River Tummel.

As an aside, Woody Speirs drove a bulldozer in the North African and Italian campaigns. At Monte Casino and while constantly under fire he supported the underside of a damaged bridge with the blade of his dozer, enabling reinforcements to move forward in that fierce battle. At one stage in a retreat in North Africa he had to abandon the transporter for his dozer much to his embarrassment. In Italy he was delighted to be able to report that he had found it again.

NATURAL OBSTRUCTIONS: HOW NATURE MAKES SALMON LEAP FOR THEIR LIVES

Opening a river north of the Fault

While the rivers crossing the Highland Boundary Fault provide two very good examples of natural barriers being opened up to allow salmon to migrate upstream with subsequent increases in stocks, the most charming example of overcoming a barrier is on a much smaller stream. The River Carnaig, a tributary of the River Fleet in Sutherland, has a spectacular waterfall which can be seen from the unclassified road between Bonar Bridge and The Mound. The fish pass built in 1864 on the Carnaig is a visible manifestation of the interest which was taken by proprietors of salmon fishings in the 19th century. Writing in 1881, Archibald Young described it as "One of the most remarkable salmon ladders in Scotland enabling salmon to ascend to Loch Buidhe in spite of a fall upwards of sixty feet in height." Young continues "The ladder was designed by Mr Bateson of Cambusmore and constructed under his direction; and he deserves much credit for this ingenious and successful device to overcome an apparent insurmountable obstruction. One noticeable feature in this ladder is that, after the salmon have taken several short jumps over steps not much exceeding one foot in height, they are provided with capacious resting pools in which to recruit their exhausted energies for the next series of jumps that await them".

The success of the pass is referred to by Grimble who reported that "salmon, grilse and sea trout ascend in fair numbers and the waters above the fall are soon stocked and yield sport to the rod." They still do. Two angling clubs share the fishing on Loch Buidhe, and reasonable numbers of parr were found in the burns above the loch during a recent electro-fishing survey.

Craighall Gorge

The R Carnaig, Sutherland

The Conwy: good engineering – but at a cost!

The mountainous country of North Wales creates rivers with steep gradients which are attractive to salmon and waterfalls which are often impassable. On the River Conwy is one of the most recent, and certainly the most expensive, fish pass built to allow salmon to overcome the natural barrier at the Conwy Falls. There had been a Victorian pass enabling salmon to surmount the falls but this was washed away many years ago and anglers on the river regularly watched salmon attempting but failing to continue their migration upstream. A very clever solution was developed which involved driving a tunnel in the rock on the left bank and incorporating a pool-and-traverse pass in the tunnel with the pools placed adjacent to one another rather than end-to-end. Thus although the gradient of the watercourse, and thus the length of the route the salmon must follow as they zigzag through the pass, are conventional, the compact layout permitted a steeper and shorter tunnel. It has proved very successful since its construction in 1993 but it must be remembered that when it was built it cost about £1 million.

The Clyde: should we or shouldn't we?

Are there still natural obstructions which could be by-passed? Now that the quality of the water in the River Clyde has improved so much and salmon have again returned to that industrial river one is inclined to ask whether the Falls of Clyde at Lanark should be opened up. It is certainly do-able but with Stonebyers, Cora Linn and Bonnington Linn to be surmounted the cost would be enormous. Furthermore, the trout fishing on the Upper Clyde attracts some extremely skilful and dedicated anglers and the risk of that classic trout fishing being spoiled by the pursuit of salmon would certainly ensure that this angler would oppose any such move.

SALT & SWEET

DICK SHELTON WAS RESEARCH DIRECTOR OF THE ATLANTIC SALMON TRUST UNTIL 2009. WITH HIS FRIEND, JENS-CHRISTIAN, HE UNDERTOOK THE PRE-SALSEA SAMPLING OF POST SMOLTS AT SEA. DICK'S FIRST BOOK, 'THE LONGSHOREMAN', DESCRIBED A LIFE DEVOTED TO NATURAL HISTORY AND MARINE BIOLOGY. HIS FASCINATION WITH THE TRANSITION ZONE BETWEEN SALT AND FRESH WATER COMES THROUGH IN THE FOLLOWING ARTICLE IN WHICH HE EXPLORES THE ADVANTAGES AND HAZARDS IN BIOCHEMICAL TERMS OF A LIFE STYLE BASED ON ANADROMY. THE CHOICE OF A SMALL FRESHWATER FISH OF WHETHER TO GO TO SEA TO GROW BIG, OR TO REMAIN IN FRESH WATER IS A LIFE DEFINING ISSUE FOR ATLANTIC SALMON AND TROUT, AND SURPRISINGLY ALSO FOR A SPECIES OF STICKLEBACK.

Here in my little corner of Fife's East Neuk, land meets sea with the uncompromising crash of wave upon rock and only in the wee pools of the upper shore do the rain showers render the water sweet enough to enable the three-spined sticklebacks to rear their fragile young. Some of the adults will have grown to maturity far out in the North Sea whose surface waters they briefly share with the post-smolt salmon migrating to their main sub-Arctic feeding grounds. Not all sticklebacks are part time seafarers. They are capable, like Atlantic salmon, of growing to maturity entirely in fresh water where the diversity of their populations may one day prove as challenging to the population geneticist as those of Salmo salar. What unites both species is their dependence on a low salinity environment for their early life stages, a characteristic that has led some taxonomists to speculate that the immediate ancestors of these unrelated fishes evolved, if not in fresh water, then perhaps in that lively transition zone that naturalists and wildfowlers call "estuarine".

Biologically speaking, estuaries are both demanding and wondrously generous. They are demanding because of the changes of salinity wrought by tide, drought and spate but generous because of the fertilizing effect of the nutrients entrained in land run off. Not all of the nutrients end up in coastal waters to fuel inshore plankton production. Some are closely bound to the colloidal particles and fine silts responsible for the frequent cloudiness of our lowland rivers. The minute electrical charges that help to maintain these particles in suspension are shorted out by their first encounter with sea water. As a result, they agglomerate like snow flakes and sink to the bottom to create mud banks that rival tropical rain forests in their biological productivity. Part of this productivity is driven by the activities of algae and photosynthetic bacteria whose energy source is sunlight. Deeper in the sediment, bacteria which draw their energy from chemical oxidation are the main primary producers and it is the sulphur compounds associated with them that give estuarine muds the characteristic odour that melds so well with the black powder residue of the 'fowler's 8-bore. Less well known is a compound called dimethyl sulphide. In very low concentrations it is responsible for the delicate flavour of both molluscan and crustacean shellfish. At the high concentrations commonly found in estuary feeding "hard fowl" like widgeon, it is a challenge to the cook which only overnight soaking in well-salted milk can meet.

The creatures that feed on the teeming hordes of estuarine micro-organisms are variously specialised to cope with the chemical vagaries of estuarine life. Some of these secondary producers cope because of the extreme tolerance of their cells to changes in the salinity of the water that bathes them. Others are able to exert a degree of control over the salt content of their body fluids and others cope by moving out of the way of inclement conditions. Sticklebacks, eels, sparling, flounders, salmon and, above all, sea trout are among the animals that are able to do both these things and to benefit accordingly. Just as the oceanographic mixing zones of sub-Arctic waters are the Atlantic salmon's banqueting table, so organically enriched coastal waters and estuaries serve the same function for sea trout. Not only are estuarine basins important for feeding purposes, but they also provide access to low salinity over-wintering areas for some of the immature sea trout that have spent but one summer tasting the salt. However long or short a period that migratory fishes spend in estuaries, their importance as gateways between fresh and salt water and therefore between reproduction and growth to maturity cannot be over-emphasised. However pristine the upper reaches of a river or however productive a sea feeding ground, the history of the industrial revolution has shown time and again that the de-oxygenation or toxic degradation of an estuary is the surest route to the local extinction for salmon and sea trout populations. That in systems like the Tyne and Clyde these lessons have at last been learned is a cause for celebration indeed. How sad therefore it is that in another sort of estuary, the sea lochs of North West Scotland, all marine life stages of sea trout and the smolt stages of salmon are daily dying of osmotic failure as sea lice from ill-regulated salmon farms devour their fragile skins.


FROM A DAY TO
A WEEK'S
SALMON FISHING

ATLANTIC SALMON Trust

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