NASCO

STATE OF NORTH ATLANTIC SALMON

NASCO is an international organization, established by an inter-governmental Convention in 1984. The objective of NASCO is to conserve, restore, enhance and rationally manage Atlantic salmon through international co-operation taking account of the best available scientific information.

www.nasco.int

Environmental change and human impacts across the Northern Hemisphere are placing salmon at risk. The International Year of the Salmon (IYS) aims to bring people together to share and develop knowledge more effectively, raise awareness and take action. 2019 is the focal year of the IYS.

www.yearofthesalmon.org

CLARENCE HOUSE

I have taken a keen interest in that most iconic of species, the salmon, for as long as I can remember, both as a fisherman and, for the last thirty-five years, as Patron of the Atlantic Salmon Trust. Therefore, I fully recognize and applaud the importance of this report, published in the International Year of the Salmon and providing a comprehensive and fascinating account of the state of salmon in the North Atlantic.

When I was first taken fishing, at the age of seven, salmon were plentiful and my experience of fishing, particularly in Scotland but also in Iceland, has left me with treasured memories. In the years since then I have witnessed, with mounting despair, the catastrophic decline of this most enigmatic and noble of fish.

Tragically, the days of abundant stocks of wild salmon are now gone. In recent years, most salmon populations have suffered serious and, in some places, disastrous collapse. As this report shows, the impact of these declines goes far beyond the loss of good fishing. Wild Atlantic salmon are embedded into the social, cultural and economic fabric of communities surrounding the North Atlantic. For centuries, returning salmon have provided both food and economic opportunities in mainly remote areas, making the species an integral and unique part of local culture and traditions.

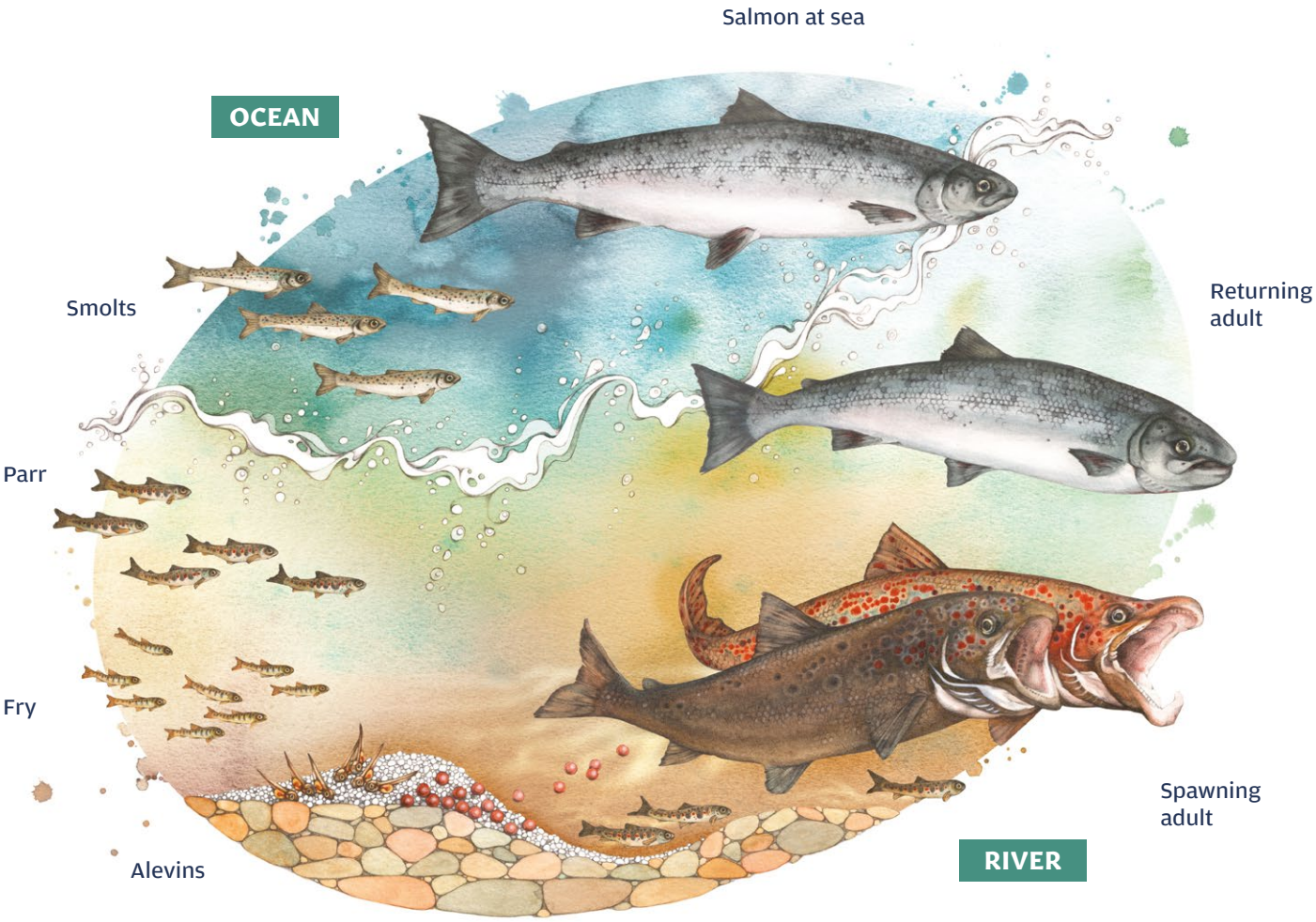
Understanding the reasons for the current state of wild Atlantic salmon is crucial. Research has revealed a range of likely factors that may be driving the collapse of salmon populations. They include dams blocking rivers, pollution of water, predation, aquaculture and by-catch on the high seas. These factors, together with the ever-increasing impacts of climate change and global warming are threatening the survival of this iconic species.

The encouraging news is that the passion which many people have for salmon means that action can be, and is being, taken. The International Year of the Salmon is providing a welcome focus, bringing people and organizations together in new ways in order to share and develop knowledge, raise awareness and take action.

The romantic connection people have with the Atlantic salmon and its extraordinary life story is leading to projects that enhance water quality; that remove barriers along rivers to enhance salmon access and improve habitat; that increase public engagement through art and literature; and research projects and conferences to develop understanding and share knowledge.

This is all vital work and I hope it will encourage more people to offer a helping hand to ensure we do not lose this spectacular fish forever. As human beings, we have an immense responsibility for the stewardship and wellbeing of this precious planet and everything that shares it with us. At present, we are seriously failing that responsibility, and, as this report highlights, wild Atlantic salmon are a powerful symbol of the health of our rivers and ocean, and of our relationship with the natural environment.

This incredibly valuable species is an aquatic canary for wider environmental change. The song it is singing tells us a great deal about the state of our freshwater and marine environments and the need to behave responsibly to look after our natural resources. If we cannot limit climate change to a manageable level – which I must add needs to be a great deal lower than the current appalling trajectory – and stem the accompanying rapid loss of biodiversity, the consequences will be truly unthinkable. So as well as understanding the story of the salmon we need to reflect carefully on what it is telling us about our own precarious situation, let alone the accumulating and unacceptable catastrophe we are bequeathing to our poor children and grandchildren, who will most likely never forgive us.



A SPECIAL LIFE CYCLE

The North Atlantic salmon begins life in the rivers of countries that surround the Atlantic basin – from Portugal, Spain and New England (USA) in the south of its range to sub-Arctic Canada and Russia in the north. Spawning occurs in the autumn and winter, with female salmon depositing between 1,000 and 2,000 eggs (ova) per kilogram of body weight into a nest (or redd) made on the gravel bottom of rivers.

Hatching occurs the following spring. The young salmon (or alevins) are nourished by the yolk sac until they emerge from the gravel as fry to commence feeding. After the first year of life, the young fish are known as parr.

Following a period in fresh water, which can range from one to seven years, the parr undergo an enormous physiological, morphological and behavioural change, known as smoltification, that allows them to adapt to the salt water of the Atlantic Ocean. These smolts, as they are now known, migrate to the ocean in the spring and, after one or more years at sea, return as adult salmon to their rivers of origin to spawn. Once back in fresh water, they change colour to a mottled reddish-brown. The male fish also change shape, developing a prominent hook or kype on the lower jaw. Most salmon die after spawning, but a small proportion, mainly females, will spawn again following another trip to sea.

Illustration: Jenny Proudfoot

A SPECIES IN CRISIS

The spectacular life cycle and historic abundance of Atlantic salmon have embedded the species into the social, cultural and economic fabric of communities around the North Atlantic. But, despite this iconic status, wild salmon numbers are at crisis levels, with reduced numbers of returning adults being seen in most rivers.

Photograph: Nick Hawkins

BETWEEN 1983 AND 2016 – a period of just 33 years – numbers of wild Atlantic salmon prior to any fishing taking place (known as the pre-fishery abundance, or PFA) fell by more than half. The rate of decline was most dramatic from 1983 to 1990, when salmon numbers fell from around seven million to five million fish. And while the rate of decline since 1990 has slowed, a further 33% of salmon have been lost – meaning the number in 2016 was estimated to be around 3.38 million.

During the same period (1983 to 2016), there was a marked reduction in exploitation. Prior to the 1960s, countries made their own rules about salmon harvest with no international discussions. In October 1983, the Convention for the Conservation of Salmon in the North Atlantic Ocean – the birth of the North Atlantic Salmon Conservation Organization (NASCO) – created a large protected zone free of targeted fisheries for Atlantic salmon in most areas beyond 12 nautical miles from the coasts.

This resulted in an immediate reduction in the commercial salmon fishery which, at its peak in 1973, harvested some 3.5 million salmon.

Despite these significant fishery reductions, numbers of Atlantic salmon continue to decline. We know this in part through the tagging of several million fish each year for assessment and research purposes.

It now (since 2007) takes about double the amount of eggs to produce one adult (compared to the period prior to 1990) that will return to that same river to spawn – an indication of the multiple pressures facing the species throughout its complex life cycle.

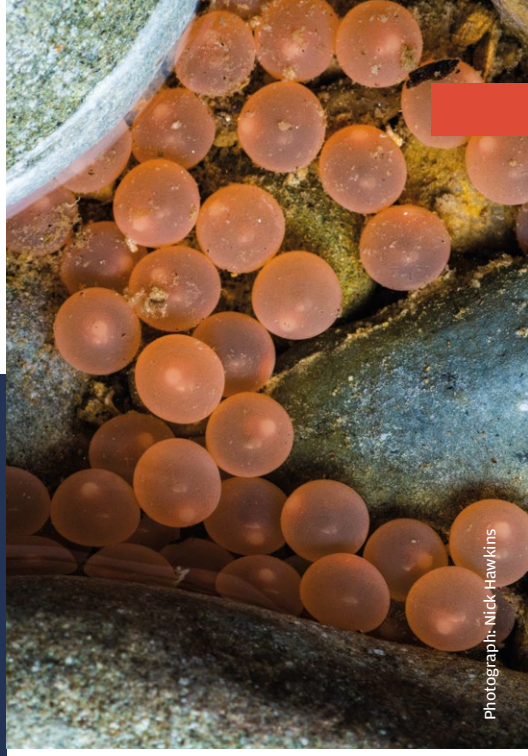
> **‘These are challenging times for wild Atlantic salmon. Abundance remains low, or even critically low in some areas. In these circumstances, our focus must be on those factors which we are able to control.’**
>
> **JÓANNES HANSEN, PRESIDENT, NASCO.**

PRIOR TO 1990

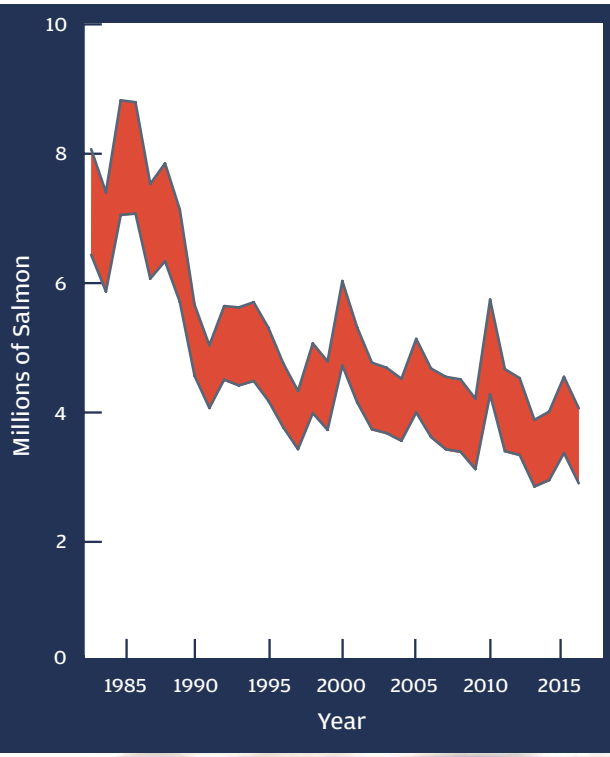
1,000 eggs = one salmon surviving first year at sea

FROM 2007 TO 2016

2,000 eggs = one salmon surviving first year at sea



Photograph: Nick Hawkins



SALMON ABUNDANCE

From 1983 to 2016, there was an alarming decline in salmon numbers prior to any fishery

Further data on the tonnage of wild salmon in specific areas of the North Atlantic prior to 1983 highlights an even more dramatic decline than shown here

SIGNIFICANT REDUCTIONS IN HARVEST SINCE THE MID-1970s

3.5 MILLION
salmon peak harvest in 1973

2 MILLION
harvested annually until the late 1980s

Fewer than
0.5 MILLION
harvested annually in recent years

THESE NUMBERS REPRESENT ALL FISHERIES, NOT JUST 'AT SEA'

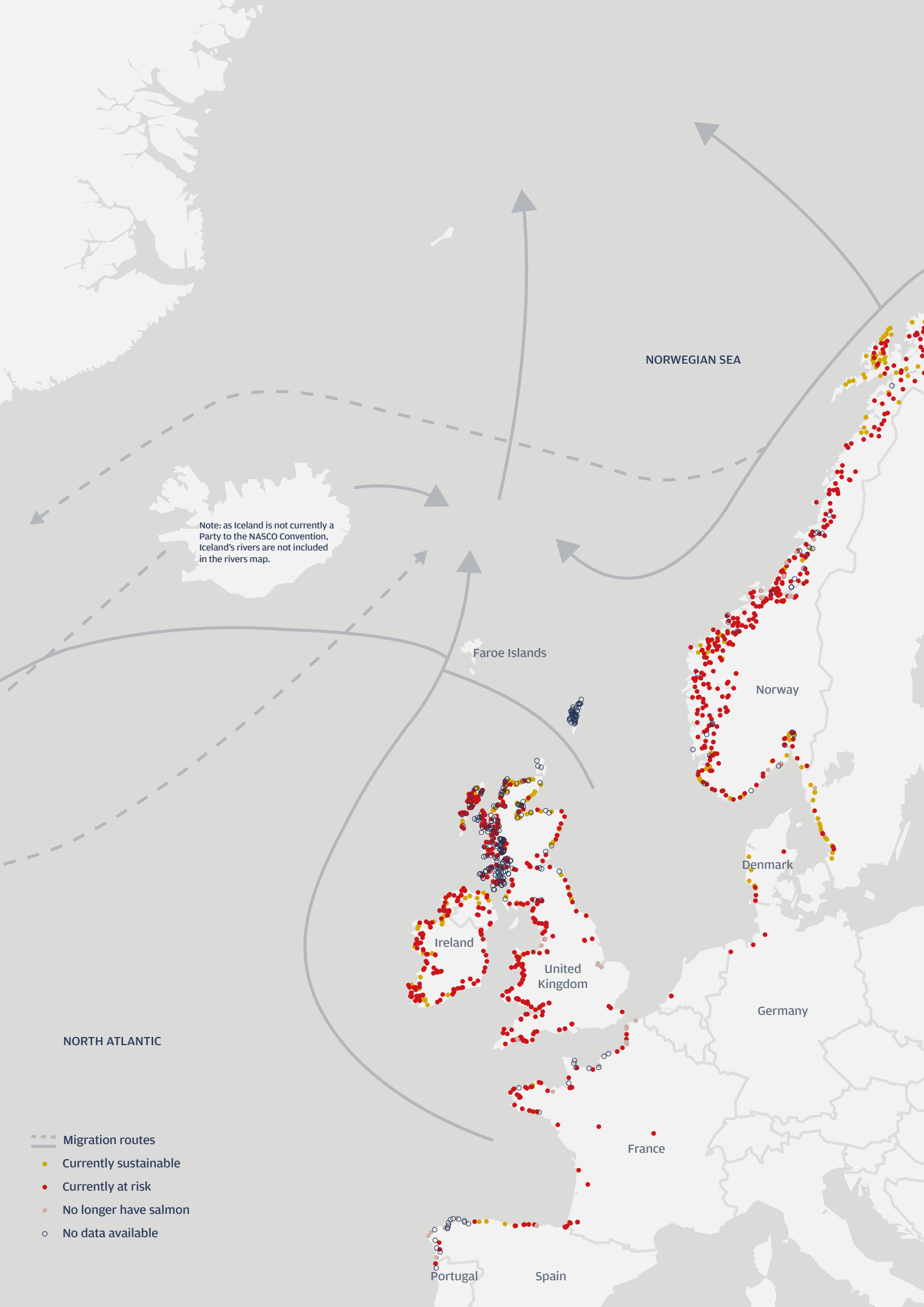
Photograph: Nick Hawkins

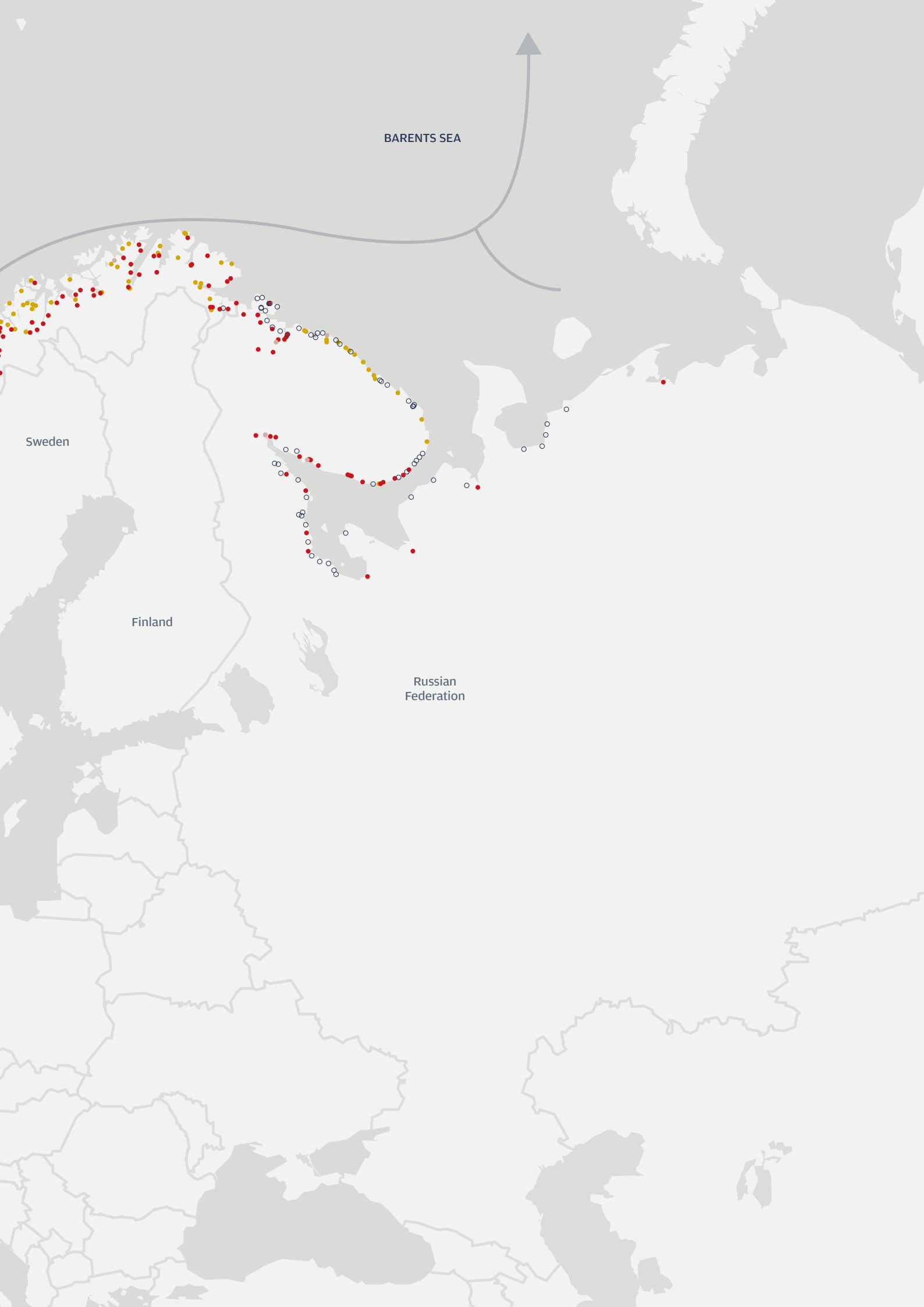
A special fish (clockwise from main): a magnificent male Atlantic salmon; a clutch of salmon eggs; fine salmon habitat in Atlantic Canada; fin tags are a key research tool

OVER 2.7 million
FISH TAGGED OR MARKED ANNUALLY
for assessment and research purposes

Photograph: Sergey Prusov


Greenland
LABRADOR SEA
Canada
United States
of America


NORWEGIAN SEA
Note: as Iceland is not currently a Party to the NASCO Convention, Iceland's rivers are not included in the rivers map.
Faroe Islands
Norway
Denmark
Ireland
United Kingdom
Germany
NORTH ATLANTIC
France
Portugal
Spain
Migration routes
Currently sustainable
Currently at risk
No longer have salmon
No data available


BARENTS SEA
Sweden
Finland
Russian
Federation

SALMON IN RIVERS

While no two rivers are exactly alike, the same can also be said for salmon populations. After their ocean migration, Atlantic salmon return to their rivers of origin, even to the same part of the river in which they hatched, to spawn. This has enabled the formation of genetically distinct populations among and within rivers, adapted to the local conditions.

IN THE EARLY STAGES of their life cycle, Atlantic salmon spend between one and seven years in the rivers that they hatch in. When they eventually venture to sea, they travel thousands of kilometres to feeding grounds in the Norwegian or Barents Seas or to the coasts of Greenland and the Labrador Sea. Following one or multiple winters at sea, the salmon return to their rivers of origin to spawn and the life cycle begins again.

NASCO's contracting Parties have worked to assess the status of the population, or stock, of the salmon in each river around the whole of the North Atlantic to create NASCO's Rivers Database. In total, 2,359 rivers have been reported on.

Of these, 174 rivers (or 7%) no longer have their once unique populations of spawning salmon. This is largely due to human activities. A further 1,014 rivers (43%) have stocks that are considered either to be at risk, threatened in some way, or declining in numbers. Only 341 rivers (14%) are considered to have sustainable salmon populations. The remaining 830 rivers have not been assessed, so the status of salmon stocks in these rivers is unknown.

STOCK STATUS FOR 2,359 RIVERS IN:

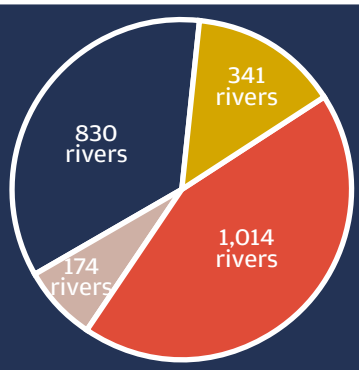
Canada, Denmark, England, Finland, France, Greenland, Germany, Ireland, Northern Ireland, Norway, Portugal, Russian Federation, Scotland, Spain, Sweden, USA, Wales.

14% currently sustainable

43% currently at risk

7% no longer have salmon

36% no data available



Photograph: Nick Hawkins

Photograph: Nick Hawkins

MORE THAN A FISH

Throughout their range, wild Atlantic salmon provide society with a host of values, benefits and ecosystem services that, together, touch us economically, socially and culturally.

IT IS FAIR TO SAY THAT pinpointing the exact value of wild Atlantic salmon to people is fraught with difficulty. After all, value can mean different things to different people – and particularly so when relating to a species that is not only economically important, but that also has deep cultural and social connections with humans.

Fishing is perhaps the most obvious example of salmon bringing value to people. In this regard, salmon contribute to the quality of life of many people around the North Atlantic both materially – as food and an economic driver – and non-materially, through the experiences gained from different forms of fishing.

Salmon fisheries themselves contribute on both counts. While net and trap fisheries provide high quality food for subsistence in local and indigenous communities, and through now limited commercial activity, many also have a significant non-material side that contributes to quality of life. This is seen in the indigenous food, social and ceremonial fisheries of Eastern Canada, and in heritage fisheries elsewhere that involve unique local fishing methods.

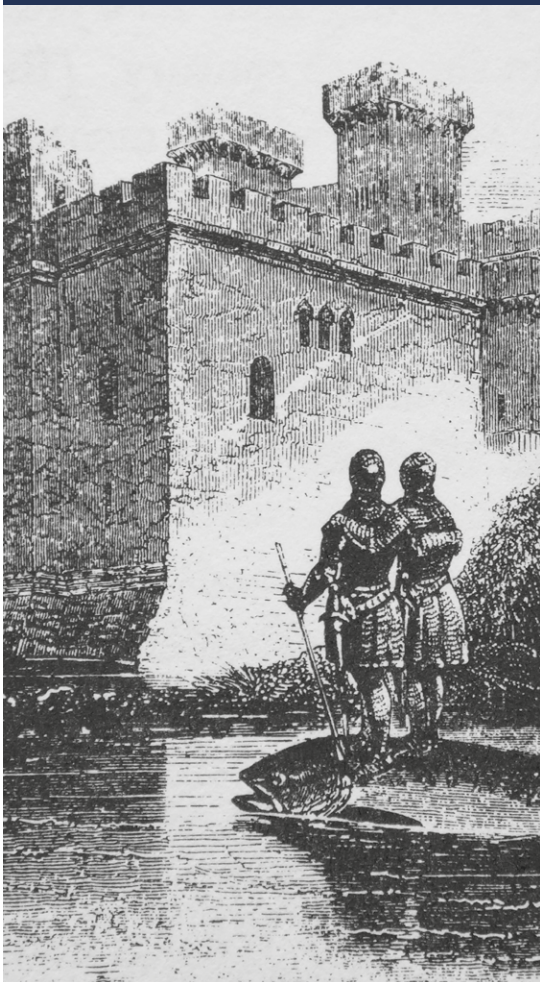
Other salmon-related activities also contribute to people's quality of life. On the River Suldalslågen in Norway, it is possible to swim with salmon as part of guided salmon 'safaris', while in many countries salmon can be seen leaping at dams and waterfalls – a natural attraction that draws visitors and photographers alike.

Atlantic salmon have a long association with spiritual and religious experiences. The species appears in folk tales, such as the Mabinogion in Wales, and as the Salmon of Wisdom in Ireland.

Similarly, salmon have provided inspiration for many forms of artistic expression, and are often included in heraldry, coats of arms and place names. In Scotland, the arms of the Royal Burgh of Peebles feature three salmon on a red field and the motto Contra Nando Incrementum – Latin for 'There is growth by swimming against the stream', which refers to migrating salmon in the nearby River Tweed.

More recently, during a leg of the Tour de France in 2017, researchers and co-workers from the National Conservatory of Wild Salmon used GPS co-ordinates, sticks and football chalk to mark the outline of an almost 280-metre-long salmon. Created to raise awareness around the preservation of the Loire-Allier river and its salmon population, it is also indicative of how salmon are valued as symbols of good environmental quality.

The Salmon of Llyn Llyw carries knights of King Arthur up the Severn Estuary. Illustration from 'The Mabinogion' translated from the Welsh by Lady Charlotte Guest. Bernard Quaritch, London, 1877



INDIGENOUS CONNECTIONS

For centuries, fjords and rivers along the North Atlantic coastline have sustained indigenous communities with returning salmon, making the species an integral part of their culture, identity, diet, economy, social relations and spiritual practices.

One of the world's most productive Atlantic salmon rivers is the Tana / Tenojoki / Deatnu (in the Sámi language), a river that forms part of the border between Norway and Finland in Sápmi (a cultural region in the northern parts of Norway, Finland, Sweden, and the Kola Peninsula in Russia, and traditionally inhabited by Sámi people). While the fishery no longer provides the same level of livelihood sustenance it once did, the salmon remains highly valued for its contribution to quality of life, social relations, and continuity of traditions.

For several years, however, biological assessments of Tana / Tenojoki / Deatnu salmon stocks have evaluated most of them to be of poor status, and the increasingly strict regulations on the length of the fishing season and permitted fishing gear have caused strong local (including Sámi) opposition.

As the reductions in fishing are found by some to erode Sámi practices and ways of living, locals are calling for a management regime that is compatible with the maintenance and continued development of Sámi fishing traditions and knowledge.

A similar situation can be found in Canada, where declining salmon stocks have prompted conservation measures that, to Western eyes, are widely regarded as the appropriate management response to any declining resource base.

However, the very meaning of conservation has caused a concern with the Mi'kmaq, an indigenous First Nations people from the Atlantic provinces of Canada. Salmon, or plamu as it is known to the Mi'kmaq, are one of many animals that contributed to their self-sufficiency historically.

A staple food, salmon were dependable, predictable, and could be found in most coastal rivers in eastern Canada. Today, because of concern over numbers, the amount of wild salmon available for community food is at an all-time low and, in some areas, the eating of wild salmon is now reserved for ceremonies and other special occasions.

As with the Sámi, the Mi'kmaq fear the loss of traditional food and cultural values as a result of the declining salmon populations and the conservative harvest regulations imposed upon the fishery. This situation can be found with indigenous communities across the range of Atlantic salmon from the Inuit in northern Canada and Greenland to the Penobscot in the USA.

Photograph: Emmanuel Lerbret - CNSS

Salmon stories: the salmon has long been an important part of cultural life for the Mi'kmaq people in Canada's Atlantic provinces (main); an outline of a giant salmon marked on the banks of the Loire-Allier River during a leg of the 2017 Tour de France (above)

Photograph: Unama'ki Institute of Natural Resources

VALUE OF CONSERVATION

The primary short-term challenge in managing Atlantic salmon for the benefit of people is to ensure that there are enough returning adults to allow a certain level of harvest without jeopardising the long-term viability of the populations.

Without a population surplus, there can be no sustainable harvest – a biological reality that has consequences for all fisheries. If local knowledge and culture are to survive, then traditions need to be practiced, which in turn relies on the continued abundant presence of salmon.

Similarly, the economic significance of Atlantic salmon depends directly on the surplus and indirectly on the values placed on the utilisation of that surplus.

Salmon are also highly valued for many other reasons unrelated to fisheries. In recent decades, there has been an increasing focus on conservation and biodiversity, with a variety of studies showing that restoration of wild Atlantic salmon in rivers can be valuable both ecologically and economically.

Public investment, the reduction of heavily polluting industries, and reduced acidic rainfall, often combined with liming of impacted rivers, have brought major improvements in the water quality and accessibility of many rivers in some countries.

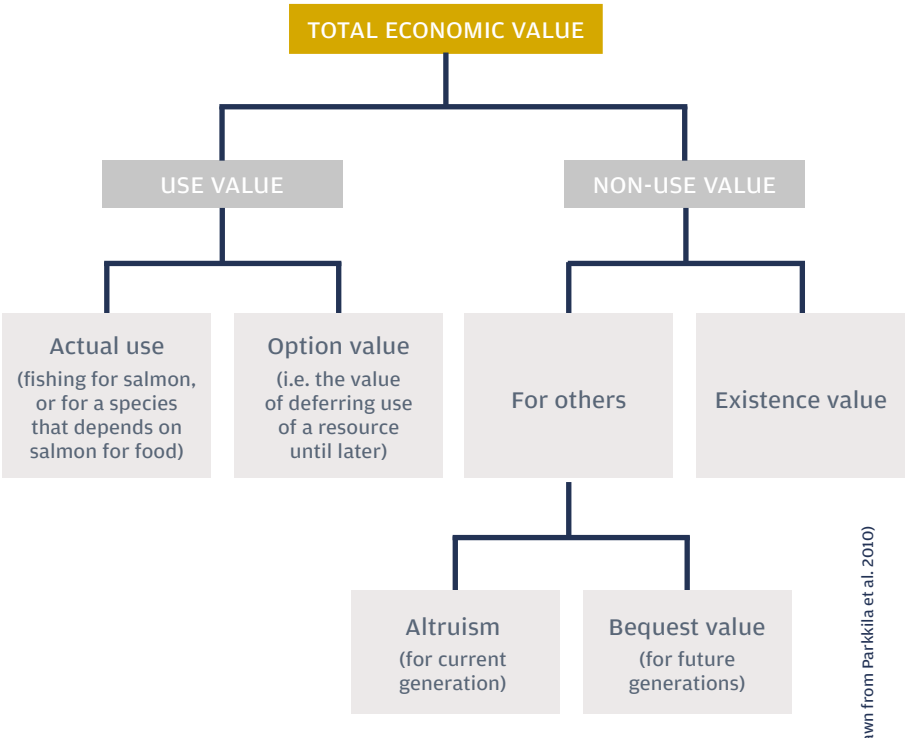
As a result, salmon have returned to rivers from which they had previously been lost or heavily reduced. And although some rivers now support valuable fisheries, such as the Tyne in England or the Skjern in Denmark, attempts to restore a self-sustaining population have often been driven by what are termed 'non-use' values, as on the River Aker which flows through the centre of Oslo, Norway. Having suffered from heavy pollution for more than a century, the Aker has been restored over the past decade, with Atlantic salmon now returning in increasing numbers each year.

As far as the wider public is concerned, non-use values may now dominate the 'total economic value' (see figure below) of Atlantic salmon in some countries – with much of the public's valuation of salmon linked to its significance as an indicator of environmental quality.

(Photograph: Oddgeir Andersen)

An angler enjoying the rejuvenated River Aker which flows through the heart of Oslo

THE BASIC COMPONENTS OF TOTAL ECONOMIC VALUE



(Redrawn from Parkkila et al. 2010)

FISHERIES SNAPSHOT

Commercial and recreational fisheries are the ultimate manifestations of the economic value of salmon. Studies comparing catches around the North Atlantic in 2017 compared with 2007 estimate the total catch of net and trap fisheries to be approximately 185,000 salmon. Some countries, such as Canada and Norway, have had largely stable catches over the decade, while others have plummeted (Scotland, Russia), or ended altogether (Northern Ireland).

Still, at least 5,400 people continue to fish for wild Atlantic salmon with nets and traps. Today, the majority are considered subsistence fisheries and are most likely upheld for their cultural benefits rather than for clear commercial purpose, so it is of little relevance to estimate the overall economic value of the catch.

Meanwhile, although there are uncertainties in the data for angling activity across the North Atlantic for 2017 compared with 2007, it is possible to indicate the scale of activity. It seems that there are around 220,000 salmon anglers fishing for more than 1,600,000 days (or roughly a week each) to catch about 380,000 salmon. Some countries with time series of rod licence sales indicate general stability in participation from 2007 to 2017, though Norway may have seen a decline – and a reduction in catch of approximately 25,000 salmon in that period.

Overall, the total expenditure of salmon anglers across the North Atlantic in 2017 is estimated to be in the range of €300 to €500 million.

One of the key changes observed over the decade studied is an increase in catch and release angling. First used as a management method to minimise take in areas where anglers could not be excluded, it has now become widespread in areas, including across Europe, where fishing rights are largely private.

The increase in catch and release angling may also be interpreted as an outcome of changing values in society and not just reflective of low stocks. Even though catch and release was already prevalent a decade ago, the trend has spread to new regions and rivers. This could indicate the recruitment of new or young anglers that value salmon and salmon angling differently.

MAINTAINING CONNECTIONS

It is clear that maintaining our connection with salmon is vital to the continued existence of the species as well as the social, economic, and cultural values that flow from it. After all, we do not miss what we never knew, which means that restoring connections can be more challenging than maintaining existing ones.

Along the way, values and perceptions may change, but ensuring continuity is critical. Restoring cultures and social conduct that depend on salmon can be achieved after a few failed seasons, but as time passes it becomes ever more difficult and knowledge is lost.

In the end, we all want the same: healthy ecosystems which provide abundant salmon. In reaching that point, it is critical to document people's connections with salmon. And with many voices supporting its case, the hope is that salmon will persist even in a rapidly changing world.

FURTHER INFORMATION

The 'Value of salmon' section is based on a recent report. Myrvold, K.M., Mawle, G.W., Andersen, O. & Aas, Ø. 2019. The Social, Economic and Cultural values of wild Atlantic salmon. A review of literature for the period 2009-2019 and an assessment of changes in values. NINA Report 1668. Norwegian Institute for Nature Research.

Vital connections: young Mi'kmaq fishers (below); a fine catch (above)

Photography: Unama'ki Institute of Natural Resources

PRESSURE POINTS

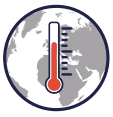
Wild Atlantic salmon face a whole range of different and, often, combined or interconnected pressures during their life cycle – with the actions of humankind very much a common thread.

Photograph: Ness District Salmon Fishery Board

BROWSING THE FISH AISLES in stores and supermarkets, the counters lined with pack after pack of Atlantic salmon, it is easy to imagine that stocks have never been healthier. But the truth is rather different as almost all Atlantic salmon available on supermarket shelves is farmed.

Today, there exists what conservationists in the United States refer to as a 'grocery store problem', with a huge discrepancy between the availability of farmed salmon in supermarkets and the declines in wild salmon throughout much of the North Atlantic. Even in areas where wild salmon populations are at risk of extinction, the ease with which salmon can be bought in supermarkets means that the general public is often unaware that wild salmon stocks are so fragile.

As the diagram opposite illustrates, wild salmon populations face a raft of challenges throughout their complex life cycle.



CLIMATE CHANGE

Complex and far-reaching, climate change impacts both the marine and freshwater phases of the Atlantic salmon's life cycle through changes in water temperature, habitat quality and survival at sea. Additionally, increasing freshwater temperatures affect how far south salmon populations can exist.

DISEASES / PARASITES

Of the 80 or so diseases and parasites that affect Atlantic salmon, only a few have been documented to have significant impacts on wild populations. Furunculosis (a bacterial disease), *Gyrodactylus salaris* (a type of parasitic flatworm) and Ulcerative Dermal Necrosis (a skin disease) are three that have decimated populations in specific areas.

STOCKING

When done with careful planning to consider genetic impacts, stocking hatchery salmon can be a critical restoration tool. However, without careful consideration, stocking can be harmful to wild populations. Stocking is also not a replacement for addressing other pressures in rivers and oceans.

INVASIVE SPECIES

Evidence exists of negative effects of invasive species on wild salmon populations, with general worldwide increases in the introduction and spread of non-native and invasive plants and animals (e.g. non-native fish species, Japanese knotweed, and *Gyrodactylus salaris*). This pressure might become even more important in the future through climate change increasing competition, predation and disease.

HABITAT DEGRADATION

Activities such as intensive agriculture, gravel extraction, commercial forestry and substrate removal for drainage schemes can alter a river's structure, increase sedimentation and reduce the quality of salmon habitat. Additionally, water extraction and hydro-regulation can greatly alter a river's hydrology, with the changes in river flow, temperature and quality having a negative impact on the productivity of salmon populations.

PREDATORS

Predation occurs both in fresh water and at sea with a variety of birds, other fish and mammals all feeding on salmon during different life stages. Predation is a naturally occurring phenomenon, but issues may arise when predator numbers are unnaturally high due to human intervention or shifting ecosystem conditions.

MIGRATION BARRIERS

An arduous migration from river to sea and back again is a key part of the salmon's life cycle, but it is a journey made even more challenging by the many weirs, locks, hydro-electric projects, culverts and tidal barrages that block their path. Even with fishways in place to help salmon move around these barriers, there can still be a negative impact on access to important areas of habitat.

POLLUTION

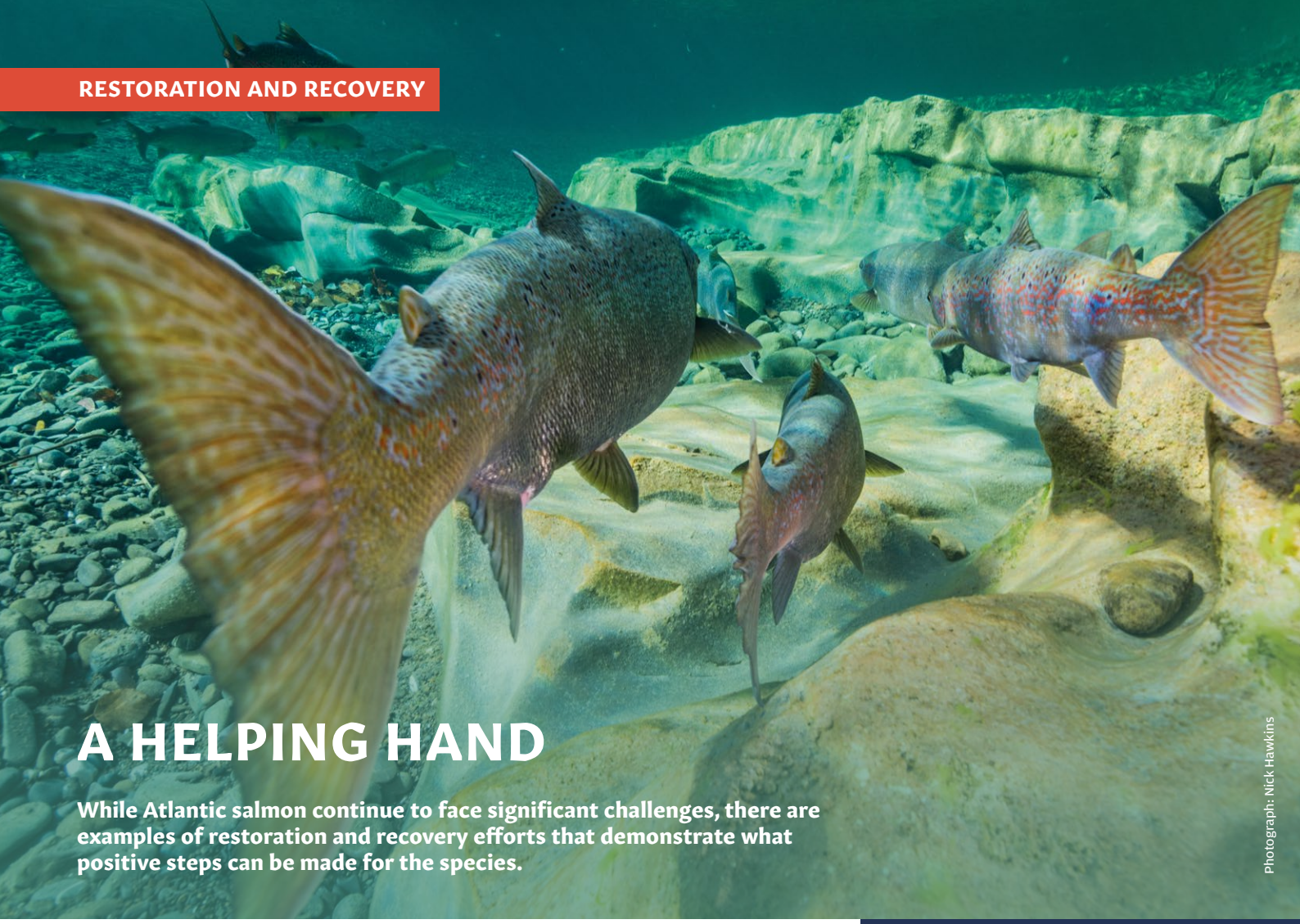
Water pollution is a major cause of the decline in stocks of Atlantic salmon, with all life stages of fish affected both directly (through exposure to chemicals and acidified waters) and indirectly (through runoff causing eutrophication of aquatic habitats) in fresh water and the ocean.

OVER-EXPLOITATION

Over-exploitation occurs when too many fish are removed from a population in freshwater or marine environments, leading to that population falling below a sustainable level. Ultimately, this results in fewer returning adult females laying fewer eggs and a far less resilient population.

AQUACULTURE (SEA LICE, ESCAPES AND DISEASES)

Aquaculture impacts Atlantic salmon stocks through the genetic effects of farmed salmon escaping into wild populations, and mortality from sea lice and diseases spreading to wild salmon. Containment, proper siting and sea-lice control are important considerations for aquaculture operations.



A HELPING HAND

While Atlantic salmon continue to face significant challenges, there are examples of restoration and recovery efforts that demonstrate what positive steps can be made for the species.

Photograph: Nick Hawkins

MAKE NO MISTAKE, the Atlantic salmon is a species under severe pressure, with an urgent need for a collective effort to reverse population declines throughout its range. Thankfully, there are glimmers of hope, with efforts – large and small – being made to improve the fortunes of salmon around the North Atlantic.

Such work is happening in part because people recognise the importance of doing so to help the wider environment. But it is also about what salmon as a species means to them. For many, salmon are a symbol of a healthy, thriving aquatic environment – with benefits for all.

CLEARING THE WAY

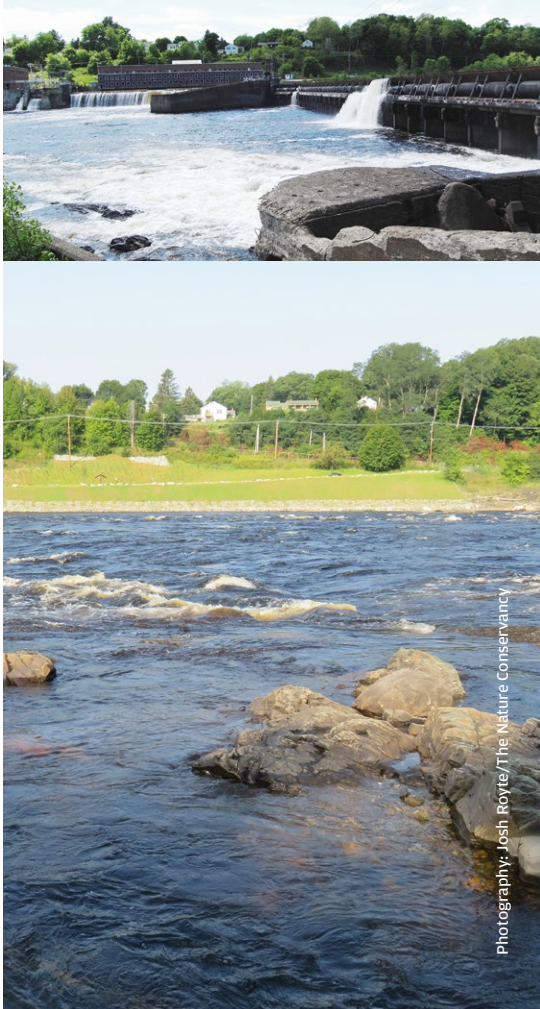
An arduous migration from river to sea and back again is a key part of a wild salmon's life cycle, and just one reason why the species is so special. But it is a journey made even more challenging by the many obstacles – from weirs, shipping locks and fish traps to hydro dams and tidal barrages – that block their path.

The problem is that when barriers are impassable, large areas of a watershed become inaccessible to migrating fish, preventing them from spawning and growing the population. Even those barriers that are partially passable can have a major effect on river flow and temperature, sediments and water chemistry – all of which are key to the health of Atlantic salmon at different stages in their lives.

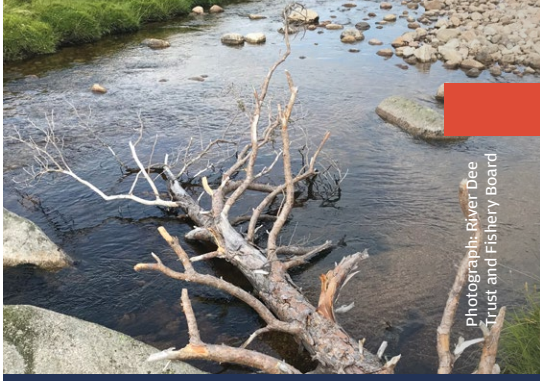
Salmon ladders and other solutions for aiding upward and downward migration help to an extent. However, it is when barriers are removed altogether – a major undertaking when it comes to larger constructions – that salmon populations have the greatest chance of recovery.

A prime example can be seen in the United States where the Penobscot River Restoration Project in Maine has brought dramatic change to the second largest river system in New England. A collaborative effort to balance fisheries restoration and hydropower production, the project included the removal of two dams that had blocked fish migrations for more than a century, and the construction of a river-like bypass around a third major dam that fish now use to access areas of habitat that are critical for their reproduction and recovery.

Before and after: the Veazie Dam was one of two major barriers removed as part of the Penobscot River Restoration Project in Maine



Photography: Josh Royte/The Nature Conservancy



More trees please: the use of large woody debris on the River Dee in Scotland (above); tree planting on the River Gairn in the upper Dee catchment (below)

Completed in 2015, and now widely considered one of the most innovative river restoration initiatives in the United States, the project has improved access to more than 3,000 kilometres of rivers and streams, not just for Atlantic salmon but for a whole variety of native sea-run fish. It has also rebalanced hydropower to maintain pre-project levels of production, plus brought benefits to many other species along the river catchment.

HABITAT RESTORATION

While migration barriers can affect both the amount and quality of habitat available to salmon, they are by no means the only cause of habitat degradation and destruction. Gravel extraction, agricultural activities, road construction, forestry and other land uses can all reduce habitat quality – with often considerable impact on the vulnerable early stages of the salmon's life cycle.

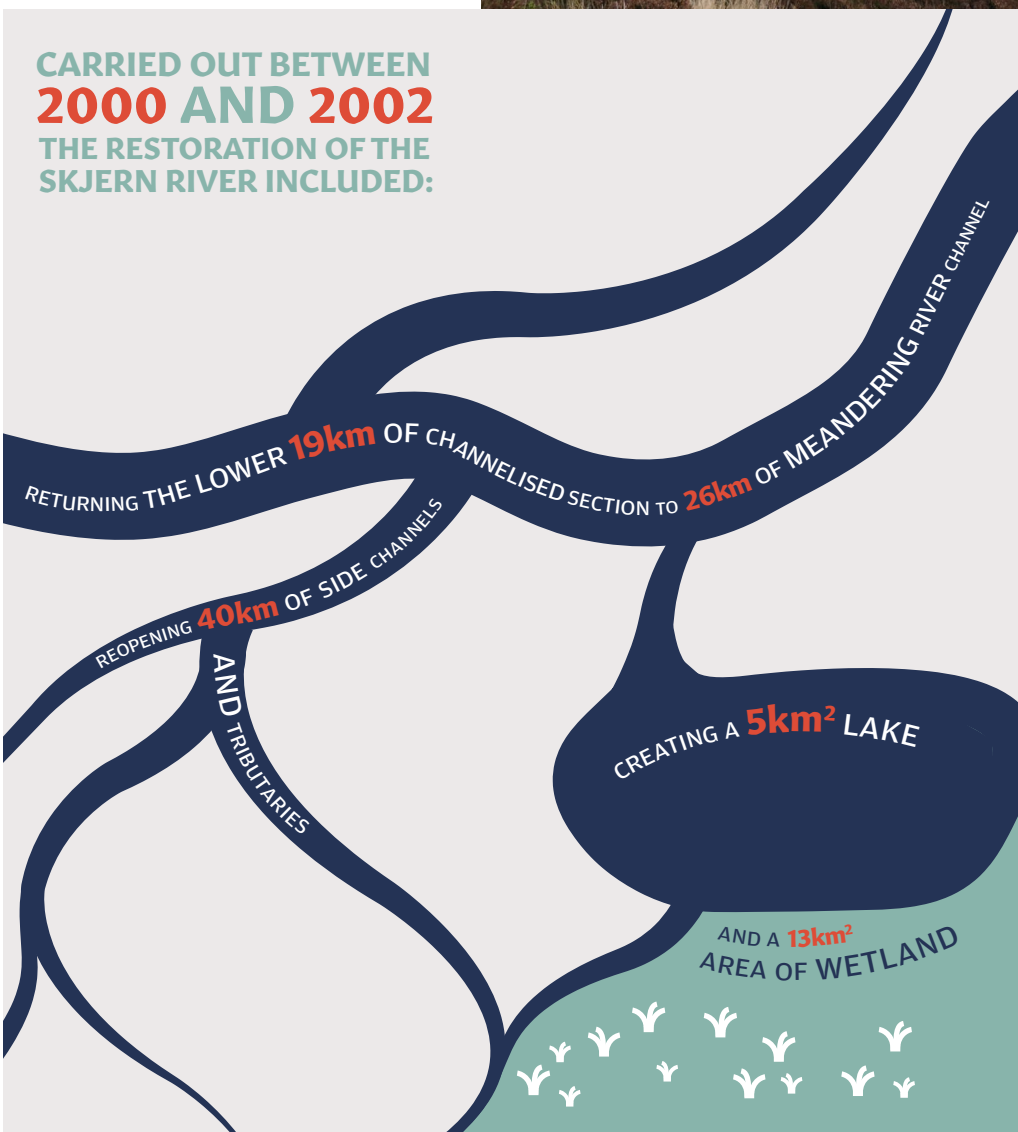
But again, recovery actions can make a big difference – and be relatively straightforward. In response to recommendations from NASCO, the River Dee Trust and Fishery Board in Scotland has undertaken a range of habitat restoration work, including a programme of tree planting in areas of the upper Dee catchment.

Planting trees can help fish in many ways: they provide shade, so lowering water temperatures; stabilise riverbanks and prevent erosion; improve the retention of rain water on land, so reducing flooding; help create new areas of habitat and input nutrients into the water by providing leaf litter and larger woody debris.

The use of large woody debris has become increasingly recognised as an important management tool for speeding up the rehabilitation of degraded watercourses. As part of a recent year-long trial on the River Dee, the Trust has added large tree branches and other woody structures to upper catchment areas in order to create diverse habitat for juvenile fish. The trial has proved so positive that the Trust now plans to add more structures elsewhere on the river system.

Habitat restoration has also taken place on a far grander scale. In Denmark, the lower section of the Skjern River – the country's most important river for Atlantic salmon – is the site of the largest river restoration project in Northern Europe. The work was carried out to reverse the ill-effects of a government initiative to bolster the country's agricultural economy in the late-1960s that involved channelising the main stem of the river and draining its floodplain to create a large area of arable land.

However, disconnecting the Skjern from its floodplain had a variety of unintended negative consequences which resulted in plans to restore the river in the late 1980s. The restoration was finally carried out between 2000 and 2002, with the habitat improvements resulting in a substantial increase in numbers of Atlantic salmon in the river.



WATER QUALITY

Water pollution is widely reported as one of the main causes of the decline in stocks of Atlantic salmon. Some rivers in parts of eastern Nova Scotia and Norway have been so chronically affected by 'acid rain' – rainfall made acidic by atmospheric pollution – that populations of Atlantic salmon have been all but lost.

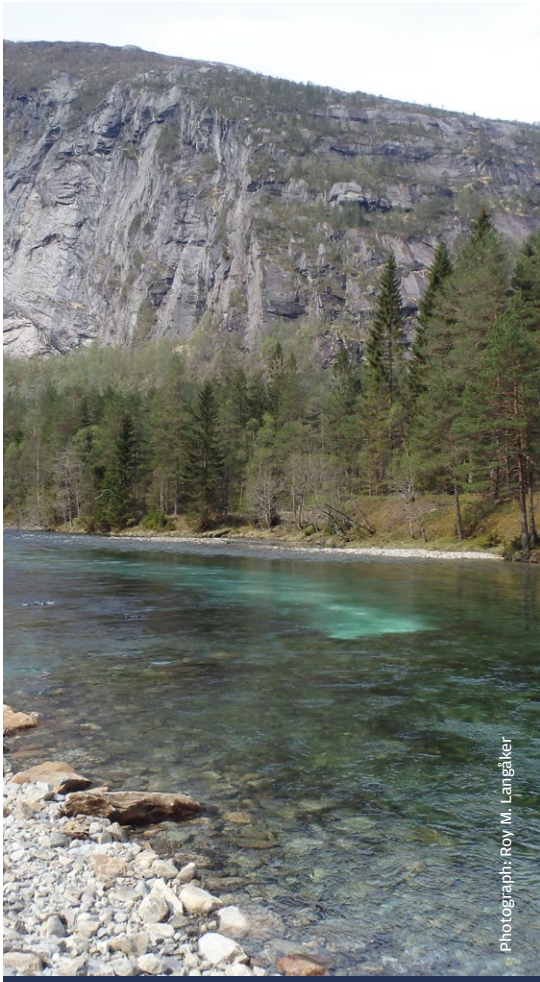
In southern Norway, acidified rivers have been mitigated with lime to help improve water quality and restore fish populations. This direct local action is coupled with European nations making agreements to reduce atmospheric emissions of acidifying compounds.

In Norway, a total of 23 acidified rivers that were virtually without salmon have been successfully restored through the National Liming Programme. Between them, they now support fisheries with a catch in recent years of between 13,000 and 19,000 salmon. Each year, the Norwegian government spends more than €5 million for the liming programme.

Recolonisation of salmon has taken place in a number of these rivers. For example, following liming in 1997, the Mandal River in Agder county recorded its first yearlings of salmon just 12 months later. Today, catches have increased to between 2,100 and 3,700 salmon, although numbers remain far below the yearly catch records of around 10,000 salmon experienced prior to acidification.

Elsewhere, in the north of England, the River Don has seen a step change in water quality over the past 30 years. Once little more than an open sewer, this Yorkshire river has benefited from a multi-million-pound programme of sewage treatment improvements, while industrial pollution is now largely a thing of the past.

As a result, the river has a thriving population of salmon and other freshwater fish and a rich diversity of wildlife. In 2015, a fish survey team found a juvenile salmon in the River Dearne, a tributary of the Don – the first evidence of successful spawning in the river for more than 150 years.



Photograph: Roy M. Langåker

River restoration: limestone powder being dispensed via pipeline into Norway's River Modalselva (above); the liming strategy has a special focus on water quality during the critical period in spring when young salmon change to smolts (below); a clutch of salmon eggs (opposite)

Photograph: Roy M. Langåker

SUSTAINABLE HARVEST

Great strides have also been made in other areas. Overexploitation of salmon stocks was once another major factor in population decline – with the salmon's life cycle adding a further layer of complexity. Given a migration that takes salmon from their rivers of origin to feeding grounds in the sub-Arctic and into the fisheries zones of other countries, reducing overexploitation was a matter that required international co-operation.

Despite some measures relating to distant-water fisheries (when vessels fish well beyond their national waters) being agreed in the 1970s, salmon catches in or near to rivers of origin continued to decline. This prompted calls for an international convention devoted to Atlantic salmon – a forum for countries to co-operate on salmon conservation, restoration, rational management and enhancement.

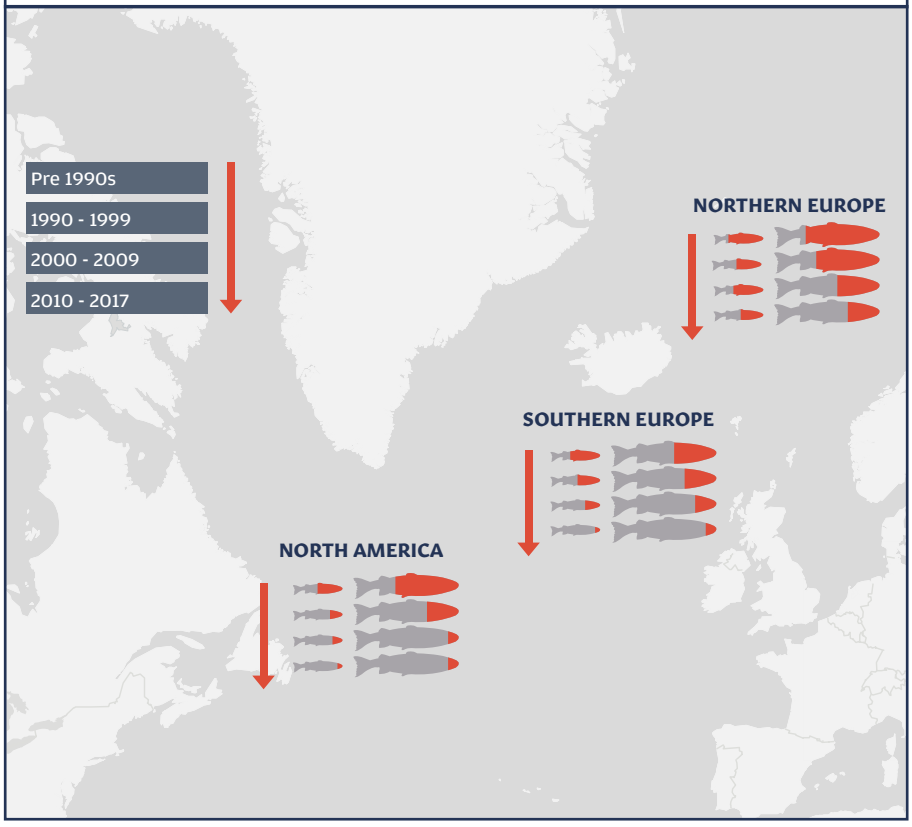
The subsequent formation of NASCO saw the immediate banning of fishing for salmon in most parts of the North Atlantic beyond 12 nautical miles from the coast – a move that created a large protected zone, free of targeted fisheries.

This and other regulatory measures established by NASCO and its contracting Parties greatly reduced harvests of salmon around the North Atlantic (see infographic, Reduced exploitation in the North Atlantic).

Today, Atlantic salmon fisheries are managed to promote and protect diversity and abundance of salmon stocks. Fishing on stocks below their conservation limit should not be permitted. If socio-economic factors override conservation, management actions should limit fishing to ensure stock recovery within a stated timeframe. NASCO and its Parties remain committed to rational management of stocks to support the conservation of the species alongside addressing the many other pressures they face.

REDUCED EXPLOITATION IN THE NORTH ATLANTIC

The big fish in the illustration (below) represent the proportion of multi-sea-winter salmon (salmon that have spent multiple winters at sea before they return to their rivers of origin to spawn). The small fish represent the proportion of one-sea-winter salmon (salmon that have spent only one winter at sea before they return to their rivers of origin to spawn). The red colour shows the different proportions harvested in each time period.



Photograph: Nick Hawkins

Photograph: Sam Levitan/The Freshwater Institute

AQUACULTURE

While fish farming, or aquaculture, has resulted in an abundance of salmon on supermarket shelves, it has not come without cost to wild populations. One impact of salmon farming is that it increases the abundance of sea lice in the marine environment, to the extent that it has a negative impact on wild salmon populations.

And timing can be everything, with salmon particularly vulnerable when they first leave their home rivers and head to sea. In an already challenging marine environment, the additional burden of a sea-lice infestation can greatly reduce the chances of survival. It is also recognised that large numbers of domesticated salmon escape from fish farms each year, with escapees observed in rivers in all regions where salmon farming occurs. For wild salmon, this causes increased competition for resources and may result in a wild fish spawning with a farmed one, compromising the genetic 'fitness' of wild populations. The latter is important because salmon populations need good genetic diversity to ensure that they are as resilient as possible to any future pressures they may experience.

So, what to do? Careful siting of fish farms away from wild salmon migration routes, state-of-the-art containment at sea, use of sterile fish, sea lice and disease management systems can all help. A further option is the development of closed-containment salmon production systems at sea or on land as an alternative method of fish farming. Such a system of aquaculture would give fish farmers complete control of the rearing environment and minimise the environmental impact of their activities on wild fish.

It is just this kind of innovative thinking, together with a range of ongoing restoration and recovery efforts, that can make a real difference to a species that needs all the support it can get.

OUR CHANGING CLIMATE

Climate change is perhaps the most complex, and far-reaching, challenge of all for wild Atlantic salmon. Although the mechanisms are not entirely understood, it is highly likely that climate change is a major factor in decreased survival of salmon at sea.

The increase in mortality at sea may be a result of altered marine conditions, with salmon prey items no longer available, as abundant, or as nutrient rich as they once were.

Worryingly, the hand of climate change is also now reaching further inland. Increases in water temperature and fluctuating levels of rainfall are predicted to impact all elements of global river systems, with just one likely outcome for Atlantic salmon: loss of habitat and increased mortality in freshwater environments.

But while it is tempting to feel powerless when faced with something so all-encompassing as climate change, restorative action can still make a positive difference. In Canada, the Department of Fisheries and Oceans has conducted Recovery Potential Assessments that provide scientific information and advice on population viability, recovery potential, plus information on threats to persistence and recovery.

Such detailed assessments are hugely valuable in determining the extinction risk, and recovery potential, of salmon populations under different environmental scenarios. This, in turn, allows pre-project analysis of the most likely outcomes of recovery and restoration actions, with efforts directed to where populations are most vulnerable, or where success is most realistic.

Additionally, habitats that are expected to be the most climate-resilient can be identified and efforts made to remove barriers that delay or prevent Atlantic salmon from accessing them, while also working to protect or restore the quality of these habitats.

Photograph: Nick Hawkins

Creative thinking: The Freshwater Institute in the United States – a programme of The Conservation Fund – has worked with the Atlantic Salmon Federation on land-based, closed-containment aquaculture solutions (left); climate change is predicted to impact all elements of global river systems (right)

MAINTAINING TRADITION

Peter Walsh reflects on his experience of a centuries-old form of salmon fishing that he hopes will make a return to Irish rivers.

Photography: Patrick Browne

SNAP NET FISHING is a historic type of salmon fishing, believed to be over 1,000 years old. This fishing method is thought to have begun on the Barrow, Nore and Suir estuaries in Ireland around the twelfth century when the Normans came to the area from Wales.

Totally dependent on tide, snap net fishing uses a short net, about 10 m in length, stretched between two cots (small boats). The snap net fishes on the river bed and when a salmon hits the net, the fishers in each cot 'snap' the net shut to trap the fish.

Salmon are not meshed in a snap net, so it is a highly skilled fishing technique. Today, the only other location where snap net fishing takes place is in Wales where salmon and sea trout are targeted.

I began snap net fishing in 1959 when salmon were much more abundant than they are now. The largest salmon I have heard of being taken in a snap net was 56 lbs in the 1890s.

Today, I'm one of just a trio of men left on the Barrow, Nore and Suir who can make the traditional cot used for snap net fishing. The construction is based on the same centuries-old design. Originally, a cot was a dug-out boat but was later built of larch planks.

Meanwhile, the ropes used for snap net fishing were originally made of horse tail hair and were spun by hand. Unsurprisingly, the ropes rotted after each season and had to be re-made every year.

According to local folklore, not a single person from the area died during the great famine of the 1840s thanks to their ability to capture salmon from the Suir using snap nets. Soon afterwards, and armed with the necessary boat and fishing skills, many snap net fishers emigrated to Newfoundland to fish for cod.

For conservation reasons, snap net fishing has not taken place on the Suir since 2013. However, with signs of stock recovery in recent years – the river reached its conservation limit for the 2019 season with a small surplus – I'm optimistic that a small snap net fishery can begin again on the Suir for future generations.

Now a historic heritage fishery rather than a commercial enterprise, it is critically important that the tradition and skills associated with this type of fishing are not lost.

ABOUT THE AUTHOR

Peter Walsh is a traditional snap net fisher based in Co. Kilkenny, Ireland.

Standing proud: Peter Walsh snap net fishing together with a friend on the River Suir, Ireland

MEMORIES OF THE RHINE

Jörg Schneider explores the cultural and economic significance of the extinct Rhine salmon.

FIRST RECOGNISED as an important river for salmon in Roman times, for centuries the Rhine has supplied the people who lived along it with an abundance of fish – with salmon both a main commercial catch and a staple food. As late as the 18th century, a river referred to with reverence as 'Father Rhine' was thought to hold a population of several million returning adults per year.

Fishing methods varied greatly. In large rivers, salmon were fished both from the shore and from boats using salmon forks and towed nets. At some weirs, the leaping salmon were caught with landing nets, while at the spawning grounds themselves, they were captured with traps, nets, spears, pitchforks and clubs.

Large, shore-operated lift nets, known as 'woogs', were particularly productive. From the 14th century, these salmon traps were controlled mostly by nobles or the church and were leased to fishers, often at great expense, as salmon became an increasingly coveted commodity.

However, through a combination of poor water quality, overfishing, habitat degradation and an increasing number of obstacles, a significant decline in salmon numbers was noted as early as the 19th century. Extensive stocking measures and an international salmon treaty in 1886 could not prevent the collapse of Europe's largest salmon stock. By the 1960s, salmon had disappeared from the Rhine altogether.

One man who remembers well the importance of salmon to the local community is Manfred Ruckschatt.

Now aged 76, he is one of the last contemporary witnesses of salmon fishing in the lower Moselle region of Germany. He even keeps a few souvenir photos from those times.

As a young boy in the late-1940s, Manfred took part in salmon fishing on the Elzbach, a minor tributary of the Moselle which feeds into the Rhine at Koblenz. 'When the salmon returned in November, we would be sent out to walk along the creek to look for them in the deep pools,' he recalls. 'When we saw the salmon, the fishing tenant was notified. Then the spectacle began.'

As Manfred explains, the stream was closed off above and below where the salmon lay using nets attached to willow sticks. The salmon were then caught by local men with nets – with the fish often driven out of their shelters with poles.

Waiting on the shore with large containers was the master fish farmer. 'The salmon were collected in the containers and spawned on the spot,' explains Manfred. 'Only then were they slaughtered. The eggs were taken to the fish farm where they were hatched and reared for stocking the following spring.'

The salmon belonged to the fishing tenant, and only the catchers got a cut. It is perhaps no surprise then that Ferdinand Perscheid, an 86-year-old neighbour of Manfred's, adds: 'Some salmon were also poached once in a while.'

Not long after, in 1951, the closure of the Moselle barrage at Koblenz saw the river effectively blocked to salmon. 'It was all over then,' explains Manfred. 'Many fish species suffered, not just salmon.'

Fast forward almost 70 years and salmon are now being reintroduced, with young salmon hatched in the creek already swimming in the river in front of Manfred's house. 'It is something that pleases all of us older residents who remember salmon being here,' he says.

ABOUT THE AUTHOR

Dr Jörg Schneider is a Senior Chief at BFS (Office for Fisheries and Freshwater Studies), Frankfurt.

Past and present (from top): Manfred with his souvenir album; some wonderful vintage images of salmon caught on local rivers; Manfred shows author Jörg Schneider the river where salmon have now returned


Photograph: James Hawkes/NOAA Fisheries Service, USA


Photograph: Rory Saunders/NOAA Fisheries Service, USA

Sea change: ready for sampling (top); a sampling station in Greenland (above); unloading a catch on the quayside (below)

TAKING STOCK

Tim Sheehan outlines the work of a long-running international sampling programme in West Greenland.

THE WATERS OFF the west coast of Greenland are home to an important mixed-stock Atlantic salmon fishery. The salmon are of North American and European origin; most are one-sea-winter salmon – having spent one winter at sea – and are destined to return to their rivers of origin as two-sea-winter spawning adults.

Atlantic salmon were first officially documented off the coast of Greenland in 1780, although anecdotal records have them there prior. Fishing for salmon has evolved from animal tendon fabricated lines with bone hooks to today's local inshore gill net fishery.

During the 1960s, the fishery became international, with vessels from Norway, Denmark, Sweden and the Faroe Islands participating in the offshore mixed-stock drift gill net fishery.

At the height of the fishery in 1971, around 2,700 tonnes of salmon were harvested. Due to concerns that this fishery was having a negative impact on contributing stocks, a quota system was agreed and implemented in 1976. Since 1984, the setting of catch regulations has been facilitated by discussions at NASCO.

An international sampling programme for the fishery has been in place since the late 1960s. Generally speaking, the sampling methodologies have varied over time as the fishery evolved: samples were collected from research vessels using commercial gill nets during the 1970s; from commercial fish processing factories during the 1980s and '90s; and from local markets, vendors, and factories when landings were permitted since 2002.

The programme has been supported to varying degrees by numerous countries and institutions with vested interests from across the North Atlantic.

For each sampled salmon, length / weight data and scale samples are collected to determine the age and life history (e.g. years spent in fresh water and at sea, continent of origin etc.).

Salmon are also scanned for fin clips or tags, which would identify their exact origin. Starting in the late 1990s, fin-tissue samples have also been collected to support genetic-based stock identification.

This is crucial work. For effective management of this fishery, annual landings data, biological characteristics data, and origin information are all needed to accurately assess the impact of the fishery on contributing stocks.

The International Council for the Exploration of the Sea uses the data collected by this programme in their assessment models to predict pre-fishery abundance of North American and European stocks. This information is then used to provide NASCO with catch options to inform negotiations for harvest regulations.

Results from long-term sampling programmes like this also provide a metre stick by which researchers can measure, compare and contrast population trends and dynamics. Continued data and sample collection will continue the five-decade-long time series and may provide yet unknown benefits as new sample processing approaches and techniques are developed. This time series can also support studies to retrospectively assess the impacts of a changing climate on Atlantic salmon to then forecast the impacts based on future climate scenarios.

This vitally important work would not be possible without the support of the fishers of Greenland who provide access to their fish.

ABOUT THE AUTHOR

Tim Sheehan is Research Fisheries Biologist at NOAA Fisheries Service, which co-ordinates the Greenland sampling programme. His organization is based in Woods Hole, Massachusetts, USA.


Photograph: Denise Deschamps/Ministère des Forêts, de la Faune et des Parcs, Canada

SHARING THE GIFT OF SALMON

Martin Lee Mueller and Aage Solbakk explore the deep cultural connections between indigenous peoples and salmon.

SINCE TIME IMMEMORIAL, the warm waters of earth's equatorial belt have formed a boundary that no Atlantic or Pacific salmon ever cross. These cold-loving fish represent a decidedly northern expression of life, with their migration drawing coastal and river peoples across the Northern Hemisphere into experiences of wonder, awe and gratitude.

From the West Pacific's volcanic islands to the dark-blue rivers that branch through Russia's taiga, from Scandinavia's great Arctic streams to the foothills of the Alps, and from the storm-beaten Newfoundland coast to Pacific America's temperate rainforests, inquisitive humans everywhere bore witness to, and celebrated, the annual return of the fish as the world rejuvenating itself as gift.

For millennia, indigenous cultures have lived attentively alongside salmon, each crafting their unique responses to the experience of living in the gift. The Sámi word bivdit describes the strangely reciprocal ties between fisher and fish; it means 'to fish', but also to entreat the fish to give themselves.

To the Sámi, the fish are not an 'It' as much as a 'Thou' – a sentient being that must be treated with respect.

Salmon have long been celebrated in yoik, a traditional form of song in Sámi music. A recreation of a song that first appeared in a book by Otto Donner in 1876, the following yoik text is a testimony to the importance of salmon in the Tana Valley – a core area of Sámi river culture in Finnmark (northern Norway):

'The Salmon, that strong and precious fish
swimming along the bottom.

It will follow the Tana River through the earth
if that is the course to follow.

Once again, it swims the long way to reach the source,
turns black and stops eating.

Once again, it turns back to where it came from,
to the great ocean where salmon abound.

Once again, it glistens in the water when it returns to its own seas.

There it will find herring to feed on, grow fat again,
and again look like its old self.'

Along the Tana River – the longest salmon-rich watercourse in Europe – salmon fishing and Sámi culture have become so closely interwoven that it is embedded in a wide range of spiritual and material aspects of daily life. In various ways, the connection is revealed in the Sámi terms for salmon: at sacred sites, or sieidier, where sacrifices were made for good luck at fishing, and in legends about the importance of salmon fishing along the river.

As widely unique and place-specific as indigenous salmon peoples are on both sides of the North Atlantic, we dare say that they all share an alertness to the ways in which salmon not only feed the flesh of our bodies, and of so many other non-human lives, but also feed the flesh of the mind – the landscape of the imagination. They are united in having carried the salmon's original gift into story, ritual, technologies of participation (rather than extraction), as well as a moral universe honouring interbeing.

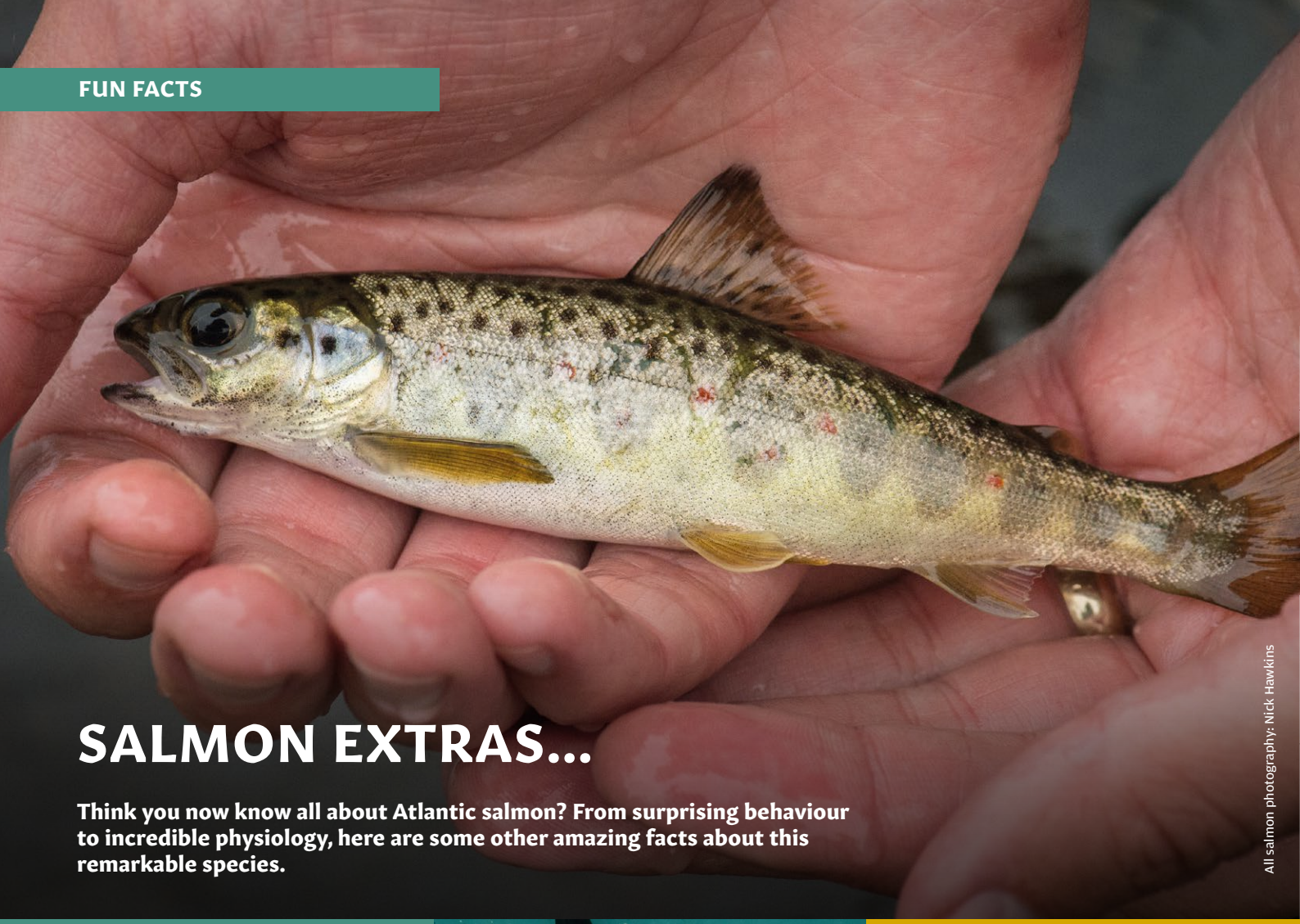
And for as long as salmon are granted the chance to journey out to sea, and to return, they will ask us humans to join the reciprocal dance of becoming through the gift and through sharing.

ABOUT THE AUTHORS

Martin Lee Mueller is a philosopher, writer and storyteller based in Oslo. Aage Solbakk is a historian and Sámi fisher from Finnmark.

Photography: Anders Foldvik

As it always was: traditional salmon fishing on the Tana River using a drift net (left) and weir net (below)



All salmon photography: Nick Hawkins

SALMON EXTRAS...

Think you now know all about Atlantic salmon? From surprising behaviour to incredible physiology, here are some other amazing facts about this remarkable species.

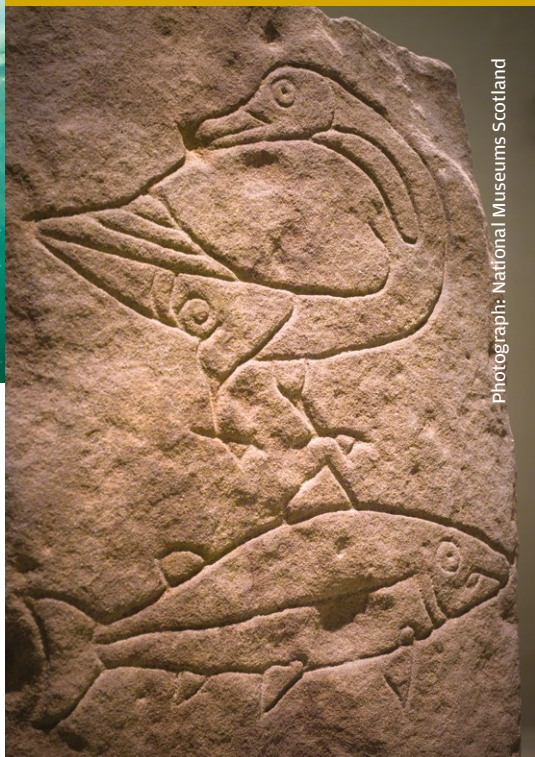
AN ATLANTIC SALMON'S SENSE OF SMELL IS ESTIMATED TO BE

1,000

TIMES GREATER THAN THAT OF A DOG

JUST PRIOR TO SPAWNING, ADULT MALES BECOME VERY COLOURFUL IN ORDER TO ATTRACT A FEMALE

ONCE SALMON BEGIN THEIR MIGRATION BACK UPSTREAM TO SPAWN, THEY DO NOT EAT AND LIVE INSTEAD OFF THEIR BODY FAT



Photograph: National Museums Scotland

CARVED IN STONE >

Atlantic salmon have been celebrated in all sorts of ways, including Pictish rock carvings found in Scotland. To the ancient Picts, and hunter-gatherers before them, the salmon was revered as a kind of god.

SOME SALMON STOCKS – REFERRED TO AS 'LANDLOCKED' SALMON – SPEND THEIR WHOLE LIVES IN FRESH WATER, SOME MIGRATING TO FRESHWATER LAKES RATHER THAN OUT TO SEA

SOME MALE PARR (USUALLY JUVENILE SALMON) MATURE EARLY AND ARE THEN REFERRED TO AS 'SNEAKER' OR 'PRECOCIOUS' MALES BECAUSE OF THE WAY THEY SNEAK UP TO SPAWNING ADULTS AND DART OVER REDD SITES TO FERTILISE EGGS

The word salmon translates into many different languages and scripts...

Kalaallisut (Greenlandic) **KAPISILLIT**

Icelandic **LAX**

Faroese **LAKSUR**

Sámi **LUOSSA DIDDI** (small salmon)

Norwegian **LAKS**

Finnish **LOHI**

Russian **Лосось**

Scottish (Gaelic) **BRADAN**

Swedish **LAX**

Estonian **LÕHE**

Latvian **LASIS**

Lithuanian **LAŠIŠA**

Danish **LAKS**

English **SALMON**

Irish (Gaelic) **BRADÁN**

Welsh **EOG**

Dutch **ZALM**

German **LACHS**

Polish **ŁOSOŚ**

Czech **LOSOS**

Hungarian **LAZAC**

French **SAUMON**

Basque **IZOKIN ARRUNTA**

Italian **SALMONE**

Spanish (Castilian) **SALMÓN**

Portuguese **SALMÃO**

Greek **Σολομός**

Labrador Inuit **KAVISILIK**

Innu **UTSHASHUMEK**

Cree **MISIWÂPAMEK** **SÔSÂSIW MISTAMEK**

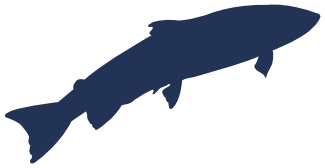
Mi'kmaq **PLAMU**

Passamaquoddy-Maliseet **POLAM**

Penobscot **SKʷÀMEKʷ**

AN ADULT TERRITORIAL MALE WILL AGGRESSIVELY DEFEND A POTENTIAL REDD SITE AGAINST OTHER MALES – OFTEN KILLING SNEAKER MALES IN THE PROCESS

Photograph: Jason Henry (Marine Scotland)/Sean Dugan (Fisheries Management Scotland)



SALMON HAVE BEEN KNOWN TO LEAP ALMOST AS HIGH AS FOUR METRES TO NEGOTIATE OBSTACLES WHEN RETURNING TO SPAWNING GROUNDS

THE HEAVIEST ATLANTIC SALMON RECORDED WEIGHED IN AT A SERIOUSLY HEFTY 45 KG (ALMOST 100 LBS)

TALE OF THE SCALE

It is possible to determine the age of a salmon from the widely-spaced rings on individual scales, much like ageing a tree using its growth rings. The scale shown here is from a sampling programme run by the International Council for the Exploration of the Sea.

Cover Photography: Nick Hawkins

North Atlantic Salmon Conservation Organization
Organisation pour la Conservation du Saumon de l'Atlantique Nord
11 Rutland Square
Edinburgh EH1 2AS
UK

Tel: Int +44 131 228 2551
hq@nasco.int
www.nasco.int

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