International Atlantic Salmon Research Board

SAG(18)02rev

Inventory of Research Relating to Salmon Mortality in the Sea

(Revised 31 July 2018)

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1. The International Atlantic Salmon Research Board's inventory of research relating to salmon mortality in the sea was established in 2002 and has been updated annually since then. It is a valuable tool in the development of research priorities for potential funding and in better coordinating existing research efforts. It had previously been noted that greater use could be made of the inventory and in both 2009 (SAG(09)10) and 2013 (SAG(13)2) a Sub-Group established by the Board's Scientific Advisory Group (SAG) had reviewed the inventory. The Board had agreed that the inventory should continue to be reviewed every 3 or 4 years. If this schedule continued to be followed then the next review of the inventory would be due in 2017. However, the SAG noted that one of the purposes of the review is to identify research needs and it recognised that the Board has agreed that its current priority is to partition mortality of salmon along their migration routes through telemetry studies (SALSEA - Track). The SAG also considered that it might be appropriate to wait until after the IYS to conduct the next review of the inventory. The Board that the the next review of the Updated Inventory of Marine Research should be postponed until 2019 or 2020.

2. The updated inventory for 2018 is attached. The Board had agreed that the summary table of ongoing and completed projects should be made available in Excel format and the 2018 inventory has again been presented in this way. Table 1 provides details of expenditure on ongoing research by topic area for each Party. The total annual expenditure on the 62 ongoing projects (5 of which are uncosted) is approximately £8.5 million. Approximately 47% of the expenditure is associated with long-term monitoring programmes.

3. In Table 2, ongoing and completed projects are listed accordingly to the five research topic areas agreed by the Board on the basis of the main focus of the research, although some projects could have been allocated to a number of these research areas.

4. In Table 3 the projects have been allocated to the relevant work package in the SALSEA Programme. The SAG considered that this presentation continued to be informative and should be retained. Table 4 provides summary information on both the ongoing (62) and completed (86) projects. Full details of these projects are contained in Annex 1.

5. In 2014, the Board adopted a Resolution, ICR(14)6 encouraging collaborative telemetry projects in order to partition marine mortality of Atlantic salmon along their migration routes. The current inventory includes 22 ongoing, and 20 completed projects related to the migratory behaviour of individual fish and these are listed under section 2(b) of Table 2. Nine new projects have been included in the inventory since its last update, some of which have been ongoing for some time and one of which is completed. The new projects are as follows:

Canada

C35: Atlantic Salmon Research Joint Venture – Life History Modelling Project for Wild Atlantic salmon

Objectives: to develop a stochastic, dynamic life history model that can be used to further explore the factors affecting the survival of Atlantic salmon. The work will involve, but not be limited to, analyses of per capita population growth, life-history elasticity, model sensitivity, and patterns of density dependence (including Allee effects) at different spatio-temporal scales. The model parameters will be based on a review of data throughout the geographic range of the species, updating one undertaken in 1998. The over-arching goal of the project is to apply the model to address fundamental questions pertaining to population viability of Atlantic salmon.

C36: Atlantic Salmon Research Joint Venture – Atlantic Salmon Post-smolt Trawl and Troll Survey in the Strait of Belle Isle

Objectives: determine the feasibility of capturing Atlantic salmon post-smolts (unharmed) as they migrate through the Strait of Belle Isle (SoBI); record presence of other fish species (predator and prey) at SoBI at the same time post-smolts are passing through; lethally sample a subset (N=100) post-smolts for fish health, growth (scales, otoliths), genetic analysis (population structure and sex), and stomach contents.

C37: Atlantic Salmon Research Joint Venture – Current status of knowledge, data, and research efforts on Atlantic salmon at Greenland: what do we have, what do we need, and what should we do moving forward?

Objectives: review historical/current state of knowledge (literature review and data inventory) of Atlantic salmon at the summer feeding area off the coast of West Greenland; review current research efforts on Atlantic salmon at the summer feeding area off the coast of West Greenland; compile future data needs and gaps; review inventory of archived databases (sampling database, genetic assignment database, etc.) and samples (scales, tissue, etc.) available from Atlantic salmon collected at the summer feeding area of the coast of West Greenland; develop recommendations for improving future fishery sampling efforts; develop short list of research themes/projects to address future data needs and gaps; develop protocols for providing access to database(s) and archived samples for collaborating researchers; develop a guide for interpreting the sampling database that considers the non-random sampling conducted in some years.

C38: Atlantic Salmon Research Joint Venture – Development of Acoustic Tracking Capabilities for Drifter Buoys

Objectives: support the scientific community's work acoustic telemetry work following the movements and survival of Atlantic salmon in the Northwest Atlantic Ocean by conducting the engineering and integration work needed to couple a Vemco VR2C underwater, cabled acoustic receiver to the MetOcean SVP drifting buoy; design the prototype so that it becomes a low-cost, add-on option (target < £ 3 K per unit) to the purchase price of the MetOcean buoy (current cost £3 K), enabling NASCO members *and other partners to contribute to high seas research of Atlantic salmon through modest, incremental contributions to the purchase prices of meteorological buoys which national authorities intend to buy and launch annually; build, test, and refine a prototype of the buoy.*

European Union - Denmark

De6: Salmon Rehabilitation Plan: monitoring numbers of spawners, spawning and nursery areas in four Atlantic salmon rivers and the achievement of the objective of self-reproduction.

Objectives: The Danish national salmon rehabilitation plan describes four rivers with natural wild salmon populations. Collected fry from River Skjern Å 2008 and 2009, and juveniles from Ribe Å and Varde Å collected during the last decade, have been analyzed by 20-25 microsatellites to identify the number of families at each spawning site. A large number of juveniles and many families would indicate proper functioning of spawning and nursery areas for many spawning fish while getting few families will indicate too scarce spawning fish and / or poor conditions in much of the spawning area. The results will be compared with ecological and environmental indicators to determine which of the described hypotheses are the most likely for the specific spawning areas. In this way the effect of the rehabilitation plan and the development of the populations is assessed (the goal is at least 1,000 spawners in each river to fulfill the plan). This study will allow estimates of marine mortality of salmon to be made.

De7: SMOLTRACK

Objectives: Marine mortality of salmon has long been acknowledged to play an important population regulating role. Marine mortality is usually defined as any mortality occurring from a smolt leaves the river until it returns as an adult spawner. Understanding the factors responsible for marine mortality is a tremendous task and will require different approaches adjusted to the specific areas and fish life stage investigated. There is evidence that the initial mortality in post-smolts moving into saltwater is very high (due to predation) and that this "point mortality" may explain most of the variation seen in return rates. Estuarine and near shore mortality may also be the part of the marine life cycle where management measures have the greatest chance of success. Hence, this project will explore the mortality of smolts and post-smolts during their migration through the lower rivers, estuaries/fiords and near-shore areas. It specifically addresses SALSEA-track priorities specified in the NASCO-IASRB Workshop on Telemetry report (recommendation SRBTW(14)7). Acoustic telemetry with wild salmon smolts is used to investigate and directly measure the mortality during the first days-to-weeks after leaving the river. Additionally, the project aims to act as a platform for EU-wide salmonid telemetry knowledge (facilitate the sharing of international best practice to EU members)/data/projects/bulk purchasers of technology, with the goal to establish an EU strategic salmon telemetry advisory group.

European Union – UK (England and Wales)

Ew19: Salmonid Management Round the Channel project (SAMARCH)

Objectives: SAMARCH 2017 –2022 will provide new transferable scientific evidence to inform the management of salmon and sea trout (salmonids) in the estuaries and coastal waters of both the French and English sides of the Channel. It will provide new information to further improve the models used in England and France to manage their salmonid stocks.

European Union – UK (Northern Ireland)

Ni5: The marine survival of Atlantic salmon from the River Bush, Northern Ireland

Objective: Investigate factors influencing the survival at sea of salmon smolts migrating from the River Bush until their return as adult salmon

Norway

N22: *ATLANTIC SALMON AT SEA - factors affecting their growth and survival (SeaSalar)*

Objectives: Examine sources of temporal and spatial variation in the survival of Atlantic salmon at sea, and establish a long-term inter-institutional collaboration platform, as a hub for present and future projects with strengthened collaborative use of data.

Table 1: Approximate Annual Expenditure on Ongoing Research Projects in Relation to Salmon Mortality at Sea by Topic Area and Party

	Canada	Denmark (Faroe Islands and Greenland)	European Union	Norway	Russian Federation	United States of America	France (in respect of St Pierre and Miquelon)	**Totals by Topic Area**
Long-term monitoring	£651,000 3	-	£2,286,800 13	£959,000 2	£60,000 1	-		**£3,973,800 20**
Distribution / Migration in the sea	£941,500 10(3)	£118,000 1	£1,393,000 7	£218,000 2(1)	-	£108,000 6	- 1(1)	**£2,778,500 27(4)**
Life history/ biological processes	£40,000 1	-	£126,000 4(1)	-	-	£115,000 2	-	**£281,000 7**
Development of methods	£152,000 2	-	-	-	-	-	-	**152,000 2**
Specific natural and anthropogenic factors	£590,000 1	-	£617,000 4	£75,000 1	-	£50,000 1	-	**£1,332,000 7**
Totals by Party	**£2,374,500 17(3)**	**£118,000 1**	**£4,422,800 28(1)**	**£1,252,000 5**	**£60,000 1**	**£273,000 9**	**- 1(1)**	**£8,517,300 63(5)**

The figures shown are in pounds sterling. The number of ongoing projects is shown below the expenditure figure, with the number of uncosted projects shown in parentheses. The costs have been allocated on the basis of the NASCO Party coordinating the research project. However, in many cases the projects involve collaboration with other Parties or with NGO partners who may have made financial contributions to the projects (some details of these contributions have been provided and are given in Annex 1).

Table 2: Allocation of ongoing and completed projects by topic area

Topic Area	**Objective/Issue**	**Comments/examples**	**Ongoing Projects**	**Completed Projects**	**Potential for cooperation among Parties**	**Priority for access to 'Fund'**
1. Long-term monitoring	a. Time-series of marine survival/growth estimates	Essential on-going tagging/monitoring programmes; require long-term national funding.	C17, C26, De3, Fi1, Fr2, Ir8, Ir15, Ir17, Sw1, Ew11, Ni2, Ni5, Sc3, N14, N22, R2	U6	Medium	Low
	b. Time series of marine survival in relation to environmental parameters (e.g. SST)	Desk studies on time series.	C37, Fi3, Sc4	E1, E3, Ir2, Ni1, N2, N6, U11	Medium	Medium
2. Distribution / migration in the sea	a. Distribution of salmon in the sea	Marine surveys of post-smolt distributions in NEAC and NAC areas; identification of fish caught (e.g. tagging, genetics).		C2, C6, C15, E2, N8, U7	High	High
	b. Migratory behaviour of individual fish	Active smolt tracking; automated data collection by DSTs.	C16, C18, C25, C27, C29, C30, C31, C32, C33, De4, De5, De7, Ir12, Ir13, Ir14, Ni4, N18, U4, U5, U10, U13, U16	C1, C3, C4, C5, C10, C11, C12, C20, C22, C23, De1, De2, Ir5, Ir9, Ew1, Ni3, N5, N12, N15, U3	High	High
	c. Origin of catches in directed fisheries	Catch sampling in distant water fisheries; genetic analysis and scale analysis, etc; changes over time.	C24, D1, N21, U9, F1	C9, C13, C14, C21, Fi2, Fr3, Ir6, Ew6, Ew10, Ew18, Sc5, Sc7, Sc8, N11, N17, N19, R3		Low
	d. Migration and bioenergetic models	Desk studies based on data obtained from other studies.		Ew4, U1	Medium	Medium
	e. By-catches in pelagic fisheries	Can be conducted as part of marine surveys of post-smolt distributions; sample commercial pelagic catches.		N3, R1	High	High
3. Life history/biological processes	a. Freshwater factors	Age, growth, migration timing, etc.	De6,	Fr1, Ew8, Ew13, Ew15	Low	Low
	b. Pre-fishery recruitment marine factors	Environment, food, predation, growth, parasites and diseases, etc.	C35, Ew19, Ir10, U14	Ew9, N7, U12	High	High
	c. Post-fishery recruitment marine factors	Environment, food, predation, maturation processes, growth, etc.	C35, Ew19, Sc6, U17	C8, C19, C28, Ew12, N1, U2	High	High
4. Development of methods	a. Post-smolt survey methods	Development of trawls with cameras, tag detection, etc.	C36, C38	Ir4, Sc1	Medium	Medium
	b. Electronic tag technology	Development of smaller/smarter/cheaper tags.			Medium	High
5. Specific natural and anthropogenic factors	a. Fish farms	Increased sea lice infestations.	Ir11, Ir16, N13,	Ir1, Ir3, Ir7, Ew3, N4, N9, N10, N16, N20	Low	Low
	b. Predation	Predation by seals, birds, fish, etc. in estuaries/coastal areas.	U15	Sc2, U8	Low	Low
	c. Obstructions to fish movements	Barrages, etc.	Ew16	Ew5	Low	Low
	d. Pollutants	Acidification; freshwater contaminants.	C34, Ew17	C7, Ew2, Ew7, Ew14	Low	Low

Note: The priorities of low, medium and high assigned to the topic areas in this table are those currently considered appropriate for international cooperation and funding. The Board will keep them under review. They are not intended to reflect overall importance of these topics.

Table 3: Ongoing and completed projects in the inventory of research allocated to SALSEA programme work packages

SALSEA Work Packages	Ongoing Projects	Completed Projects
Work Package 1: Supporting Technologies		
Task 1: Genetic tagging to determine stock origin	C24, D1, Fi3, N21, U9, F1	C9, C13, C14, C21, Fi2, Fr3, Ir6, Ew6, Ew10, Ew18, Sc5, Sc7, Sc8, N11, N17, N19, R3
Task 2: Sampling equipment evolution	-	-
Task 3: Signals from scales	Ir17, Sc4, U17	C8, C19, C28, Ew12, N1, U2
Work Package 2: Early Migration through the Inshore Zone: fresh waters, estuaries and coastal waters		
Task 1: Investigate the influence of biological characteristics of Atlantic salmon smolts on their marine mortality	C17, C26, C35, De3, De6, De7, Fi1, Fr2, Ir8, Ir15, Sw1, Ew11, Ew19, Ni2, Ni5, Sc3, N14, R2	Ir2, U6
Task 3: The impacts of physical factors in fresh water on marine mortality of Atlantic salmon	Ew16	Fr1, Ew5, Ew8, Ew9, Ew13, Ew15
Task 3: Preparing to migrate – investigate the influence of freshwater contaminants on the marine survival of Atlantic salmon	C34, Ew17	C7, Ew2, Ew7, Ew14
Task 4: The part played by key predators	U15	Sc2, U8, U12
Task 5: The impact of aquaculture on mortality of salmon	Ir11, Ir16, N13	Ir1, Ir3, Ir7, Ew3, N4, N9, N10, N16, N20
Work Package 3: Investigating the distribution and migration of salmon at sea		
Task 1: Distribution and migration mechanisms – develop theoretical migration models	-	Ew4, N2, U1
Task 2: A common approach – refine the plans for a large-scale marine survey	-	-
Task 3: Salmon at sea – carry out a comprehensive survey - marine surveys	-	C2, C6, C15, E2, N7, N8, U7
- acoustic tagging surveys	C16, C18, C25, C27, C29, C30, C31, C32, C33, De4, De5, Ir12, Ir13, Ir14, Ni4, N18, U4, U5, U13, U16	C1, C3, C4, C5, C10, C11, C12, C20, C22, C23, De1, De2, Ir5, Ir9, Ew1, Ni3, N5, N12, N15, U3
- data storage tags	U10	-
- others	Ir10, Sc6, U14	N3, N6, R1, U11
Task 4: Distribution and migration – analyse and collate data	N22	-
Appendix 1: Supporting technologies, further development of which will support the SALSEA programme		
1. Novel trawl sampling technologies	C36	Ir4, Sc1
2. Data storage tags	-	-
3. Coded wire tagging	-	-
4. Sonic tags and sonic detector arrays	C38	-

Table 4: Summary of ongoing and completed research projects relating to salmon mortality in the sea

Jurisdiction	Project No	Title	Status	Summary of Objectives	Research Dates	Topic Area	Objective/Issue	Area of Research	Collaborating Countries	Coordinating Scientist	Annual Expenditure
Canada	C1	Marine migration and survival of post-smolt Atlantic salmon from Bay of Fundy rivers	Completed	Provide knowledge about marine habitat (migration routes and feeding grounds) used by salmon post-smolts from Bay of Fundy rivers. Determine the location, timing and extent of salmon post-smolt mortality at sea. Investigate the causes and mechanisms of marine mortality of salmon post-smolts. Provide information to fuel the recovery programme for inner Bay of Fundy salmon stocks.	2001 - 2003	Distribution/ migration in the sea	Migratory behaviour of individual fish	Bay of Fundy and Gulf of Maine	USA	Gilles L Lacroix	
Canada	C2	Distribution, health and condition of Atlantic salmon from Bay of Fundy rivers while at sea	Completed	Provide knowledge about marine habitat and health of salmon post-smolts from Bay of Fundy rivers. Investigate the causes and mechanisms of marine mortality of salmon post-smolts. Provide information to fuel the recovery programme for inner Bay of Fundy salmon stocks.	2002 - 2004	Distribution/ migration in the sea	Distribution of salmon in the sea	Bay of Fundy and Gulf of Maine	USA and Norway	Gilles L Lacroix	
Canada	C3	Marine migration and survival of post-smolt Atlantic salmon from the Saint-Jean River (Gaspé)	Completed	Provide knowledge of the marine habitat (migration routes and feeding grounds) used by salmon post-smolts from Bay of Gaspé rivers. Determine the location, timing and extent of salmon post-smolt mortality at sea. Investigate the causes and mechanisms of marine mortality of salmon post-smolts.	2005 - 2006	Distribution/ migration in the sea	Migratory behaviour of individual fish	Saint-Jean River, Gaspé Peninsula, Quebec		Julian Dodson, François Caron	
Canada	C4	Marine migration and survival of kelt Atlantic salmon from the Saint-Jean River (Gaspé)	Completed	Provide knowledge of the marine habitat (migration routes and feeding grounds) used by salmon kelts from Bay of Gaspé rivers. Determine the location, timing and extent of kelt mortality at sea. Investigate the causes and mechanisms of marine mortality of salmon kelts.	2006 - 2007	Distribution/ migration in the sea	Migratory behaviour of individual fish	Saint-Jean River, Gaspé Peninsula, Quebec		Julian Dodson, François Caron	
Canada	C5	Tracking experimentally 'escaped' farmed salmon	Completed	Determine the course tracks and fates of sonically tagged farmed salmon released in winter and spring.	2005	Distribution/ migration in the sea	Migratory behaviour of individual fish	Cobscook Bay, Maine, USA; Quoddy region, NB, Canada		Fred Whoriskey	
Canada	C6	Atlantic salmon distribution and abundance at sea	Completed	Determine salmon distribution and abundance at sea, particularly post-smolts in the Labrador Sea and Northern Grand Banks; collect biological and other data; investigate the relationship between salmon and their prey; investigate the relationship between oceanographic parameters and salmon abundance; tag and release salmon.	2001 - 2005	Distribution/ migration in the sea	Distribution of salmon in the sea	Labrador Sea and Northern Grand Banks		David Reddin	
Canada	C7	Integrated field and laboratory assessment of the effects of endocrine – disrupting substances on Atlantic salmon smolts	Completed	Laboratory tests of the effects of endocrine-active substances in municipal, and industrial effluents; field tests of the effects of endocrine-active substances in municipal and industrial effluents; field tests on caged smolts near sites with potential for significant agriculture run-off; ocean field tests of link between exposure of smolts to endocrine - disrupting substances and subsequent lower adult returns.	2003 - 2007	Specific natural and anthropogenic factors	Pollutants	Atlantic Canada and Co. Mayo, Ireland	Ireland	Wayne Fairchild	
Canada	C8	Use of stable isotopes to assess long-term changes in marine trophic ecology of Atlantic salmon (*Salmo salar*)	Completed	Assess trophic and dietary information through analysis of stable isotope signatures of carbon and nitrogen from previously compiled scale samples from various salmon stocks; compare isotopic signatures within and among stocks to infer differences in feeding ecology in time and space; examine evidence of environmental influences on trends in isotopic signatures; examine linkages of stable isotope signatures with trends in abundance.	2006 – 2007	Life history/ biological processes	Post-fishery recruitment marine factors	Desk study examining archived material and samples from Newfoundland, the Maritime Provinces, the Quebec North Shore, and the Barents Sea (Tana River, Finland)	Finland	J Brian Dempson	
Canada	C9	Effective population size, gene flow and population structure of Atlantic salmon in Newfoundland and Labrador	Completed	Document population structure and connectivity (gene flow) among Newfoundland and Southern Labrador rivers. Test for temporal stability of the structure over the past 50 years.	2003 - 2008	Distribution/ migration in the sea	Origin of catches in directed fisheries	Newfoundland and Labrador		Daniel Ruzzante, Friso Palstra	

Jurisdiction	Project No	Title	Status	Summary of Objectives	Research Dates	Topic Area	Objective/Issue	Area of Research	Collaborating Countries	Coordinating Scientist	Annual Expenditure
Canada	C10	River and extended estuary acoustic tracking of Atlantic salmon (*Salmo salar*) kelts and bright salmon	Completed	Track and document migratory behaviour of Atlantic salmon kelts as they leave the river for the open ocean and bright salmon as they return to rivers; identify possible critical habitat sites utilized by kelts and bright salmon during their migration; examine the mortality rates of kelts and bright salmon during migration.	2006 - 2008	Distribution/ migration in the sea	Migratory behaviour of individual fish	LaHave River and estuary, Nova Scotia		Peter G. Amiro, A Jamie F. Gibson	
Canada	C11	Integrated modelling of juvenile Atlantic salmon movement and physical habitat in fluvial and estuarine environments	Completed	Develop an innovative geomatic approach capable of relating the behaviour of smolts during their migration to the characteristics of the physical habitat in rivers and estuaries; apply this approach to the analysis of the migration of smolts through the estuaries of the St. Jean, Dartmouth and York rivers and down the Baie de Gaspé; detect possible change in migration pattern of smolts in response to the presence of sea cages.	2005 - 2008	Distribution/ migration in the sea	Migratory behaviour of individual fish	York River and Baie de Gaspé, Quebec	UK	Julian Dodson	
Canada	C12	Estuary acoustic tracking of Atlantic salmon (*Salmo salar*) smolts and kelts – Conne River, Little River, and Bay d'Espoir, Newfoundland	Completed	Tag and track migratory behaviour of Atlantic salmon smolts and kelts as they leave the Conne River, Newfoundland; determine the movements and migration patterns throughout the Bay d'Espoir fjord; provide insight into the initial survival and residency of smolts and kelts migrating through the fjord.	2006 - 2008	Distribution/ migration in the sea	Migratory behaviour of individual fish	Conne River, Little River and Bay d'Espoir fjord, Newfoundland		J. Brian Dempson, Keith Clarke	
Canada	C13	Spatio-temporal distribution of Atlantic salmon stocks and the impact of the West Greenland fishery	Completed	Provide knowledge about the river origin of the salmon catch in the commercial fishery at West Greenland.	2006 - 2008	Distribution/ migration in the sea	Origin of catches in directed fisheries	Samples from West Greenland		Louis Bernatchez, Tim King	
Canada	C14	Genetic population structure of Atlantic salmon in Eastern Canada and its implication for conservation	Completed	Elucidate the genetic population structure of Atlantic salmon from a small (river) to a large (Eastern Atlantic coast) spatial scale and propose conservation units for the Canadian distribution range.	2004 - 2008	Distribution/ migration in the sea	Origin of catches in directed fisheries	Rivers in Quebec, Canada		Louis Bernatchez, Mélanie Dionne	
Canada	C15	Pelagic ecosystem survey of the Northwest Atlantic	Completed	Sample the upper pelagic ecosystem during the period corresponding to the early post-smolt phase. Determine distribution and relative abundance of post-smolts at selected locations and times along hypothesised ocean migration route. Obtain data on relative abundance of other species including macroplankton aggregations to provide information on the role of salmon in the pelagic ecosystem. Obtain oceanographic information.	2008 - 2011	Distribution/ migration in the sea	Distribution of salmon in the sea	North West Atlantic (stations 49-58ºN)	USA	Gerald Chaput, Dave Reddin, Tim Sheehan	
Canada	C16	**Miramichi River and Restigouche River kelt movements and survival**	**Ongoing**	Document the spring movements and survival of kelts from the Miramichi River and Restigouche River as they return to the sea and on their subsequent return as repeat spawners. Determine the locations and causes of kelt mortalities in the marine environment.	2008 – 2016	Distribution/ migration in the sea	Migratory behaviour of individual fish	Miramichi River and estuary Restigouche River and estuary and Gulf of St Lawrence, Atlantic Ocean		Jon Carr	£108,000
Canada	C17	**Marine survival of Canadian Atlantic salmon stocks: long-term monitoring**	**Ongoing**	Long term assessments of smolt production and adult return estimates from a number of rivers in Newfoundland region, Maritimes region, Gulf region and Quebec.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	Canadian rivers in Newfoundland region, Maritimes region, Gulf region and Quebec		Carole Grant	£600,000
Canada	C18	**Atlantic salmon smolt migration and survival within Canadian rivers, estuaries and during the marine life stage**	**Ongoing**	Provide a time-series of stage specific estimates of mortality rates for smolts and post-smolts at various points of their sea migration, including for their transitions through freshwater, the estuary and to various points in the ocean; examine the relation between biological characteristics of the fish and survival rates to attempt to isolate mortality causes; document the migration pathways and speeds of smolts from different rivers.	2003 -	Distribution/ migration in the sea	Migratory behaviour of individual fish	Miramichi River and estuary; Restigouche River and Baie des Chaleurs; Cascapedia River and estuary; St-Jean (Côte-Nord) River and estuary; Strait of Belle Isle, Cabot Strait, Labrador.	USA	Jon Carr, Fred Whoriskey	£435,000

Jurisdiction	Project No	Title	Status	Summary of Objectives	Research Dates	Topic Area	Objective/Issue	Area of Research	Collaborating Countries	Coordinating Scientist	Annual Expenditure
Canada	C19	Stable isotope ratios to infer trophic structure and condition of Atlantic salmon during their life at sea	Completed	Improve understanding of marine ecology of salmon through studies of trophic state and condition. Questions to be addressed include: are trophic states of 1SW non-maturing fish similar between NAC and NEAC origin salmon?; Are trophic states of 1SW non-maturing fish different from those of maturing 1SW fish of the same cohort? Can this tell us anything about when these different maturity groups separate in the North Atlantic?; Has there been a trophic state change between West Greenland and return to home rivers as 2SW salmon? How do current measures of trophic status compare with measures from archival scales and do differences indicate significant changes?	2008 – 2014	Life history/ biological processes	Post-fishery recruitment marine factors	West Greenland and from salmon returning to the index rivers of Eastern Canada.	Greenland	Heather Dixon, Mike Power, J. Brian Dempson, Gerald Chaput, Tim Sheehan	
Canada	C20	Identification of essential habitat for repeat spawning Atlantic salmon of Inner Bay of Fundy origin	Completed	Identify the freshwater and marine habitats used by post-spawning Atlantic salmon of inner Bay of Fundy (iBoF) origin for reconditioning and identify the sites and times of mortality.	2008 - 2013	Distribution/ migration in the sea	Migratory behaviour of individual fish	Big Salmon, Gaspereau and Hammond Rivers		Gilles L Lacroix, Ross Jones	
Canada	C21	Genomic basis of adaptive divergence and marine survival among Atlantic salmon populations	Completed	Elucidate the genetic basis of adaptive divergence and marine survival in Atlantic salmon populations from eastern Canada. Contribute to the identification of management units.	2010 - 2014	Distribution/ migration in the sea	Origin of catches in directed fisheries	Québec, Maritimes, Newfoundland and Labrador	Norway, USA	Louis Bernatchez, Mélanie Dionne, Patrick O'Reilly, Vincent Bourret	
Canada	C22	River and extended estuary acoustic tracking of Atlantic salmon (*Salmo salar*) smolts in Southern Uplands rivers	Completed	Estimate mortality rates, assess the spatio-temporal dynamics of natural mortality and examine migratory behaviour during the fresh to saltwater transition of wild Atlantic salmon *Salmo salar* smolts from four river systems in an area of Nova Scotia, Canada known as the Southern Upland.	2008 - 2010	Distribution/ migration in the sea	Migratory behaviour of individual fish	LaHave River, St. Mary's River, Gold River, and West River (Sheet Harbour)		E Halfyard, A Jamie F Gibson	
Canada	C23	Effects of early captive exposure on measures of fitness later in life for Inner Bay of Fundy (IBoF) Atlantic Salmon	Completed	Assess the effects of standard and novel conservation rearing strategies on measures of fitness for the recovery of IBoF salmon. Part of the research involved acoustic tagging to assess return migration ability.	2010 - 2015	Distribution/ migration in the sea	Migratory behaviour of individual fish	Upper Salmon River		Corey Clarke	
Canada	C24	**Genomic stock identification techniques provide distribution information of regional groups of Atlantic salmon from eastern North America and estimates of exploitation in mixed stock marine fisheries**	**Ongoing**	Identify to regional groups the origin of salmon from mixed stock fisheries of Labrador (Canada), Saint-Pierre & Miquelon, and at West Greenland; estimate total catch by regional group and examine region specific variations in distribution at sea and availability of Atlantic salmon in marine fisheries.	2013 - 2017	Distribution/ migration in the sea	Origin of catches in directed fisheries	Eastern North America, West Greenland	France, NASCO West Greenland sampling Programme (see D1)	Ian Bradbury	£130,100
Canada	C25	**Rearing wild-origin IBoF salmon smolts in marine netpens for release as adults to supplement stocking of Fundy National Park (FNP) Rivers**	**Ongoing**	Experimentally supplement FNP spawning adult salmon populations to effective population size for one salmon generation (4-5years) and produce cohorts of naturally spawned and captive-free migrating smolts.	2014 – 2019	Distribution/ migration in the sea	Migratory behaviour of individual fish	Upper Salmon River, Point Wolfe River (Fundy National Park) *Petitcodiac		Corey Clarke	£100,000
Canada	C26	**Smolt monitoring on Middle River, Cape Breton, Nova Scotia, Canada**	**Ongoing**	The objectives are to: estimate run size, age structure and phenology of Atlantic Salmon smolts from the Middle River, Nova Scotia; allow estimation of survival in the marine environment from smolt to adult life phases; allow collection of smolts for other research projects and collaborations (e.g. behavioural tagging studies); and contribute information to inform recovery planning and traditional ecological knowledge.	2011 - 2016	Long-term monitoring	Time-series of marine survival/growth estimates	Middle River, Cape Breton, Nova Scotia		Shelley Denny	£13,000
Canada	C27	**Tracking the migration behaviour of Atlantic salmon kelts (Middle and Baddeck rivers), through a unique inland brackish sea of Cape Brenton, Canada**	**Ongoing**	Study life history variation, habitat use patterns and underlying physiology of Atlantic salmon kelts from Middle and Baddeck rivers as well as evaluating management practices associated with broodstock collection program on these rivers.	Kelt Acoustic Tagging: 2014 & 2015, November – December. Kelt Tracking: 2012 - 2017	Distribution/ migration in the sea	Migratory behaviour of individual fish	Middle & Baddeck rivers, Cape Breton, Nova Scotia, Bras d'Or Lakes, Cabot Strait, Strait of Belle Isle		Glenn Crossin, Xavier Bordeleau, Bruce Hatcher, Fred Whoriskey, Shelly Denny	£19,400

Jurisdiction	Project No	Title	Status	Summary of Objectives	Research Dates	Topic Area	Objective/Issue	Area of Research	Collaborating Countries	Coordinating Scientist	Annual Expenditure
Canada	C28	Evaluating the role of bottom-up effects of prey availability on the survival or local abundance of repeat spawning Atlantic salmon between two ecosystems	Completed	Contrary to the overall pattern of declining survival of maiden Atlantic salmon, survival of Miramichi River (Gulf of St. Lawrence, GSL) consecutive MSWS has increased and appears to be linked with local forage fish abundance (Chaput and Benoît, 2012). This project contrasts the links with forage fish abundance and environmental factors in the GSL, to the patterns observed in the Bay of Fundy ecosystem where the survival of repeat spawning salmon is considerably lower. The project aims to provide evidence of the importance of forage fish in affecting population dynamics of these highly migratory species by confirming their likely prey using stable isotopes and by contrasting responses among multiple ecosystems and for two salmon spawner groups (local reconditioning vs high seas reconditioning).	2014 - 2017	Life history/ biological processes	Post-fishery recruitment marine factors	Nashwaak River (Bay of Fundy), Miramichi River (Gulf of St Lawrence), Bay of Fundy, Scotian Shelf, Gulf of St Lawrence, Labrador Sea		Hugues Benoît	
Canada	C29	**Movements and survival rates of acoustic tagged smolts from Campbelton River, Newfoundland**	**Ongoing**	Study migration rates, habitat use and early phase marine survival of salmon smolts from a northeast coast Newfoundland river.	2014 - 2017	Distribution/ migration in the sea	Migratory behaviour of individual fish	Cambelton River, Newfoundland		Kristin Boee	-
Canada	C30	**Research into factors of early marine phase postsmolt mortality using acoustic predator-detection tags**	**Ongoing**	Assess the extent to which predation by native fishes explains the loss of acoustically tagged Atlantic salmon smolts during the early phase of migration; assess how run timing modifies predation and loss rates	2017 -	Distribution/ migration in the sea	Migratory behaviour of individual fish	Northwest Miramichi River, New Brunswick, Canada		Jon Carr	-
Canada	C31	**Research into factors of early marine phase postsmolt mortality using acoustic predator-detection tags**	**Ongoing**	Assess the extent to which predation explains the loss of acoustically tagged Atlantic salmon smolts during the early phase of migration; assess how run timing modifies predation and loss rates	2017 -	Distribution/ migration in the sea	Migratory behaviour of individual fish	Stewiacke River, Inner Bay of Fundy, Nova Scotia, Canada		David Hardie,	£73,000
Canada	C32	**Migration, distribution, survival of smolts from Nashwaak River**	**Ongoing**	Assess riverine, estuarine, near and distant marine migration and survival of Nashwaak River smolts; assess the survival of pre-smolts tagged and released in river and in laboratory; compare the migration and survival of smolts tagged the preceding fall as pre-smolts and recently tagged smolts	2017 – 2018	Distribution/ migration in the sea	Migratory behaviour of individual fish	Nashwaak River, Saint John River		David Hardie	£76,000
Canada	C33	**Early marine phase migration, and survival of Atlantic post-smolts from multi-sea-winter salmon populations of Quebec**	**Ongoing**	Study migrations, distribution and post-smolt survival of Atlantic salmon smolts into and to exit from the Gulf of St. Lawrence.	2017	Distribution/ migration in the sea	Migratory behaviour of individual fish	Gulf of St. Lawrence, eastern Canada		Martin Castonguay, Julien April	-
Canada	C34	**West River Acid Rain Migration Project**	**Ongoing**	Evaluate the efficacy of acid rain mitigation techniques, including lime dosing, catchment liming and additional supporting restoration techniques (e.g. physical habitat restoration, the creation of artificial spring habitats) with regard to marine mortality. Smolt production in the limed WRSH and the Little River tributary (unlimed) was estimated between 2007-2014 using a 'smolt wheel' and fyke nets. Beginning in 2015, returning adult salmon have been counted in both the limed WRSH and Little River using a novel resistance board weir and a traditional 'picket-style' weir.	2016 - 2019	Specific natural and anthropogenic factors	Pollutants	Nova Scotia Southern Upland		Eddie Halfyard	£590,000

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Canada	C35	**Atlantic Salmon Research Joint Venture – Life History Modelling Project for Wild Atlantic salmon**	**New Entry**	Develop a stochastic, dynamic life history model that can be used to further explore the factors affecting the survival of Atlantic salmon. The work will involve, but not be limited to, analyses of per capita population growth, life-history elasticity, model sensitivity, and patterns of density dependence (including Allee effects) at different spatio-temporal scales. The model parameters will be based on a review of data throughout the geographic range of the species, updating one undertaken in 1998. The over-arching goal of the project is to apply the model to address fundamental questions pertaining to population viability of Atlantic salmon.	2017 - 2019	Life history/biological processes	Post-fishery recruitment marine factors	North Atlantic		Dr Jeff Hutchings	£40,000
Canada	C36	**Atlantic Salmon Research Joint Venture – Atlantic Salmon Post-smolt Trawl and Troll Survey in the Strait of Belle Isle**	**New Entry**	Determine the feasibility of capturing Atlantic salmon post-smolts (unharmed) as they migrate through the Strait of Belle Isle (SoBI); record presence of other fish species (predator and prey) at SoBI at the same time post-smolts are passing through; lethally sample a subset (N=100) post-smolts for fish health, growth (scales, otoliths), genetic analysis (population structure and sex), and stomach contents.	2017 - 2019	Development of methods	Post-smolt survey methods	Strait of Belle Isle, Canada	USA	Jonathan Carr, Atlantic Salmon Federation	£94,000
Canada	C37	**Atlantic Salmon Research Joint Venture – Current status of knowledge, data, and research efforts on Atlantic salmon at Greenland: what do we have, what do we need, and what should we do moving forward?**	**New Entry**	Review historical/current state of knowledge (literature review and data inventory) of Atlantic salmon at the summer feeding area off the coast of West Greenland; review current research efforts on Atlantic salmon at the summer feeding area off the coast of West Greenland; compile future data needs and gaps; review inventory of archived databases (sampling database, genetic assignment database, etc.) and samples (scales, tissue, etc.) available from Atlantic salmon collected at the summer feeding area of the coast of West Greenland; develop recommendations for improving future fishery sampling efforts; develop short list of research themes/projects to address future data needs and gaps; develop protocols for providing access to database(s) and archived samples for collaborating researchers; develop a guide for interpreting the sampling database that considers the non-random sampling conducted in some years.	2017 - 2018	Long-term monitoring	Desk studies on time series		Canada, USA, Greenland, European Union - Ireland	Tim Sheehan, Niall Ó Maoiléidigh, Rasmus Nygaard, Jonathan Carr	£38,000
Canada	C38	**Atlantic Salmon Research Joint Venture – Development of Acoustic Tracking Capabilities for Drifter Buoys**	**New Entry**	Support the scientific community’s work acoustic telemetry work following the movements and survival of Atlantic salmon in the Northwest Atlantic Ocean by conducting the engineering and integration work needed to couple a Vemco VR2C underwater, cabled acoustic receiver to the MetOcean SVP drifting buoy; design the prototype so that it becomes a low-cost, add-on option (target < £ 3 K per unit) to the purchase price of the MetOcean buoy (current cost £3 K), enabling NASCO members and other partners to contribute to high seas research of Atlantic salmon through modest, incremental contributions to the purchase prices of meteorological buoys which national authorities intend to buy and launch annually; build, test, and refine a prototype of the buoy.	2017 - 2018	Development of methods	Post-smolt survey methods		Canada, USA	Dr Fred Whoriskey	£58,000
Denmark - Greenland	D1	**West Greenland Salmon Fishery Sampling Programme**	**Ongoing**	Continue time series of data on the continent of origin and biological characteristics of salmon in the fishery; provide data on mean weight and length and continent of origin for input to models; collect information on the recovery of internal and external tags; collect other additional biological samples as required.	Annual	Distribution/ migration in the sea	Origin of catches in directed fisheries	Sisimiut, Maniitsoq, Paamiut and Qaqortoq, Greenland	USA, UK, Ireland, Canada	Helle Siegstad	£118,000

Jurisdiction	Project No	Title	Status	Summary of Objectives	Research Dates	Topic Area	Objective/Issue	Area of Research	Collaborating Countries	Coordinating Scientist	Annual Expenditure
European Union	E1	SALMODEL Concerted Action – A co-ordinated approach towards the development of a scientific basis for management of wild Atlantic salmon in the North-East Atlantic	Completed	Improve ability to set conservation limits and examine methods of estimating pre-fishery abundance (PFA) and determine how these PFA estimates can be used to provide catch advice.	2000 - 2002	Long-term monitoring	Time series of marine survival in relation to environmental parameters	Desk study	France, Ireland, Finland, Norway, Iceland, Sweden, Canada, UK	Walter Crozier	
European Union	E2	SALSEA-Merge: Advancing understanding of Atlantic salmon at sea: Merging genetics and ecology to resolve stock – specific migration and distribution patterns	Completed	Merge genetic and ecological investigations to advance understanding of stock specific migration and distribution patterns and overall ecology of the marine life of Atlantic salmon and gain an insight into the factors resulting in recent significant increases in marine mortality.	2008 - 2011	Distribution/ migration in the sea	Distribution of salmon in the sea	North-East Atlantic with marine surveys off coast of Ireland and UK, around the Faroes and in the Northern Norwegian Sea and Barents Sea	Denmark, Finland, France, Faroes, Iceland, Ireland, Norway, Spain, UK	Jens Christian Holst	
European Union	E3	ECOKNOWS (Effective Use of Ecosystem and Biological Knowledge in Fisheries): Improving fisheries assessment methods by integrating new sources of biological knowledge	Completed	The objectives include improving ways to find generic and understandable biological reference points. An age and stage-based life-cycle population dynamic model which explicitly separates the freshwater and marine phases and incorporates the variability of life histories (river and sea ages) is one output from the project.	2010 - 2014	Long-term monitoring	Time series of marine survival in relation to environmental parameters	North Atlantic	ECOKNOWS Consortium: Finland, Denmark, Philippines, Greece, Spain, Ireland, UK, Canada, Sweden, France	One Coordinating Scientist for each of the Seven Work Packages	
European Union - Denmark	De1	Estuarine migration of smolts in the River Skjern Å (North Sea) and River Guden Å	Completed	Assess the effect of restoration of habitat in the River Skjern Å on the smolt runs of salmon and sea trout, in particular with regard to predation by piscivorous birds. To investigate the migration of salmon smolts in the River Guden Å.	2002 - 2003	Distribution/ migration in the sea	Migratory behaviour of individual fish			Gorm Rasmussen	
European Union - Denmark	De2	Mortality of Atlantic salmon smolts during estuary migration	Completed	Estimate mortality of salmon smolts during migration through estuaries and compare the return ratio of wild, stocked ½- and one-yearlings.	2000 - 2008	Distribution/ migration in the sea	Migratory behaviour of individual fish	River Skjern Å and River Stor Å (North Sea) and River Guden Å (Kattegat) and their estuaries		Anders Koed, Kim Aarestrup	
European Union - Denmark	De3	**Salmon Rehabilitation Plan: monitoring numbers of spawners, spawning and nursery areas in four Atlantic salmon rivers and the achievement of the objective of self-reproduction**	**Ongoing**	The Danish national salmon rehabilitation plan describes four rivers with natural wild salmon populations. This project monitors the effect of the rehabilitation plan and the development of the populations (the goal is at least 1,000 spawners in each river to fulfil the plan). This study will allow estimates of marine mortality of salmon to be made.	Annually	Long-term monitoring	Time series of marine survival /growth estimates	River Skjern, River Ribe, River Storå, River Varde and River Sneum. The rivers flow into the North Sea		Anders Koed, Einar Eg Nielsen, Niels Jepsen	£110,300
European Union - Denmark	De4	**Marine behaviour of Atlantic salmon**	**Ongoing**	Obtain more knowledge about the salmon's distribution and migration at sea using DSTs and PSAT tags and isotopes.	2010 - 2017	Distribution/ migration in the sea	Migratory behaviour of individual fish	River Skjern Å and River Storå		Kim Aarestrup	£35,000
European Union - Denmark	De5	**Strengthen the Danish Atlantic Salmon Popultions (SDPAS)`**	**Ongoing**	The vision of the project is to strengthen Danish Atlantic salmon populations towards a state where the populations are completely self-sustainable and can be exploited under a dynamic catch quota approach. The project comprises six work packages including limiting factors for smolt and pre-smolt run and survival, limiting factors for kelt survival and improving quality and post-release survival of stocked salmon.	2016 – 2020	Distribution/ migration in the sea	Migratory behaviour of individual fish	River Skjern	Denmark	Anders Koed	£630,000

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European Union – Denmark	De6	**Salmon Rehabilitation Plan: monitoring numbers of spawners, spawning and nursery areas in four Atlantic salmon rivers and the achievement of the objective of self-reproduction**	**New Entry**	The Danish national salmon rehabilitation plan describes four rivers with natural wild salmon populations. Collected fry from River Skjern Å 2008 and 2009, and juveniles from Ribe Å and Varde Å collected during the last decade, have been analyzed by 20-25 microsatellites to identify the number of families at each spawning site. A large number of juveniles and many families would indicate proper functioning of spawning and nursery areas for many spawning fish while getting few families will indicate too scarce spawning fish and / or poor conditions in much of the spawning area. The results will be compared with ecological and environmental indicators to determine which of the described hypotheses are the most likely for the specific spawning areas. In this way the effect of the rehabilitation plan and the development of the populations is assessed (the goal is at least 1,000 spawners in each river to fulfill the plan). This study will allow estimates of marine mortality of salmon to be made.	Annually	Life history / biological processes	Freshwater factors	River Skjern, River Ribe, River Storaa, River Varde, Kongeå and River Sneum		Anders Koed, Einar Eg Nielsen and Niels Jepsen	£46,300
European Union - Denmark	De7	**SMOLTRACK**	**New Entry**	This project will explore the mortality of smolts and post-smolts during their migration through the lower rivers, estuaries/fiords and near-shore areas. It specifically addresses SALSEA-track priorities specified in the NASCO-IASRB Workshop on Telemetry report (recommendation SRBTW(14)7). Acoustic telemetry with wild salmon smolts is used to investigate and directly measure the mortality during the first days-to-weeks after leaving the river. Additionally, the project aims to act as a platform for EU-wide salmonid telemetry knowledge (facilitate the sharing of international best practice to EU members)/data/projects/bulk purchasers of technology, with the goal to establish an EU strategic salmon telemetry advisory group.	2017 - 2019	Distribution/ migration in the sea	Migratory behaviour of individual fish	Ireland – River Erriff Northern Ireland – River Bush England – River Tamar Spain – River Ulla & River Tea Denmark – River Skjern	European Union: Ireland, Northern Ireland, England, Spain and Denmark	Niels Jepsen, Kim Aarestrup	£263,000
European Union - Finland	Fi1	**Long-term variation in population dynamics, life history characteristics, sea growth and origin (wild/reared) of salmon in the rivers Teno (Tana) and Näätämöjoki (Neidenelva)**	**Ongoing**	Collect long-term data on variation in the stock components, life histories, sea growth and abundance of escaped farmed salmon in the salmon stocks of the rivers Teno and Näätämöjoki. Relate the population dynamics of the juvenile salmon and returning adult salmon in preceding and subsequent generations.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	Northern Finland and Norway	Norway	Jaakko Erkinaro	£275,000
European Union - Finland	Fi2	Joint use of high-throughput SNP assay infrastructure in Atlantic salmon	Completed	The key aims of the project include: I) A concerted effort to identify genomic regions that affect ecologically and economically important phenotypic traits in domesticated and wild Atlantic salmon; II) efficient joint utilization of a state-of-the-art Nordic genomics infrastructure to generate large-scale salmon SNP datasets;	2009 - 2010	Distribution/ migration in the sea	Origin of catches in directed fisheries	Norway and Finland	Norway	Craig Primmer	
European Union - Finland	Fi3	**Integrative science for adaptive co-management in the Arctic: Teno Atlantic salmon as a model system (ISAMA)**	**Ongoing**	The aims of the project are to: 1) characterise the ecological and genetic changes in the Teno salmon stock over the past 40 years; 2) identify the key human-mediated/climatic factors that have contributed to these changes; 3) determine the relationships between these changes and the co-occurring societal and political changes; 4) better understand the genetic basis of life-history traits important for maintaining stock diversity and stability and thus salmon-related livelihoods; 5) use local knowledge and management of Teno salmon as a case study to examine the links between scientific research, local resource users, and adaptive co-management and policy.	2015 -2018	Long-term monitoring	Desk studies on time series	Finland and Norway	Norway	Craig Primmer, Jaakko Erkinaro	£400,000

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European Union - France	Fr1	Evolution of biological characteristics in Atlantic salmon from all the Armorican massif rivers (Brittany and Low-Normandy, France)	Completed	Examine relationships between the cumulative effects of climate warming and other anthropogenic stresses and changes in biological features in populations in the southern part of the European distribution range of the species.	1972 - 2005	Life history/ biological processes	Freshwater factors	Salmon rivers in the Armorican Massif (about 25 – 30 rivers)		Jean-Luc Baglinière	
European Union - France	Fr2	**The sea survival of Atlantic salmon from the River Scorff, Brittany**	**Ongoing**	Estimation and long-term monitoring of survival at sea in the southern part of the European distribution range of the species.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	River Scorff (Southern Brittany)		Etienne Prévost	£143,000
European Union – France	Fr3	Atlantic salmon metapopulation investigation in Normandy rivers	Completed	Estimate exchanges between rivers flowing into the Mont Saint-Michel Bay and the impact on management of salmon populations.	2007 - 2010	Distribution/ migration in the sea	Origin of catches in directed fisheries	Rivers flowing into Mont Saint-Michel Bay, Normandy		Jean-Luc Baglinière	
European Union - Ireland	Ir1	Assessment of the levels of the parasite *Lepeophtheirus salmonis* on Atlantic salmon post-smolts in salmon aquaculture bays along Ireland's western seaboard	Completed	Determine whether sea lice from marine salmon farms are a contributory factor in increased marine mortality of salmon post-smolts migrating from bays with salmon aquaculture. Gather information on salmon post-smolt migration patterns.	2002	Specific natural and anthropogenic factors	Fish farms	South-West Coast (Kenmare Bay), West Coast (Killary Harbour, Bertraghboy Bay, Clew Bay), North-West Coast (Inver Bay).		Paddy Gargan	
European Union - Ireland	Ir2	Oceanic factors influencing marine survival of Irish salmon stocks	Completed	Provide information on marine survival at various stages of ocean migration.	2001 - 2005	Long-term monitoring	Time series of marine survival in relation to environmental parameters	Desk study utilising oceanic data from around North Atlantic	USA	Niall Ó Maoiléidigh, Kevin Friedland	
European Union - Ireland	Ir3	Sustainable management of interactions between aquaculture and wild salmonid fish	Completed	Assess efficacy of prophylactic treatments for salmon smolts migrating through aquaculture bays.	2003 – 2006	Specific natural and anthropogenic factors	Fish farms	Kilkerrin Bay, Bertraghboy Bay, Connemara	UK, Norway	Paddy Gargan,	
European Union - Ireland	Ir4	Early distribution and migration of Atlantic salmon smolts off the west of Ireland	Completed	Test new pelagic trawl in open waters off Irish coast; train and familiarise staff on the operation and development of the trawl for further surveys in 2008 and 2009; obtain samples of post-smolts for biological and genetic analyses; relate run-timing, timing of migration, swimming speed, growth, etc to oceanographic parameters.	2007	Development of methods	Post-smolt survey methods	North-west coast of Ireland	UK	Niall Ó Maoiléidigh	
European Union - Ireland	Ir5	Migration of salmon in estuarine and coastal waters	Completed	Investigate the timing, route of migration and aspects of the biology of migrating ranched salmon smolts in comparison to the native wild smolt migration.	2005 - 2008	Distribution/ migration in the sea	Migratory behaviour of individual fish	Burrishoole catchment, Newport and Clew Bay, Co. Mayo	UK	Russell Poole, Deirdre Cotter, Niall Ó Maoiléidigh	
European Union – Ireland	Ir6	National Development Plan - National Genetic Stock Identification Project	Completed	Identify and map discrete spawning areas within tributaries of Irish salmon rivers and collect juveniles for establishment of genetic baseline for mixed sample analysis. Undertake molecular genetic analysis of juvenile salmon tissue and adult scales to determine relative contributions of different baseline river populations within mixed samples.	2006 - 2008	Distribution/ migration in the sea	Origin of catches in directed fisheries	All Irish rivers	UK, Spain	Tom Cross, Paddy Gargan, Philip McGinnity	
European Union – Ireland	Ir7	Interactions between aquaculture and wild salmonid fish	Completed	Assess efficacy of prophylactic treatments for salmon smolts migrating through aquaculture bays.	2003 - 2009	Specific natural and anthropogenic factors	Fish farms	Burrishoole, Shannon, Lee and Screebe rivers, and drift net fisheries around Irish coast		D Jackson	
European Union - Ireland	Ir8	**Marine survival of wild and hatchery reared salmon: National coded wire tagging and tag recovery programme and Burrishoole wild salmon census**	**Ongoing**	Provide information on marine survival and exploitation rates by commercial fisheries; estimate the contribution of individual river stocks to catches; examine the performance of selected experimental groups; and evaluate potential for salmon ranching.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	Tag recovery from around North Atlantic. Salmon census facility, Newport, Co Mayo	Norway, UK, Faroes, France, Spain, Germany, Denmark	Niall Ó Maoiléidigh Russell Poole	£472,000
European Union – Ireland	Ir9	Kelt survival	Completed	Tag salmon kelts from four rivers in southern Ireland and monitor marine migration, depth and temperature preferences.	2010 - 2012	Distribution/ migration in the sea	Migratory behaviour of individual fish	Southern Ireland		Audun H. Rikardsen	
European Union – Ireland	Ir10	**The ecology of salmon (*Salmo salar* L.) at sea – environmental factors affecting marine growth, survival and migration of Atlantic salmon**	**Ongoing**	Investigate the decline in North Atlantic salmon stocks in the past two decades in an ecosystem context and provide new information for use in forecast models of abundance and size of current stocks.	2012 - 2016	Life history/ biological processes	Pre-fishery recruitment marine factors	Ireland, Norway	Norway, UK	Dr. D. Brophy	£50,000

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European Union – Ireland	Ir11	**Experiment to determine the potential impact of sea lice from marine salmon farms on out-migrating salmon smolts in western Ireland**	**Ongoing**	Assess the efficacy of prophylactic treatments for salmon smolts migrating through aquaculture bays	2014 - 2017	Specific natural and anthropogenic factors	Fish farms	River Erriff and Killary Harbour, River Corrib and Galway Bay		Paddy Gargan	£69,000
European Union – Ireland	Ir12	**Salmonid West Programme 2014-2019**	**Ongoing**	Investigate migration, distribution, habitat usage and survival of sea trout and salmon smolts in the marine environment on the west coast. Determine factors that may influence salmonid migration and survival and identify key marine habitats. Investigate ecology of smolts/kelts in freshwater / marine interface and marine zone. Improve understanding of salmonid ecology at sea and allow assessment of impacts of development on wild salmonids. Enable quality environmental impact assessment and optimised spatial planning.	2014 - 2019	Distribution/ migration in the sea	Migratory behaviour of individual fish	Killary Harbour and River Erriff, Corrib River and Galway Bay		William Roche, Patrick Gargan	£64,000
European Union – Ireland	Ir13	**Investigation of the early migration of salmon and brown trout from the Burrishoole National Index River using telemetry technology in freshwater, brackish and inshore marine areas**	**Ongoing**	Apply tracking technology to track early migration of salmon and trout through the Burrishoole system and assess mortality on entry to marine milieu; experimentally compare early migration and migratory behaviours of local versus foreign Atlantic salmon smolts ranched from the Burrishoole system; and link long-term biological data on Atlantic salmon and sea trout with climate time series to assess the effect of potential thermal mismatch between freshwater and marine environments on post-smolt survival.	2016 - 2019	Distribution/ migration in the sea	Migratory behaviour of individual fish	Burrishoole and environs. Newport, Co. Mayo		Niall Ó Maoiléidigh, T Reed	£119,500
European Union – Ireland	Ir14	**Investigation of the causes of early migration mortality in salmon and sea trout from the Burrishoole National Index River using acoustic telemetry in estuarine, marine and coastal areas**	**Ongoing**	Objectives include: building national capacity in the use of telemetry to monitor movements of migratory fish species; evaluating and optimising methods for the tagging of wild and reared post-smolts; describing and mapping the migration routes taken by post-smolts of Atlantic salmon and sea trout during their seaward migration from the Burrishoole catchment; and estimating survival of tagged post-smolts during their seaward migration from the Burrishoole catchment.	2016 - 2019	Distribution/ migration in the sea	Migratory behaviour of individual fish	Burrishoole River, Clew Bay and environs, Co. Mayo	-	Niall Ó Maoiléidigh, Deirdre Brophy	£119,500
European Union – Ireland	Ir15	**Estimate marine survival of wild Atlantic salmon in the North-East Atlantic from the National Salmonid Index Catchment in the west of Ireland**	**Ongoing**	Estimate pre-adult to adult marine survival rates in the National Salmonid Index Catchment and the Corrib system in the west of Ireland.	2015 – 2021	Long-term monitoring	Time series of marine survival/growth estimates	River Erriff, West of Ireland		Paddy Gargan	£36,000
European Union - Ireland	Ir16	**Sea lice model for the sustainable development of Atlantic salmon fisheries and aquaculture**	**Ongoing**	Support the development of a sea lice integrative model that will take into account relevant parameters, including biological, environmental, oceanographic, anthropogenic etc, with the aim of predicting the potential for the sea lice to occur at different locations at different times of the year and under different environmental conditions. The project will contribute to developing best management practice for sea lice control.	January 2017 – December 2018	Specific natural and anthropogenic factors	Fish farms	Ireland (National Salmonid Index Catchment), Norway and Scotland	Norway and Scotland	Paddy Gargan	£280,000

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European Union - Ireland	Ir17	**Unlocking the archive: using scale and otolith chronologies to resolve climate impacts**	**Ongoing**	Improvements in the availability and accessibility of environmental monitoring data allows reasearchers to more accurately describe the external conditions that contribute to changes in growth, phenology, migration and survival. Exceptionally detailed records of individual responses to these conditions can be gleaned from hard tissues (scales and otoliths) of teleost fish. Visable periodic increments provide an internal chronological record of life history traits such as age, growth and migration timing. Recent analytical advances also allow the reconstruction of temperature and feeding histories and migration pathways. Archived collections of scales and otoliths can generate incredibly detailed longterm biological time-series. Coupling this information with measurements of external conditions can yield powerful insight into how populations respond to environmental change and can perform predictions of likely future responses.	2017 - 2021	Long-term monitoring	Time series of marine survival/growth estimates	Marine Institute, Newport Research Facility, Co Mayo and Galway/Mayo Institute of Technology		Deirdre Brophy, Deirdre Cotter, Niall ÓMaoiléidigh, Russell Poole	£67,500
European Union - Sweden	Sw1	**Long-term variation in population dynamics, life-history and exploitation of salmon stock in the index River Åtran**	**Ongoing**	Estimate long-term variation of survival in different life-stages, life-history characteristics, stock recruitment and growth of wild salmon in the River Åtran and its major tributary Högvadsån.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	Sweden (west coast; Kattegatt)		Erik Degerman	£43,000
European Union - UK (England and Wales)	Ew1	Salmonid migration and climate change	Completed	Describe and model the enivonmental factors affecting the migration of salmonids and predict the effects of climate change on salmonid migration and survival in the sea.	1999 - 2004	Distribution/ migration in the sea	Migratory behaviour of individual fish	Coastal waters around the UK and extending to salmon feeding grounds in Faroes and Greenland Seas		Andy Moore	
European Union - UK (England and Wales)	Ew2	Impacts of agricultural contaminants on wild salmonids	Completed	Describe the nature and extent of the impacts of aquatic contaminants derived from agriculture on migration and marine survival of salmonid smolts and post-smolts.	1999 - 2004	Specific natural and anthropogenic factors	Pollutants	England and Wales	Sweden and Canada	Andy Moore	
European Union - UK (England and Wales)	Ew3	Impact of intensive in-river aquaculture on wild salmonids	Completed	Describe the nature and extent of the impact of aquatic contaminants derived from intensive freshwater aquaculture (effluents, pesticides, antibiotics and hormones) on reproduction and migration of wild salmonids.	2001 - 2005	Specific natural and anthropogenic factors	Fish farms	England and Wales		Andy Moore	
European Union - UK (England and Wales)	Ew4	Modelling the bioenergetics of salmon migration	Completed	Model the energetic requirements of salmon during their marine migrations and predict the effects of environmental and oceanographic changes on smolt growth and survival.	2002 - 2005	Distribution/ migration in the sea	Migration and bioenergetic models	England and Wales		Andy Moore	
European Union - UK (England and Wales)	Ew5	Cardiff Bay Fisheries Monitoring Programme	Completed	Assess the impact of Cardiff Bay barrage on salmon stocks of the rivers Taff and Ely.	1990 - 2006	Specific natural and anthropogenic factors	Obstructions to fish movements	Cardiff Bay at mouth of rivers Taff and Ely, South Wales, UK		Peter Gough	
European Union - UK (England and Wales)	Ew6	Atlantic Salmon Arc Project, ASAP	Completed	Define exploitation at sea on a regional basis using genetic tools. Create a long-term database for these studies and create an international management tool to inform decision-making.	2004 - 2008	Distribution/ migration in the sea	Origin of catches in directed fisheries	Europe, North Atlantic	Spain, France, Ireland, Scotland, USA, Iceland	Dylan Bright	
European Union - UK (England and Wales)	Ew7	Diffuse pollution and freshwater fish populations	Completed	Investigate the role of diffuse aquatic contaminants in regulating populations of freshwater fish with particular reference to salmonid stocks and fisheries.	2005 - 2010	Specific natural and anthropogenic factors	Pollutants	England and Wales		Andy Moore	
European Union - UK (England and Wales)	Ew8	The influence of the freshwater environment on salmonid populations	Completed	Examine the impact of environment change on juvenile salmon production and ecology. One aspect of the research directly related to marine survival is the potential role of assessment techniques (trapping, anaesthetisation tagging) in influencing marine survival.	2005 - 2010	Life history/ biological processes	Freshwater factors	England and Wales		Andy Moore	

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European Union - UK (England and Wales)	Ew9	Factors affecting the distribution and behaviour of salmonid populations	Completed	Investigate the habitat requirements of adult salmonids within the estuarine and freshwater environments. One key element of the research is to investigate how changes in prey availability within the marine environment may influence recruitment of stocks between years.	2005 - 2010	Life history/ biological processes	Pre-fishery recruitment marine factors	England and Wales		Andy Moore	
European Union - UK (England and Wales)	Ew10	Genetic sampling to type British salmon stocks	Completed	Coordinate and support the establishment of baseline information on the genetic character of breeding populations within and among rivers in Britain.	2008 – 2010	Distribution/ migration in the sea	Origin of catches in directed fisheries	England, Wales, Northern Ireland and Scotland	Northern Ireland and Scotland	Miran Aprahamian	
European Union - UK (England and Wales)	Ew11	**Deriving estimates of marine survival for monitored river stocks in England and Wales**	**Ongoing**	Establish 'monitored' rivers where estimates of marine survival can be derived and compared with other North Atlantic stocks.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	River Dee (North Wales), River Tamar (SW England)¶River Frome (S England)		Ian Davidson, Rob Hillman, Ian Russell, Rasmus Lauridsen	£150,000
European Union - UK (England and Wales)	Ew12	The marine life of Atlantic salmon: evidence from the microchemistry of scales	Completed	Measure the stable isotope and trace element compositions from salmon scales in relation to variations in the marine environment and develop a model to predict impacts of changes in the marine environment on return rates of salmon.	2007 – 2010	Life history/ biological processes	Post-fishery recruitment marine factors	England and Wales		Clive Trueman	
European Union - UK (England and Wales)	Ew13	Development and application of salmonid life cycle models	Completed	Review available models to assess suitability and build on existing models or develop new models to *inter alia* compare marine and freshwater factors affecting stocks.	2009 – 2013	Life history/ biological processes	Freshwater factors	England and Wales		Ted Potter	
European Union - UK (England and Wales)	Ew14	The impacts of contaminants and temperature on freshwater fish populations	Completed	Study the impacts of contaminants derived from intensive agriculture and aquaculture facilities on wild salmonids and investigate the implications of predicted climate change scenarios on the impacts of different sources of diffuse and point source pollution on wild fish populations.	2009 – 2014	Specific natural and anthropogenic factors	Pollutants	England and Wales		Andy Moore	
European Union - UK (England and Wales)	Ew15	Impacts on juvenile salmonid populations from a changing freshwater environment	Completed	Investigate how predicted changes in the freshwater environment might impact on juvenile salmonid populations and how changing conditions during the early life history stages may influence their behaviour and subsequent survival within the marine environment.	2009 – 2015	Life history/ biological processes	Freshwater factors	England and Wales		Bill Riley	
European Union - UK (England and Wales)	Ew16	**Impacts of in-river hydropower production on migratory fish**	**Ongoing**	Examine the cumulative effects of freshwater hydropower schemes on habitat connectivity within river basins and on the migratory behavior and survival of Atlantic salmon and European eels, and assess potential effects at the fish population level. Examine how delays to seaward migration of smolts as a result of in-river renewable energy schemes may compromise the fish once they enter the sea.	2012 - 2017	Specific natural and anthropogenic factors	Obstructions to fish movements	Rivers in Southern England (e.g. Frome and Ribble)		Andy Moore	£168,000
European Union - UK (England and Wales)	Ew17	**Estuarine habitat requirements and distribution of diadromous fish**	**Ongoing**	Examine the residency and habitat preferences of migratory fish within estuaries and assess the impact of construction and operation of man-made structures on the migratory behavior and survival of key diadromous fish species as they move between the marine and freshwater environments.	2012 - 2016	Specific natural and anthropogenic factors	Pollutants	Estuaries and coastal waters in England and Wales		Andy Moore	£100,000
European Union - UK (England and Wales)	Ew18	Genetic stock indentification of salmon caught in the Faroes fishery	Completed	Catalogue scale samples collected from 1984 to 2000; identify a selection of scales that will best represent the stock composition during a baseline period(s); use GRAASP to provide country/region of origin assignments; report on how the results can be used in the provision of catch advice.	2012 - 2015	Distribution/ migration in the sea	Origin of catches in directed fisheries	Laboratory based study in Norway and UK; samples from Faroese fishery	UK, Norway, Faroes	Ted Potter	

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European Union – UK (England and Wales)	Ew19	**Salmonid Management Round the Channel (SAMARCH)**	**New Entry**	SAMARCH will provide new transferable scientific evidence to inform the management of salmon and sea trout (salmonids) in the estuaries and coastal waters of both the French and English sides of the Channel. It will provide new information to further improve the models used in England and France to manage their salmonid stocks. Although the project involves working on a number of rivers in the Channel area, the majority of the data collection and research will focus on the five salmon and sea trout "index" rivers in the Channel area. These are the rivers Frome and Tamar in the south of England and the Scorff, Oir and Bresle in northern France.	2017 - 2022	Life history/biological processes	Post-fishery recruitment marine factors	France and England – Channel area and the River Frome and Tamar (southern England) and the rivers Scorff, Oir and Breasle in northern France	European Union - France	Dylan Roberts	
European Union – UK (Northern Ireland)	Ni1	Development of conservation limits, pre-fishery abundance and management of the Foyle salmon fishery	Completed	Build upon the existing Foyle salmon management system, develop it into a precautionary catch advice framework that fully takes account of biological data on stock abundance and which fulfils all the main requirements of the Precautionary Approach.	2005 - 2008	Long-term monitoring	Time series of marine survival in relation to environmental parameters	Foyle area, Ireland	Ireland, France, Scotland	Patrick Boylan	
European Union – UK (Northern Ireland)	Ni2	**The marine survival of Atlantic salmon from the River Bush, Northern Ireland**	**Ongoing**	Investigate factors influencing the survival at sea of salmon smolts migrating from the River Bush until their return as adults.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	River Bush, N. Irish/Irish coastal waters and distant-water fisheries	Ireland (tag recovery programme)	Dennis Ensing	£260,000
European Union – UK (Northern Ireland)	Ni3	Investigating the movement and mortality of Atlantic salmon in the Foyle from river to sea	Completed	To establish movement and potential for loss of smolts in their riverine migration and early marine phase	2013 - 2016	Distribution/ migration in the sea	Migratory behaviour of individual fish	Foyle catchment and L Foyle to where it entered the North Atlantic	Scotland	Patrick Boylan	
European Union – UK (Northern Ireland)	Ni4	**COMPASS (Collaborative Oceanography & Monitoring for Protected Areas and Species)**	**Ongoing**	Tracking sea-trout and salmon movement in the near-shore marine environment	2017 - 2022	Distribution/ migration in the sea	Migratory behaviour of individual fish	Island of Ireland; coast Belfast to Dublin	UK (Northern Ireland, Scotland), Ireland	Dr Robert Rosell	£162,000
European Union – UK (Northern Ireland)	Ni5	**The marine survival of Atlantic salmon from the River Bush, Northern Ireland**	**New Entry**	This long-term project centres on enumerating numbers of migrating wild smolts and returning adults to the River Bush, by means of trapping facilities, in order to assess return rates and maturation schedules. A programme of microtagging hatchery-origin smolts provides detailed information on exploitation levels and patterns in coastal and distant-water fisheries. Run-reconstruction modelling provides information on return rates to Irish homewaters, which provides an index of natural survival at sea.	Started in 1973 Project ongoing in 2018	Long-term monitoring	Time-series of marine survival / growth estimates	River Bush, Northern Irish/Irish coastal waters and distant-water fisheries.	European Union - Ireland (tag recovery programme)	Dr Dennis Ensing	£270,000
European Union – UK (Scotland)	Sc1	Testing and development of Institute of Marine Research (IMR), Bergen, Norway, salmon trawl gear	Completed	Test a prototype trawl developed by IMR, Bergen, Norway, which, rather than capturing post-smolts, records, by use of CCTV, their passage as they pass through an open-ended trawl net. A supplementary objective, dependent on the success of the gear trials, was to conduct a post-smolt survey at the shelf edge.	2006	Development of methods	Post-smolt survey methods	Scalloway Deeps (Shetland), the Minches	Norway	Julian MacLean, Jens Christian Holst, Dick Shelton	
European Union – UK (Scotland)	Sc2	Protecting salmonid fisheries from seal damage	Completed	Develop and apply new molecular tools for discriminating among species of fish in the diets of seals from their remains in scats. Test the possibility of using molecular tools to quantify the occurrence of diet components. Develop and deploy cetacean-friendly seal-scarer. Identify factors influencing in-shore migration routes of salmon. Characterise behavioural interactions between salmon and their predators and seals and their prey. Investigate the digestion of otoliths during passage through a seal's gut.	2003 - 2008	Specific natural and anthropogenic factors	Predation	Principally North West (Shieldaig), North-East Scotland (Cromarty Firth). Possible work in other estuaries as required.		John Armstrong	
European Union – UK (Scotland)	Sc3	**Post-smolt mortality of Atlantic salmon**	**Ongoing**	Assess post-smolt mortality rates of Atlantic salmon from three Scottish rivers, and the contribution of these salmon to fisheries that exploit them.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	North Esk, Aberdeenshire Dee (two tributaries), River Conon		Gordon Smith, Iain Malcolm, John Armstrong	£50,000

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European Union – UK (Scotland)	Sc4	**Analysis of post-smolt life history by scale reading**	**Ongoing**	Investigate the relationship between growth and mortality, particularly during the marine phase, by analysis of scale growth patterns. Identify periods crucial to survival.	Annual	Long-term monitoring	Time series of marine survival in relation to environmental parameters	Samples from around Scotland and from North Esk and Girnock Burn in particular	USA and Canada	Gordon Smith	£10,000
European Union – UK (Scotland)	Sc5	Fisheries-induced evolution	Completed	Analyse the prevalence and consequence of fisheries-induced adaptive changes in exploited salmon stocks.	2007 - 2010	Distribution/ migration in the sea	Origin of catches in directed fisheries	Scotland and Ireland and across European species' distribution, including marine migration routes.	Austria, Norway, France, Denmark, Belgium, UK, Netherlands, Finland, Germany, Spain	Ulf Dieckman, John Gilbey, Philip McGinnity	
European Union – UK (Scotland)	Sc6	**Size and condition of returning grilse (1SW) and MSW salmon**	**Ongoing**	Investigate decadal trends in the size and condition of adult salmon returning to Scotland.	Annual	Life history/ biological processes	Post-fishery recruitment marine factors	Six locations in Scotland, in particular North Esk.		Philip Bacon	£30,000
European Union – UK (Scotland)	Sc7	Development of a General Spatial Model of within river population structuring in Scottish Atlantic salmon (POPMOD)	Completed	Improve the scientific basis for *inter alia* setting biologically appropriate conservation limits, providing advice on conservation and restoration initiatives, accurately and cost-effectively monitoring the status of salmon stocks.	2008 - 2011	Distribution/ migration in the sea	Origin of catches in directed fisheries	River systems across Scotland		Eric Verspoor	
European Union – UK (Scotland)	Sc8	Focusing Atlantic salmon management on Atlantic salmon (FASMOP)	Completed	Establish the number and spatial boundaries of breeding populations of salmon within any Scottish river system; establish the ancestral relationships and functional biological differences between wild salmon stock components across Scottish rivers; improve local management practice and increase the focus of management on local breeding populations.	2009 – 2013	Distribution/ migration in the sea	Origin of catches in directed fisheries	River systems across Scotland		Stuart Middelmas, Calum Sinclair	
Norway	N1	Identification of salmon by geochemical signatures; further development and testing of methods	Completed	Test if geochemical signatures are stable from year to year; test if geochemical signatures of salmon scale samples can be used to discriminate among fish from different rivers; develop analytical procedures (otolith core sampling, chemical and statistical analyses) for application of this method in ecological studies on Atlantic salmon.	2002	Life history/ biological processes	Post-fishery recruitment marine factors	Laboratory study		Peder Fiske	
Norway	N2	Development of models to predict marine survival and return of salmon to Norway	Completed	Identify and examine the feasibility of applying time series of marine environmental data, zooplankton productivity, productivity of pelagic fish and salmon life-history information for model development. Develop appropriate models.	2002 - 2005	Long-term monitoring	Time series of marine survival in relation to environmental parameters	Desk study of existing data	USA, Canada, EU	Lars Petter Hansen	
Norway	N3	By-catch in pelagic fisheries as a population-regulating factor in wild salmon stocks	Completed	Investigate the extent of by-catch of salmon post-smolts and develop management advice to reduce by-catch while maintaining catch rates in the mackerel fishery.	2001 - 2005	Distribution/ migration in the sea	By-catches in pelagic fisheries	Norwegian Sea	Russia, Scotland	Jens Christian Holst	
Norway	N4	Sea lice as a population-regulating factor in Norwegian salmon: status, effects of measures taken and future management	Completed	Further clarify the effects of sea lice on wild salmon populations and propose measures to reduce sea lice infections in wild salmon and develop alternative measures in critically affected stocks.	2002 - 2005	Specific natural and anthropogenic factors	Fish farms	Sognefjord and Altafjord		Jens Christian Holst	
Norway	N5	Distribution of salmon in relation to environmental parameters and origin in the North Atlantic – capture, tagging and release of salmon with data storage tags (DSTs)	Completed	Investigate the temporal and spatial distribution of DST-tagged salmon in the Norwegian Sea and adjacent areas, with emphasis on spatial distribution and temperature preferences; growth in relation to environmental parameters; and diurnal vertical distribution.	2003 - 2006	Distribution/ migration in the sea	Migratory behaviour of individual fish	Northern North Sea, Norwegian Sea, Iceland Sea, Greenland Sea	Faroe Islands, Iceland	Marianne Holm	
Norway	N6	Temporal variation in abundance of the northern-most populations of Atlantic salmon with emphasis on the River Tana	Completed	Examine the influence of ocean climate, predation, marine fisheries and smolt production on the abundance of salmon with emphasis on the River Tana	2002 - 2006	Long-term monitoring	Time series of marine survival in relation to environmental parameters	River Tana	Finland, Russia, Canada	Martin Svenning	

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Norway	N7	The importance of early marine feeding on the growth and survival of Atlantic salmon post-smolts in Norwegian fjords	Completed	Analyse spatial variation in early marine post-smolt feeding and growth along a north-south geographical scale; investigate how post-smolt feeding and growth is associated with timing of smolt descent, marine prey availability, parasite infection, fjord migration, and abiotic factors.	2002 - 2007	Life history/ biological processes	Pre-fishery recruitment marine factors	Central and Northern Norway	Canada	Bengt Finstad	
Norway	N8	Distribution and ecology of post-smolts and salmon at sea	Completed	Analyse age, growth and migratory paths in relation to environmental conditions and competitors so as to expand understanding of salmon marine life-history in order to explain observed variations in salmon survival.	2002 - 2007	Distribution/ migration in the sea	Distribution of salmon in the sea	West of Ireland – Faroes, northern North Sea, Norwegian Sea	Faroe Islands	Marianne Holm	
Norway	N9	Dispersal of salmon lice in Norwegian fjords	Completed	Estimate and describe to what extent free-living salmon lice larvae disperse from wild and farmed sources within and between areas.	2007	Specific natural and anthropogenic factors	Fish farms	Hardangerfjord, Norway		Karin Kroon Boxaspen	
Norway	N10	Experimental tagging programme for investigating the behaviour of escaped farmed salmon: pilot study	Completed	Examine the migration of escaped large farmed salmon and test if they are transported with the currents and appear in Norwegian waters.	2006 - 2007	Specific natural and anthropogenic factors	Fish farms			Lars Petter Hansen	
Norway	N11	Individual assignment of salmon caught in the ocean to region of origin	Completed	Investigate genetic variation in Norwegian Atlantic salmon populations on different spatial scales. Provide calibrated data from micro-satellite markers for a database. Analyse samples caught in the ocean and assign to country/region of origin.	2006 - 2009	Distribution/ migration in the sea	Origin of catches in directed fisheries	Norway	Finland	Oystein Skaala, Vidar Wennevik	
Norway	N12	Migratory behaviour of smolts and post-smolts of cultured Atlantic salmon	Completed	Study the change in migratory behaviour from smolts during the post-smolt stages in cultured Atlantic salmon.	2008 - 2009	Distribution/ migration in the sea	Migratory behaviour of individual fish	Masfjorden, western Norway		Ove Skilbrei	
Norway	N13	**Significance of salmon lice for growth and survival of salmon in the sea**	**Ongoing**	Estimate the effects of salmon lice on post-smolt growth and survival, dependent on release site and time and year of release.	2006 -	Specific natural and anthropogenic factors	Fish farms	Western Norway; River Dale and nearby coast.		Vidar Wennevik	£75,000
Norway	N14	**Marine survival, growth and exploitation of salmon from the Rivers Figgjo, Imsa, Drammenselv and Halselv**	**Ongoing**	Estimate marine survival, marine growth and marine exploitation of salmon from four rivers in Norway. Develop predictive models.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	Rivers Figgjo, Imsa, Drammenselv and Halselv with tag recovery programme in fisheries along Norwegian coast and elsewhere		Peder Fiske,Nina Jonsson. Arne Johan Jensen	£134,000
Norway	N15	Population-limiting mechanisms for Atlantic salmon during early estuarine and coastal migration (SALPoP)	Completed	Map migratory behaviour and quantify where, when and why mortalities occur; correlate data on migration and mortalities with health status and major population-limiting factors; develop improved mitigating actions and management strategies to contribute to sustainability of salmon populations.	2008 - 2012	Distribution/ migration in the sea	Migratory behaviour of individual fish	Eresfjord in Møre and Romsdal, mid Norway	Sweden, UK, Canada	Bengt Finstad	
Norway	N16	The Hardangerfjord salmon lice project	Completed	Improve sea lice monitoring and management; evaluate success of sea lice management strategies; quantify the abundance and distribution of salmon lice in the Hardangerfjord area; analyse data sets for possible risk factors associated with varying lice infection pressure.	2007 - 2010	Specific natural and anthropogenic factors	Fish farms	Hardangerfjord on the Norwegian west coast	Canada, UK	Bengt Finstad	
Norway	N17	Origin of Atlantic salmon off Svalbard	Completed	Identify the origin of Atlantic salmon occurring in gill net fisheries at Isfjorden, Spitsbergen, by life history (age, growth) and genetic analyses.	2008 - 2012	Distribution/ migration in the sea	Origin of catches in directed fisheries	Isfjorden, Spitsbergen		Arne Johan Jensen	
Norway	N18	**SALMOTRACK - Electronic tracking of northern anadromous salmonids**	**Ongoing**	Track different life-stages of northern Atlantic salmon and other anadromous species in river, fjord and open ocean.	2006 – 2012 2013 - 2016	Distribution/ migration in the sea	Migratory behaviour of individual fish	Northern Norway (Alta, Neiden, Tana, Skibotn); Mid Norway (Orkla); Western Norway (Hardangerfjord)	Denmark, UK, Finland, USA, Japan, Ireland, Canada	Audun H. Rikardsen	£0

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Norway	N19	Trilateral cooperation on our common resource; the Atlantic salmon in the Barents region (Kolarctic salmon 2011 - 2013)	Completed	Develop an integrated, long-term management of Atlantic salmon in the sea and in rivers in the northernmost distribution areas of the Atlantic salmon; provide data to implement customized, sustainable, knowledge-based harvesting regimes, and to preserve the rich traditions of fishing and coastal culture; unite empirical knowledge (local and traditional) with scientific knowledge; provide synthesized and new knowledge about Atlantic salmon, its adaptation to climate change and its migration along the coast.	2011 - 2013	Distribution/ migration in the sea	Origin of catches in directed fisheries	Barents region; Northern Norway, Finland and Russia	Finland, Russian Federation	Tiia Kalske	
Norway	N20	Effects of salmon lice on wild salmonid populations; filling in knowledge gaps (LicePop)	Completed	To assess: to what extent lice from farms occur on wild fish; how many lice a wild fish can tolerate under natural conditions before its viability is compromised; to what extent wild fish are able to combat lice infection through adaptations aimed at reducing infestations; and to what extent sea lice can reduce or regulate wild populations of salmonids.	2013 – 2015	Specific natural and anthropogenic factors	Fish farms	Hardangerfjord, Norway	New Zealand, UK (Scotland)	Bengt Finstad	
Norway	N21	**Salmon migrating through a maze in a changing world: building a dynamic management regime for a multi-stock system affected by extensive mixed-stock fisheries**	**Ongoing**	Analyze and explain the historical variation amd recent decline in the abundance of Atlantic salmon from different sub-populations of the Tana complex.	2015 - 2017	Distribution/ migration in the sea	Origin of catches in directed fisheries	Barents Sea and Tana river	Norway, Finland	Martin A.Svenning	£218,000
Norway	N22	**ATLANTIC SALMON AT SEA - factors affecting their growth and survival (*SeaSalar*)**	**New Entry**	A consortium has been formed aiming to build a knowledge platform and study how the marine survival of Atlantic salmon is affected by abiotic and biotic variables in the ocean. This will be done by examining the physical and biological environment at sea that can potentially influence Atlantic salmon growth and survival, mapping the marine distribution and migration routes, analyse the variation in growth and survival over time and geographic areas, and combining data to identify factors affecting marine survival. It will establish a long-term inter-institutional collaboration platform, as a hub for present and future projects with strengthened collaborative use of data.	August 2018 - 2022	Long-term monitoring	Time-series of marine survival / growth estimates	Atlantic Ocean and Barents Sea	Norway, Canada, European Union - Ireland and European Union - UK	Eva B. Thorstad	£825,000
Russian Federation	R1	Assessment of by-catch of post-smolts of Atlantic salmon in pelagic fisheries in the Norwegian Sea	Completed	Assess the occurrence of post-smolts in catches by Russian vessels engaged in the pelagic fisheries for mackerel, blue whiting and herring.	2002 - 2007	Distribution/ migration in the sea	By-catches in pelagic fisheries	Norwegian Sea		Boris Prischepa, Alexander Zubchenko	
Russian Federation	R2	**Monitoring of the stock status, abundance assessment and provision of advice on the allowable level of harvest of Atlantic salmon**	**Ongoing**	Estimate survival of juveniles and adult return rates; estimate natural and fishing mortality; study population dynamics; assess population sizes and spawning escapement; and estimate allowable catch.	Annual	Long-term monitoring	Time series of marine survival/growth estimates	Atlantic salmon rivers of the Murmansk Region, Archangel Region, Nenets Autonomous Okrug, Republic of Komi, and Karelian Republic		Sergey Prusov, Igor Studenov	£60,000
Russian Federation	R3	Establishing a genetic baseline of northern salmon populations across the Russian – Norwegian border for management purposes	Completed	Establish a genetic baseline of sufficient resolution for the purposes of partitioning bag net catches between Russian and Norwegian regions.	2009 - 2010	Distribution/ migration in the sea	Origin of catches in directed fisheries	Northern Norway, North West of the Russian Federation	Norway	Vidar Wennevik (IMR), Sergey Prusov (PINRO)	
United States of America	U1	Forecasts of Atlantic salmon transoceanic migration: climate change scenarios and anadromy in the North Atlantic	Completed	Develop and evaluate marine migration models for Atlantic salmon from North America and Europe; evaluate the potential effects of climate change on migration patterns of Atlantic salmon.	2002 - 2004	Distribution/ migration in the sea	Migration and bioenergetic models	Desk study	Canada	Kevin Friedland	
United States of America	U2	Stable isotope composition of Atlantic salmon scales	Completed	Develop a retrospective time series of stable isotope ratios for the DPS in Maine and the mixed-stock samples from the continental stock complex to evaluate feeding patterns of the stocks over time.	2001 - 2002	Life history/ biological processes	Post-fishery recruitment marine factors	Desk study. Analysis of scale samples collected at West Greenland and from US returns.	International collaboration in obtaining samples	Kevin Friedland	

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United States of America	U3	Ultrasonic telemetry of smolts and post-smolts in the Narraguagus River and Narraguagus Bay	Completed	Evaluate migration timing and pathways in the lower Narraguagus River and Narraguagus Bay and estimate survival of migrating smolts and post-smolts.	2002 - 2009	Distribution/ migration in the sea	Migratory behaviour of individual fish	Narraguagus River, Narraguagus Bay and Gulf of Maine	Canada	James Hawkes	
United States of America	U4	**Penobscot hatchery versus wild smolt telemetry**	**Ongoing**	Evaluate migration timing and pathways in the Penobscot Estuary and Bay and estimate survival of migrating smolts and post-smolts.	2005 - 2017	Distribution/ migration in the sea	Migratory behaviour of individual fish	Penobscot Estuary, Penobscot Bay	Canada	James Hawkes	£10,000
United States of America	U5	**Comprehensive evaluation of marine survival of hatchery-stocked smolts: migration behaviour and success of Dennys River smolts**	**Ongoing**	Evaluate migration speed and behaviour from lower river release sites through estuarine habitat; estimate survival of migrating smolts and identify areas where mortality may be occurring.	2001 - 2017	Distribution/ migration in the sea	Migratory behaviour of individual fish	Dennys River, Cobscook Bay, Gulf of Maine	Canada	James Hawkes	£10,000
United States of America	U6	Comprehensive evaluation of marine survival of hatchery-stocked smolts: Dennys River smolt stocking assessment	Completed	Evaluate smolt-to-adult survival rates based on temporal and spatial patterns of release; determine optimal stocking levels to achieve stock rebuilding objectives.	2001 - 2012	Long-term monitoring	Time series of marine survival/growth estimates	Dennys River, Cobscook Bay, Gulf of Maine	Recovery of marked fish through NASCO West Greenland sampling programme	Joan Trial	
United States of America	U7	Evaluation of estuary and nearshore marine distributions of Atlantic salmon post-smolts in Penobscot Bay and the Gulf of Maine	Completed	Evaluate nearshore distribution and migration pathways of smolts and post-smolts; estimate the relative contribution of stocked hatchery smolts to overall post-smolt populations; evaluate the relative contribution of spatially and temporally distinct smolt releases on post-smolt populations; evaluate the physiological condition of post-smolts in marine environments.	2001 - 2011	Distribution/ migration in the sea	Distribution of salmon in the sea	Penobscot Bay, Gulf of Maine		Tim Sheehan	
United States of America	U8	Cormorant harassment in the Narraguagus River/Narraguagus Bay	Completed	Reduce predation on migrating salmon smolts by excluding double-crested cormorants from the Lower Narraguagus River and Bay, and assess the efficacy of non-lethal predator exclusion as a means of reducing predation on migrating Atlantic salmon smolts.	2005 - 2012	Specific natural and anthropogenic factors	Predation	Lower Narraguagus River, Estuary and Narraguagus Bay, Maine		James Hawkes	
United States of America	U9	**SALSEA Greenland**	**Ongoing**	Advance understanding of the ecology of the Atlantic salmon West Greenland stock complex and to gain insights into the factors resulting in recent significant increases in marine mortality across the North Atlantic. (The baseline sampling programme at West Greenland is described in project D1)	2009 - 2018	Distribution/ migration in the sea	Origin of catches in directed fisheries	Ilulissat, Sisimiut, Nuuk and Qaqortoq, Greenland	Colloborative project with countries detailed in project D1 and scientists from SALSEA-Merge	Tim Sheehan	£15,000
United States of America	U10	**Using Pop-up Satellite Tags (PSATs) to track adult Atlantic salmon in the Northwest Atlantic**	**Ongoing**	Provide information on localized movement patterns of Atlantic salmon off the coast of West Greenland, large scale movement and migration patterns en route to natal rivers in North America and Europe, locations of overwinter residences and depths and temperatures experienced during the second or third winter at sea in the North Atlantic. These data will be used to evaluate if conditions experienced from September through April are favourable for survival and subsequent spawning escapement.	2010 - 2017	Distribution / migration in the sea	Migratory behaviour of individual fish	Coastal waters off West Greenland	Norway, Greenland and UK	Mark Renkawitz	£10,000
United States of America	U11	Impact of oceanographic changes on Atlantic salmon survival in the Northwest Atlantic	Completed	Determine mechanisms controlling the ecosystem-salmon connections and hypothesize on their implications for salmon populations in the future.	2010 -2014	Long-term monitoring	Time series of marine survival in relation to environmental parameters	Desk study		Tim Sheehan	
United States of America	U12	Evaluation of the importance of predator and prey fields and ocean circulation on Atlantic salmon growth and survival in the Gulf of Maine	Completed	Evaluate the consequences for Atlantic salmon post-smolt growth and survival of the match or mismatch of spawning runs of diadromous fishes, aggregations of other marine forage fishes, and thermal/circulation patterns in the Gulf of Maine (GoM) with the timing of Atlantic salmon out-migration.	2010 - 2014	Life history/biological processes	Pre-fishery recruitment marine factors	Desk study		John Kocik	

Jurisdiction	Project No	Title	Status	Summary of Objectives	Research Dates	Topic Area	Objective/Issue	Area of Research	Collaborating Countries	Coordinating Scientist	Annual Expenditure
United States of America`	U13	**Migration timing of Atlantic salmon smolts from Penobscot Bay to the Scotian Shelf**	**Ongoing**	Evaluate the migration timing and likely spatial extent of Gulf of Maine Atlantic salmon post-smolts along migration to the Ocean Tracking Network's Halifax Array and other distant water telemetry assets in the OTN network.	2013 - 2017	Distribution / migration in the sea	Migratory behaviour of individual fish	Desk study	Canada	John Kocik	£10,000
United States of America`	U14	**Impact of oceanographic changes on Atlantic salmon survival in the Northwest Atlantic**	**Ongoing**	Investigate the hypothesis that ecosystem changes have influenced the energy needed by and available to Atlantic salmon and thereby have affected salmon growth, survival, and productivity during their marine phase	2014 - 2019	Life history/biological processes	Pre-fishery recruitment marine factors	Desk Study		Tim Sheehan	£70,000
United States of America`	U15	**Species interactions in the Penobscot Estuary**	**Ongoing**	Merge datasets from acoustic telemetry smolt tagging studies and hydro-acoustic data collected within the Penobscot Estuary; describe overlap of timing and location (along river and within the water column) data of Atlantic salmon smolts and hydro-acoustic data targets (river herring); and describe and compare these data and how it relates to survival.	2013 - 2017	Specific natural and anthropogenic factors	Predation	Penobscot Estuary, Maine		James Hawkes	£50,000
United States of America`	U16	**Acoustic telemetry evaluation of migration performance in the Kennebec Estuary**	**Ongoing**	Evaluate smolt emigration dynamics and timing in the Lower Kennebec River and Estuary and Merrymeeting Bay; and estimate survival of migrating smolts and post-smolts	2014 - 2017	Distribution / migration in the sea	Migratory behaviour of individual fish	Kennebec Estuary, Maine		Graham Goulette	£53,000
United States of America	U17	**Effects of climate-driven ecosystem change on Atlantic salmon growth and survival at sea; analyses of West Greenland salmon**	**Ongoing**	Understand Atlantic salmon growth as a mechanism linking ecosystem conditions to population outcomes.	2017 - 2018	Life history/biological process	Post-fishery recruitment marine factors	Desktop study. Scale samples collected at Greenland.	Canada	Timothy Sheehan	£45,000
France – St Pierre and Miquelon	F1	**St Pierre and Miquelon Salmon Fishery Sampling Programme**	**Ongoing**	Improve understanding of the biological characteristics and origin of salmon harvested in the fishery at St Pierre and Miquelon.	Annual	Distribution/ migration in the sea	Origin of catches in directed fisheries	Around the islands of St Pierre and Miquelon	Canada	Herlé Goraguer	-

Annex 1

Inventory of Research relating to Salmon Mortality in the Sea

Project Details

CANADA

Project No. C1 Status: Completed

Party or relevant jurisdiction	Canada Maritimes Region
Title of project	**Marine migration and survival of post-smolt Atlantic salmon from Bay of Fundy rivers**
Objective of research project	Provide knowledge about marine habitat (migration routes and feeding grounds) used by salmon post-smolts from Bay of Fundy rivers. Determine the location, timing and extent of salmon post-smolt mortality at sea. Investigate the causes and mechanisms of marine mortality of salmon post-smolts. Provide information to fuel the recovery programme for inner Bay of Fundy salmon stocks.
Brief description of research project	**Salar MAP**, the Atlantic Salmon Marine Acoustic-tracking Project, tagged wild Atlantic salmon smolts from inner and outer Bay of Fundy rivers and monitored their movements in the Bay of Fundy and Gulf of Maine over a period of up to 6-8 months after entry into sea water. A new generation of coded acoustic tags, automated underwater receivers, and new methodology developed and tested by Salar MAP over the past 6 years was used to map the migration routes and fine-scale distribution of post-smolts over time. Wild smolts captured using rotary screw traps or other live traps were tagged and released throughout the migration period to examine issues of synchrony related to the transition from fresh to salt water and subsequent distribution. Naturally-emigrating wild smolts were used to clarify possible environmental influences originating in fresh water on migration and survival. A key feature of the approach developed is that the high efficiency of the tag detection screens (ref. 1999 pilot study) could provide a direct measure of survival of tagged post-smolts over specific periods and to specific points along the migration route. Other fishery-independent information obtained by tagging included the timing, location and rate of departure from the river and inner and outer bay sectors, travel direction, behaviour and movements in relation to environmental associations. The potential for interaction with aquaculture cage sites was also determined by tracking. Post-smolt migration routes and distribution throughout the Bay of Fundy were determined during the first summer at sea. Extended monitoring to early winter could discover where salmon of inner bay stocks go to over-winter, which may be crucial to any recovery plans. The information obtained from tagging will help direct the efforts of marine surveys using trawling to capture live Atlantic salmon for examination and release.
Dates during which research took place	This project, which commenced in 2001, was completed in September 2002. Data were analyzed through to the fall of 2003.
Area in which research took place	Bay of Fundy and Gulf of Maine
Estimated number and weight of salmon retained	None. All smolts sampled and those surgically tagged were released alive.

Resources	
Estimated cost of the research project	Estimated £176 K per year (includes DFO ship time and salaries including overheads) Approx. £245 K spent in 2000/01 by NGO partners for capital acquisitions and O&M to start up project. Principal Supporting Partners (NGO): Atlantic Salmon Federation VEMCO Limited First Nations
Number of participating scientists	
Name of coordinating scientist in charge of project	Gilles L Lacroix LacroixG@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Tracking vessel: SALAR (licence no. C02371NB; Rosborough RF-247, 7.5 m fibreglass boat with twin 115 hp outboard motors, based at St. Andrews Biological Station) Gear deployment vessels: CCG Pandalus III (Canada Coast Guard, 12.5 m research vessel, based at St. Andrews Biological Station) Commercial Charters (inshore and offshore lobster boats) Other CCG vessels (as required)
Type and amount of gear and other equipment used	Coded acoustic tags (Vemco, various pinger types, sizes, and durations, approx. 200-300 tags per year). Automated underwater acoustic monitoring receivers (Vemco, various types, approx. 200 units). Tracking receivers (Vemco, various types for detection and active tracking). Receiver moorings (various types and designs, approx. 200). Traps for capture of live smolts in rivers (various types and designs, including E.G. Solutions rotary screw fish traps, approx. 4 traps). Surgical gear and method as per established protocol.
Details of any collaborating countries	U.S.A.: John Kocik, National Marine Fisheries Service, NOAA Ken Beland, State of Maine Atlantic Salmon Commission (smolt tagging and collaboration in tracking post-smolts in the Gulf of Maine)

Summary of Findings:

Atlantic salmon smolts were tagged in the spring of 2002 (n=378) and released from inner and outer Bay of Fundy rivers (241 inner bay, 137 outer bay). Two lines comprising 132 receivers (VR-2, Vemco Ltd.) were deployed for tracking inner and outer bay movements of post-smolt salmon. Data is being analyzed to publish in 2004.

No resources were allocated to this project in 2003, and no resources will be allocated in 2004. The project represented the first phase of research to define the migration and early marine survival of post-smolts from rivers of the Bay of Fundy, and it has now been completed.

Publication:

Lacroix, G.L., McCurdy, P., and Knox, D. 2004. Migration of Atlantic Salmon Postsmolts in Relation to Habitat Use in a Coastal System. Transactions of the American Fisheries Society 133: 1455-1471.

Lacroix, G.L., and Knox, D. 2005. Distribution of Atlantic salmon (*Salmo salar*) postsmolts of different origins in the Bay of Fundy and Gulf of Maine and evaluation of factors affecting migration, growth, and survival. Canadian Journal of Fisheries and Aquatic Sciences 62: 1363-1376.

Lacroix, G. 2008. Influence of origin on migration and survival of Atlantic salmon (Salmo salar) in the Bay of Fundy, Canada. Canadian Journal of Fisheries and Aquatic Sciences 65: 2063-2079.

Lacroix, G.L., D. Knox, T.F. Sheehan, M.D. Renkawitz, and M.L. Bartron. 2012. Distribution of U.S. Atlantic Salmon Postsmolts in the Gulf of Maine. Trans. Amer. Fish. Soc., 141 (4): 934-942.

Lacroix, G.L. 2013. Migratory strategies of Atlantic salmon (*Salmo salar*) postsmolts and implications for marine survival of endangered populations. Can. J. Fish. Aquat. Sci. 70: 32-48.

Project No. C2 Status: Completed

Party or relevant jurisdiction	Canada Maritimes Region
Title of project	**Distribution, health and condition of Atlantic salmon from Bay of Fundy rivers while at sea**
Objective of research project	Provide knowledge about marine habitat and health of salmon post-smolts from Bay of Fundy rivers. Investigate the causes and mechanisms of marine mortality of salmon post-smolts. Provide information to fuel the recovery programme for inner Bay of Fundy salmon stocks.
Brief description of research project	The project proposed to conduct annual marine surveys using specialised trawling gear and techniques developed specifically to capture live Atlantic salmon of all sizes for examination and release. Gear and method development and testing cruises were conducted in 2000 and a 3-week survey was successfully completed in the Bay of Fundy in 2001. The survey determined the distribution of salmon from Bay of Fundy rivers during post-smolt migration at sea and may help discover the location of critical feeding habitat for assessment. The capture of live salmon at sea allowed assessment of health and condition over time and provided key information on growth, prey items, diseases and parasites, genetic origin, physiology, and environmental associations. This knowledge is essential in uncovering potential causes of marine mortality (through identification of factors involved or reduction of hypotheses listed to explain mortality). The project benefitted from the Salar MAP research activities because prior knowledge of migration routes and timing obtained through tagging and tracking helped find increasingly rare wild salmon of inner bay origin and decrease requirements for expensive ship time in the search for salmon.
Dates during which research took place	May to June, 2002-2004 Surveys during late May to mid-June 2003.
Area in which research took place	Bay of Fundy and Gulf of Maine
Estimated number and weight of salmon to be retained	All wild post-smolts and wild adult salmon captured alive were sampled and released. Fishing mortality (expected to be <5% based on 2001 survey) and salmon identified as having escaped from aquaculture sites retained.
Resources	
Estimated cost of the research project	Estimated £112 K per year (includes DFO ship time and salaries including overheads) Approx. £22 K spent in 2000/01 by NGO partners for capital acquisitions to start up project. Principal Supporting Partners (NGO): Atlantic Salmon Federation First Nations
Number of participating scientists	

Name of coordinating scientist in charge of project	Gilles L Lacroix LacroixG@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Trawling vessel: CCG Alfred Needler (Canada Coast Guard, 40 m fishing/research vessel, based at Bedford Institute of Oceanography, Dartmouth)
Type and amount of gear and other equipment used	Akrehamn post-smolt trawls (2 prototypes designed for surface trawling) and various extensions and accessories. Thyboron trawl doors (Type 8 doors for pelagic trawling). Light bridles and main warps for surface trawling. Live fish capture and holding cod-end tanks (several prototypes designed after fish-lift and aquarium developed by J.C. Host, IMR, Norway). Live fish holding tanks (aboard ship) and fish sampling gear.
Details of any collaborating countries	U.S.A.: Russell Brown, National Marine Fisheries Service, NOAA, Woods Hole (post-smolt trawling survey in the Gulf of Maine) Kevin Friedland, Umass/NOAA CMER Programme (retrospective growth analysis from scales) Norway: J.C. Holst and M. Holm, Institute of Marine Research, Bergen (post-smolt trawling surveys in fjords and at sea)

Summary of Findings:

Atlantic salmon *Salmo salar* post-smolts migrating through the Bay of Fundy and Gulf of Maine were surveyed and sampled in 2001-2003 by trawling in surface waters. Post-smolts were aggregated in several areas while in the Bay of Fundy and then dispersed over a broader area in the Gulf of Maine, and their distribution reflected major surface current patterns. There was considerable spatial and temporal overlap between migrating post-smolts and the herring fishery. Post-smolt origin (e.g., wild vs. hatchery, inner vs. outer Bay of Fundy) did not affect their distribution. The low density of post-smolts indicated that they were too scarce to form large schools that offer protection from pelagic predators. The recapture rate of marked post-smolts was higher for wild than for hatchery fish, but it was nil for wild fish from the salmon farming area. The health and condition of post-smolts was excellent; they had no bacterial or viral pathogens and no salmon sea lice. Environmental conditions and food supply apparently did not limit growth of post-smolts; new circuli on scales and their spacing indicated that growth at sea had started and was accelerating. Post-smolts had shifted to a pelagic foraging behaviour, feeding opportunistically on different prey depending on location; the main food items were amphipods, euphausiids, and fish larvae. Post-smolts of hatchery and wild origin consumed the same prey but the larger hatchery fish did so in much greater quantity than the wild post-smolts, possibly giving them a growth and survival advantage.

A trawling survey for post-smolts was conducted 4-18 June 2003 in Canadian waters of the outer Bay of Fundy and northern Gulf of Maine. Catches (n = 42 post-smolts) were lower than in the previous two years, and only 24% of the post-smolts captured were wild. They were in good health and free of diseases and sea lice. Analyses of growth and feeding habits were completed. The observed distribution confirmed and extended the distribution and origin data obtained in 2002.

Publications:

Lacroix, G. L. 2008. Influence of origin on migration and survival of Atlantic salmon (Salmo salar) in the Bay of Fundy, Canada. Canadian Journal of Fisheries and Aquatic Sciences 65: 2063-2079.

Lacroix, G. L and D. Knox. 2005.Distribution of Atlantic salmon (Salmo salar) postsmolts of different origins in the Bay of Fundy and Gulf of Maine and evaluation of factors affecting migration, growth, and survival. Canadian Journal of Fisheries and Aquatic Sciences 62: 1363-1376.

Project No. C3 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Marine migration and survival of post-smolt Atlantic salmon from the Saint-Jean River (Gaspé)**
Objective of research project	Provide knowledge of the marine habitat (migration routes and feeding grounds) used by salmon post-smolts from Bay of Gaspé rivers. Determine the location, timing and extent of salmon post-smolt mortality at sea. Investigate the causes and mechanisms of marine mortality of salmon post-smolts.
Brief description of research project	
Dates during which research took place	2005-2006
Area in which research took place	
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	
Number of participating scientists	
Name of coordinating scientist in charge of project	Julian Dodson julian.dodson@bio.ulaval.ca François Caron francois.caron2@mrnf.gouv.qc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	
Details of any collaborating countries	

Summary of Findings:

Publication:
Martin, F., Hedger, R.D., Dodson, J.J., Fernandes, L., Hatin, D., Caron, F., Whoriskey, F.G. 2009. Behavioural transition during the estuarine migration of wild Atlantic salmon (*Salmo salar* L.) smolt. Ecology of Freshwater Fish 18: 406-417.

Abstract
Ultrasonic telemetry and hydrodynamic modelling were used to study the migratory behaviour of 54 wild Atlantic salmon (*Salmo salar*) smolt captured in freshwater during their downstream migration and tracked in 2 years through a shallow estuary system. A high-density, fixed array of receivers provided detailed spatial and temporal resolution of behaviour in the second year of study. Smolt migration in the river occurred mostly at night and downstream migration was slower during the day.

In the estuary, smolt moved seaward on ebbing tides and landward on flooding tides. The effect of current velocity was greater during the night than during the day. We documented for the first time that current velocity and diurnal period only accounted for approximately one-third of the variation in smolt ground speeds in the estuary, indicating that smolt movements were far less passive than previously reported. Smolt energetic status had no effect on smolt swimming behaviour or migratory performance. With an increase in salinity, smolt seaward movements during flooding tides were more frequent, and overall seaward ground velocity increased. The increase in salinity experienced by the smolt during their migration through the leading edge of saltwater intrusion thus induced a behavioural transition from a more passive, fluvial migration to a more active- and seaward-oriented migration.

Project No. **C4** **Status:** **Completed**

Party or relevant jurisdiction	Canada
Title of project	**Marine migration and survival of kelt Atlantic salmon from the Saint-Jean River (Gaspé)**
Objective of research project	Provide knowledge of the marine habitat (migration routes and feeding grounds) used by salmon kelts from Bay of Gaspé rivers. Determine the location, timing and extent of kelt mortality at sea. Investigate the causes and mechanisms of marine mortality of salmon kelts. Provide information about migration routes used at sea, using code that can be detected by ASF project (see Fred Whoriskey project) at sea.
Brief description of research project	
Dates during which research took place	2006-2007
Area in which research took place	
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	
Number of participating scientists	
Name of coordinating scientist in charge of project	Julian Dodson julian.dodson@bio.ulaval.ca François Caron francois.caron2@mrnf.gouv.qc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	
Details of any collaborating countries	

Summary of Findings:

Publication:

Hedger, R.D., Hatin, D., Dodson, J.J., Martin, F., Fournier, D., Caron, F., Whoriskey, F.G. 2009. Migration and swimming depth of Atlantic salmon kelts *Salmo salar* in coastal zone and marine habitats. Marine Ecology Progress Series 392: 179-192.

Abstract

Factors influencing the migration and swimming depth of Atlantic salmon kelts *Salmo salar* L. within the York Estuary and Gaspe Bay (Quebec, Canada), and in the Gulf of St. Lawrence between Gaspe Bay and the Strait of Belle Isle (Newfoundland, Canada) were studied using acoustic telemetry. In 2006 and 2007, a total of 49 kelts were tagged with acoustic transmitters equipped with depth sensors, released in the river delta leading into the estuary, and tracked using a fixed receiver array within the

estuary and the bay. A large variation in migratory behavior existed, with some kelts making a direct, strongly oriented traverse across the estuary and bay, and others showing multiple changes in orientation. There was long-term residence (typically several weeks) in the river delta and rapid migration once kelts reached the estuary and bay resulting from seaward swimming, with a net seaward movement even on a flood tide. Diving was more frequent during daytime. It was hypothesized that diving may have been related to feeding and/or the identification of more temporally consistent sub-surface salinity gradients or current flow directions. The patterns of migration within the coastal zone were similar to those identified for smolts, implying a universal pattern of coastal zone migratory behavior in both smolts and kelts. Migration speed within the marine habitat was dependent on date of departure from Gaspe Bay, which in turn was dependent on the length of time kelts had remained in the delta. It was hypothesized that extended feeding within the delta allowed kelts to improve their physical condition, enabling them to migrate more rapidly in the marine habitat.

Project No. C5 Status: Completed

Party or relevant jurisdiction	Canada Scotia Fundy Region NGO (Atlantic Salmon Federation)/DFO collaboration (St. Andrews Biological Station)
Title of project	**Tracking experimentally 'escaped' farmed salmon**
Objective of research project	Determine the course tracks and fates of sonically tagged farmed salmon released in winter and spring
Brief description of research project	Salmon were obtained from a commercial grower in Cobscook Bay, Maine, fitted with tags and released. Their short-term displacements were compared to current circulation models developed by DFO for the region. Receivers were placed in rivers during the spawning season to determine if the fish survived to enter them. Results were used to evaluate the potential to recapture escaped farmed salmon in this fast (3kn – 5kn) environment.
Dates during which research took place	Winter/spring 2005
Area in which research took place	Cobscook Bay, Maine, USA; Quoddy Region, NB, Canada
Estimated number and weight of salmon retained	400 fish, tagged and released
Resources	
Estimated cost of the research project	Approx. £114 K for operations, salaries and acoustic tags Approx. £68 K for receiver arrays Approx £91 K for smolt wheels (Partner contribution: 6 wheels and their operation) Total: approx £273 K Principal Supporting Partners: Heritage Salmon
Number of participating scientists	8
Name of coordinating scientist in charge of project	Dr. Fred Whoriskey: asfres@nb.aibn.com
Details of research vessels, e.g. name, registration, call sign and description of vessel	Small boats (less than 20 feet in length) Chartered fishing vessel (approx 35 feet) for gear deployment
Type and amount of gear and other equipment to be used	Up to 76 VR 2 acoustic receivers 400 acoustic tags
Details of any collaborating countries	

Summary of Findings:

Publication:
Whoriskey, FG; P. Brooking, G. Doucette, S. Tinker, and J.W. Carr. 2006. Movements and survival of sonically tagged farmed Atlantic salmon released in Cobscook Bay, Maine, USA. ICES Journal of Marine Science 63: 1218-1223.

Abstract. We sonically tagged and released farmed Atlantic salmon (Salmo salar) from a cage site in Cobscook Bay, Maine, USA. The fish were released in January (n=75) and in April and May (n=198) 2004 to study their movement patterns and survival and to assess the possibility of recapturing them. Inshore and offshore waters in this region are subject to intense tidal currents. Tagged salmon dispersed >1km from the cage site within a few hours of their release. Mortality was high within Cobscook Bay and the surrounding coastal region (56% of the winter (January) releases; 84% of the spring (March) releases), probably the result of seal predation. Most surviving fish exited the coastal zone and entered the Bay of Fundy along the routes of the dominant tidal currents, passing through Canadian waters. No tagged fish were detected during the wild salmon spawning season in autumn 2004 in any of the 43 monitored salmon rivers draining into the Bay of Fundy, or during 2005 either in the Magaguadavic River, the site of the hatchery in which the fish were reared to the smolt stage, or by a limited coastal receiver array.

Project No. C6   Status: Completed

Party or relevant jurisdiction	Department of Fisheries and Oceans, Newfoundland Region
Title of project	**Atlantic salmon distribution and abundance at sea**
Objective of research project	(1) Determine the distribution and abundance of salmon, particularly post-smolts, in the Labrador Sea and northern Grand Banks; (2) Collect biological, meristic, morphometric, and biochemical data on salmon; (3) Investigate the relationship between salmon and prey by collecting stomach contents; (4) Investigate the relationship between sea temperature and other oceanographic parameters and salmon abundance; (5) Tag and release salmon in good condition.
Brief description of research project	The distribution of Atlantic salmon were studied using multiple mesh drift nets, and a surface trawl in the autumn. Relative abundance with respect to spatial distribution and sea temperature were inferred from catch rates. Fishing took place between 49^{o} 00’ N and 57^{o} 00’ N and 40^{o} 00’ W and 60^{o} 00’ W.
Dates during which research took place	September, 2001 Autumn 2003 and 2005
Area in which research took place	Labrador Sea and Northern Grand Banks
Estimated number and weight of salmon retained	500 post-smolts, ~ 0.5 t
Resources	
Estimated cost of the research project	£146 K (including overheads) in 2005
Number of participating scientists	1
Name/e-mail of coordinating scientist in charge of project	David Reddin ReddinD@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	CCGS Wilfred Templeman Canadian CGDV 50 m long of 925 GRT
Type and amount of gear and other equipment to be used	~2000 fathoms of monofilament drift gill nets of 77, 89, 102, 115, and 127 mm stretched measure. Surface trawl
Details of any collaborating countries	

Summary of Findings:

Trip program was reduced due to the need to survey for scallops in St. Pierre-Miquelon area and due to Search and Rescue missions. The Norwegian surface trawl was successfully fished from the Templeman. In total, there were 9 trawl sets with only one salmon post-smolt capture. Comparative fishing with gillnets resulted in the capture of 60 post-smolts. Other species caught in the trawl included billfish, Atlantic mackerel, lantern fish, jelly fish, squid, and amphipods. Two drift net sets were completed in the Labrador sea. Forty-seven post smolt salmon and 11 adult salmon were caught with an average length of each set being approx. 16 hrs. Disease survey on 35 specimens indicated no pathogens present. This trip brings to a close at sea research in the Labrador Sea/Grand Banks area.

Project No. C7 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Integrated field and laboratory assessment of the effects of endocrine-disrupting substances on Atlantic salmon smolts**
Objective of research project	- Laboratory tests of the effects of endocrine-active substances in municipal and industrial effluents, including estrogens, androgens, phytosterols and nonylphenol ethoxylates - Field tests of the effects of endocrine-active substances in municipal and industrial effluents, including estrogens, androgens, phytosterols and nonylphenol ethoxylates (caging and exposure and release studies) - Field tests caging smolts near sites with potential for significant agricultural runoff - Ocean field test of link between exposure of smolts to endocrine-disrupting substances and subsequent lower adult returns (Burrishoole River, Ireland, initially and Canada if methods prove feasible)
Brief description of research project	This project proposal was based on research conducted over the past three years under ESSRF/TSRI (DFO projects 95052 and 92548) funding which evaluated the effects of nonylphenol and other endocrine-disrupting substances on growth and survival of Atlantic salmon (*Salmo salar*) during and after smoltification. Nonylphenol, and the larger group of nonylphenol ethoxylates, are in use in almost all commercial, industrial and domestic sectors. These compounds are members of the second-largest class of non-ionic surfactants in use today, the alkylphenol polyethoxylates. Concentrations of these compounds occurring presently in the environment have been shown to have endocrine-disruptive effects on fish in rivers and estuaries downstream of municipal sewage treatment works. Sewage treatment works emit about 4% of their total nonylphenolic compound input as nonylphenol itself. This is a significant percentage as nonylphenol has a greater bioaccumulation potential than the nonylphenol ethoxylates. Nonylphenol ethoxylates are also used in about 20-25% of all pesticide and herbicide formulations available today. Nonylphenol itself (4-nonylphenol) has been used in the past as a major constituent in certain pesticide formulations, some of which were applied in Canada. The current research indicating estrogenic effects on fish at low 4-nonylphenol levels ($\mu g/l^{-1}$ range) raises the potential that pesticide formulations containing nonylphenol ethoxylates and leaving residues in water may be capable of affecting fish due to the presence of nonylphenol ethoxylate degradation products (including 4-NP), and not necessarily due to the presence of the pesticide's active ingredient. Atlantic salmon inhabit streams and lakes for their juvenile stages, and in eastern Canada have been exposed to pesticides applied for forest protection most years since the 1950s. Sensitive life stages may be affected by exposure to nonylphenol. Smoltification is a time of great stress for salmon, as they are changing physiologically and adapting to

	a new environment. Endocrine hormones play an integral part in the smoltification process. Additional stress or modification of endocrine function at this crucial life stage may pose problems for growth and survival of smolts as they enter salt water.
Dates during which research took place	2003-2007
Area in which research took place	Atlantic Canada and Co. Mayo, Ireland
Estimated number and weight of salmon retained	600 wild smolts per year from Miramichi River (Canada); about 14,000 smolts per year from Burrishoole River (Ireland).
Resources	
Estimated cost of the research project	About £115 K per year during 2003-2005, majority from DFO ESSRF plus other funds and in-kind support from Environment Canada, DFO, Marine Institute, Ireland, and others. In 2006 and 2007 no funding is expected but analysis of results will be ongoing.
Number of participating scientists	12 (DFO, Env Can, UNB, Marine Institute) plus two graduate students
Name and e-mail of coordinating scientist in charge of project	Wayne L. Fairchild FairchildW@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment used	Trap nets and fish holding cages in rivers in Canada
Details of any collaborating countries	Collaboration with Ken Whelan and Deirdre Cotter of the Marine Institute, Salmon Management Services Division, Furnace, Newport, Co. Mayo, Ireland - hatchery facilities, fish husbandry, capture and counting capability for Burrishoole River salmon.

Summary of Findings:

In 2004, smolts were exposed to pesticides (herbicides and nonylphenol) while in fresh water, and subsequent growth and survival was measured in the aquarium at the St. Andrews Biological Station, St. Andrews, NB. In 2003 and 2004, smolts were exposed to nonylphenol and estrogen at the Marine Institute, on the Burrishoole River, County Mayo, Ireland, and were then released to the North Atlantic. Adults were monitored in the returns to the river and in the interceptions in the coastal fisheries. Results from both treatment years (2003 and 2004) indicate variable survival among years and a decrease in sea survival of a cohort exposed to nonylphenol relative to controls. Field operations are complete, data are still being verified and analysed.

Publications:

Jardine, T.D., MacLatchy, D.L., Fairchild, W.L., Chaput, G. and Brown, S.B. 2005. Development of a short-term in-situ caging methodology to assess long-term effects of industrial and municipal discharges on salmon smolts. Ecotoxicology and Environmental Safety, 62:331-340.

Jardine, T.D., MacLatchy, D.L., Fairchild, W.L., Cunjak, R.A. and Brown, S.B. 2004. Rapid carbon turnover during growth of Atlantic salmon (*Salmo salar*) smolts in sea water, and evidence for reduced food consumption by growth-stunts. Hydrobiologia 527:63-75.

Arsenault, J.T., Fairchild W.L., Maclatchy, D.L., Burridge, L., Haya, K. and Brown, S.B. 2004. Effects of water-borne 4-nonylphenol and 17ß-estradiol exposures during parr-smolt transformation on growth and plasma IGF-I of Atlantic salmon (*Salmo salar* L.). Aquatic Toxicology 66:255-265.

Project No. C8 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Use of stable isotopes to assess long-term changes in marine trophic ecology of Atlantic salmon (*Salmo salar*)**
Objective of research project	1) To assess trophic and dietary information through analyses of stable isotope signatures of carbon and nitrogen ($\delta^{13}C$ and ^{15}N) from previously compiled scale samples of various stocks of Atlantic salmon; 2) To compare isotopic signatures within (temporal) and among (spatial) stocks to infer differences in salmon feeding ecology in time and space; 3) To examine evidence for any environmental influences on trends in isotopic signatures; 4) To examine linkages with stable isotopic signatures with trends in abundance of salmon.
Brief description of research project	Recent investigations have proposed that marine food webs have changed dramatically owing to ever-increasing and unsustainable levels of exploitation – the so-called 'fishing down marine food webs' hypothesis - while others have provided evidence of trophic cascades. In addition, evidence exists for dramatic changes in ocean climate conditions in the northwest Atlantic, particularly during the early 1990s, prompting some to suggest there has been a marine climate regime shift. Ocean climate conditions have been shown to affect productivity and survival of Atlantic salmon. Salmon are considered opportunistic feeders during the marine life-history phase, often targeting prey in the upper end of the size spectrum, with a preference for fish over crustaceans should both be available. Thus, the species lends itself well to studies associated with marine environmental conditions and food web interactions. Accordingly, long-term variability in the trophic ecology of Atlantic salmon were examined using analyses of stable isotope signatures of carbon and nitrogen ($\delta^{13}C$; $\delta^{15}N$). Specifically, changes in stable isotope signatures were evaluated for evidence of Pauly's food web hypothesis and also in relation to variation in marine climate conditions in the north Atlantic over the past several decades. These analyses should provide an additional means to understand, in whole or in part, observed variability in abundance and survival of various stocks of Atlantic salmon.
Dates during which research took place	2006 - 2007
Area in which research took place	Project has examined stable isotope signatures from six (6) Newfoundland salmon stocks, two (2) Maritime stocks and one (1) Quebec north shore population. In addition, to provide a greater geographic contrast with Eastern Canadian populations, analyses have also been carried out on a north European stock that empties into the Barents Sea, the River Tana (Teno).
Estimated number and weight of salmon retained	N/A

Resources	
Estimated cost of the research project	£27.5 K. Project funded by Fisheries and Oceans Canada under the International Governance of High Seas Fisheries program. Scientist time for analysis of about £5 K.
Number of participating scientists	Two scientists: one from DFO Newfoundland Region, the other from the University of Waterloo, Waterloo, Ontario, Canada.
Name and e-mail address of coordinating scientist in charge of project	J. Brian Dempson dempsonb@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	Samples obtained from the River Tana (Teno) were provided by scientists from Finland.

Summary of Findings:

Publication:

Niloshini Sinnatamby. R., J. B. Dempson, G. Chaput, F. Caron, E. Niemelä, J. Erkinaro, and M. Power. 2009. Spatial and Temporal Variability in the Trophic Ecology of Atlantic Salmon in the North Atlantic Inferred from Analyses of Stable Isotope Signatures. American Fisheries Society Symposium 69:447–463.

In many areas of the North Atlantic, populations of Atlantic salmon *Salmo salar* are now either in a state of decline or extirpated such that concern over the continued survival of the species has been given more attention in recent years despite large reductions in directed ocean fisheries. Previous investigations have established linkages between ocean climate conditions and variability in abundance or survival. However, one avenue not previously explored considers whether changes in marine food webs owing to ever increasing and unsustainable levels of exploitation on many marine species—the so-called “fishing down marine food webs” hypothesis—could influence survival and abundance of salmon as a result of shifts in trophic position or changes in energy flows. Since Atlantic salmon are opportunistic feeders during the marine life history phase, the species lends itself well to studies associated with marine environmental conditions and food web interactions. Here, we examine long-term variability in the trophic ecology of Atlantic salmon using analyses of stable isotope signatures of carbon and nitrogen (d13C and d15N). Signatures were extracted from the marine growth portion of scales of maiden one-sea-winter fish. Data were obtained from nine Canadian and one north European river (Teno) covering periods extending over three to four decades. Significant differences in d13C and d15N signatures were found to exist among rivers, as well as among years within rivers. Trends over time in either d13C or d15N signatures were evident in only a few situations, thus providing little evidence of substantive changes in the trophic ecology of salmon in the North Atlantic. In addition, isotopic signatures were largely invariant in relation to variations in abundance or to various environmental measures characterizing ocean climate conditions in the North Atlantic.

Project No. C9 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Effective population size, gene flow and population structure of Atlantic salmon in Newfoundland and Labrador**
Objective of research project	1. To document population structure and connectivity (gene flow) among Newfoundland and southern Labrador rivers 2. To test for the temporal stability of the structure over the past 50 years.
Brief description of research project	Population structure arises as a consequence of genetic drift, gene flow, mutation, natural selection and their interactions. Population size plays a central role in determining the balance between these forces: Large populations are thought to be better able to respond to natural selection than small populations. Small populations, in turn, are thought to be more influenced by genetic drift, which is more likely to lead to the loss of genetic variation, accumulation of inbreeding depression and increased extinction risk. Gene flow can alleviate such genetic adversity while simultaneously limiting the extent of adaptive divergence between populations. This type of information is thus essential to effective management and conservation as well as restoration efforts, especially for species of conservation concern. The objective was to estimate effective population sizes and connectivity (gene flow) among Atlantic salmon populations from Newfoundland and Labrador. We examined genetic variability in a suite of 14 microsatellite DNA loci among ca 3000 individuals from some 20 populations from around Newfoundland and from southern Labrador collected over the period of the last 5 decades starting in the 1950s to the present. The availability of extensive temporal samples allowed for tests of changes in effective population size related to the declines and subsequent closure of commercial fisheries. Our analyses provided information on the relationship between effective population size and gene flow. We are also examined the genetic basis for phenotypic and life history differences by means of common garden experiments with salmon from two populations in Newfoundland.
Dates during which research took place	2003 - 2008
Area in which research took place	Contemporary samples were analyzed from 18 rivers in Newfoundland and 2 in southern Labrador. Temporal replicates were available from 10 Newfoundland and 2 Labrador rivers. Samples for common-garden experiments were secured from 2 rivers in Newfoundland.
Estimated number and weight of salmon to be retained	N/A
Resources	

Estimated cost of the research project.	₤ 28 K Fisheries and Oceans Canada (DFO) Academic Subvention Grant to DER at Dalhousie ₤ 16 K Dalhousie University grants. ₤ 20 K NSERC (DER)
Number of participating scientists	Three scientists: Daniel Ruzzante (Dalhousie University), Friso Palstra (PhD student), and Michael O'Connell (DFO).
Name and e-mail address of coordinating scientist in charge of project	Daniel E Ruzzante, Daniel.ruzzante@dal.ca Friso Palstra (PhD student), fpalstra@dal.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

Publication:

Palstra, F.P., O'Connell, M.F., and Ruzzante, D.E. 2009. Age Structure, Changing Demography and Effective Population Size in Atlantic Salmon (*Salmo salar*). Genetics 182: 1233-1249.

Effective population size (Ne) is a central evolutionary concept, but its genetic estimation can be significantly complicated by age structure. Here we investigate Ne in Atlantic salmon (*Salmo salar*) populations that have undergone changes in demography and population dynamics, applying four different genetic estimators. For this purpose we use genetic data (14 microsatellite markers) from archived scale samples collected between 1951 and 2004. Through life table simulations we assess the genetic consequences of life history variation on Ne. Although variation in reproductive contribution by mature parr affects age structure, we find that its effect on Ne estimation may be relatively minor. A comparison of estimator models suggests that even low iteroparity may upwardly bias Ne estimates when ignored (semelparity assumed) and should thus empirically be accounted for. Our results indicate that Ne may have changed over time in relatively small populations, but otherwise remained stable. Our ability to detect changes in Ne in larger populations was, however, likely hindered by sampling limitations. An evaluation of Ne estimates in a demographic context suggests that life history diversity, density-dependent factors, and metapopulation dynamics may all affect the genetic stability of these populations.

Palstra, F.P., O'Connell, M.F., and Ruzznate, D.E. 2007. Population structure and gene flow reversals in Atlantic salmon (*Salmo salar*) over contemporary and long-term temporal scales: effects of population size and life history. Molecular Ecology 16: 4504-4522.

Metapopulation dynamics are increasingly invoked in management and conservation of endangered species. In this context, asymmetrical gene flow patterns can be density dependent, with migration occurring mainly from larger into smaller populations, which may depend on it for their persistence. Using genetic markers, such patterns have recently been documented for various organisms including salmonids, suggesting this may be a more general pattern. However, metapopulation theory does not restrict gene flow asymmetry to 'source-sink' structures, nor need these patterns be constant over longer evolutionary timescales. In anadromous salmonids, gene flow can be expected to be shaped by various selective pressures underlying homing and dispersal ('straying') behaviours. The relative importance of these selective forces will vary spatially and for populations of different census size. Furthermore, the consequences of life-history variation among populations for dispersal and hence gene flow remain poorly quantified. We examine population structure and connectivity in Atlantic

salmon (*Salmo salar* L.) from Newfoundland and Labrador, a region where populations of this species are relatively pristine. Using genetic variation at 13 microsatellite loci from samples (N = 1346) collected from a total of 20 rivers, we examine connectivity at several regional and temporal scales and test the hypothesis that the predominant direction of gene flow is from large into small populations. We reject this hypothesis and find that the directionality of migration is affected by the temporal scale over which gene flow is assessed. Whereas large populations tend to function as sources of dispersal over contemporary timescales, such patterns are often changed and even reversed over evolutionary, coalescent-derived timescales. These patterns of population structure furthermore vary between different regions and are compatible with demographic and life-history attributes. We find no evidence for sex-biased dispersal underlying gene flow asymmetry. Our findings caution against generalizations concerning the directionality of gene flow in Atlantic salmon and emphasize the need for detailed regional study, if such information is to be meaningfully applied in conservation and management of salmonids.

Project No. C10 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**River and extended estuary acoustic tracking of Atlantic salmon (*Salmo salar*) kelts and bright salmon**
Objective of research project	1) To track and document migratory behaviour of Atlantic salmon kelts as they leave the river for the open ocean and bright salmon at they return to rivers; 2) To identify possible critical habitat sites utilized by kelts and bright salmon during their migration; 3) To examine the mortality rates of kelts and brigh salmon during migration.
Brief description of research project	The population of Atlantic salmon in the LaHave River on the Atlantic coast of Nova Scotia has been in decline in the 1990s and continues to decline because of low marine survival of both smolts and post-spawning adult salmon (kelts). Reasons could include poor physiological condition, interference with migration or increased predation. In this study acoustic tags and receivers are being used to provide evidence on the migration, timing and fate of migrating adult salmon. Thirty kelts were captured and implanted with the acoustic tags, including 5 tags that transmit depth data. Continuous recording acoustic receivers have been placed in the river 15 km above tide to 24 km below tide at the outer limits of the estuary to monitor the passage of tagged fish. Active searches were also used to locate marine summer holding habitat and to locate missing tags that may indicate mortalities. The array remained in place from May to October. Environmental data were also collected at each receiver location on a periodic basis and temperature was continuously recorded at some receiver locations.
Dates during which research took place	2006 - 2008
Area in which research took place	LaHave River, and estuary, Lunenburg, Nova Scotia, Northwest Atlantic Ocean, Canada. 44°23' N, 64°32' W
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£30 K per annum. Project is funded by Fisheries and Oceans Canada, LaHave River Salmon Association and affiliates.
Number of participating scientists	Three scientists from DFO Maritimes Region. Also one graduate student and scientist from Acadia University, Wolfville Nova Scotia, Canada.
Name and e-mail address of coordinating scientist in charge of project	Peter G. Amiro AmiroP@mar.dfo-mpo.gc.ca A Jamie F. Gibson GibsonAJF@mar.dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A

Type and amount of gear and other equipment used	Vemco VR2 and VR60 receivers, Vemco V13 transmitters
Details of any collaborating countries	N/A

Summary of Findings:

Hubley, P.B., P.G. Amiro, A.J.F. Gibson, G.L. Lacroix, and A.M. Redden. 2008. Survival and behaviour of migrating Atlantic salmon (Salmo salar L.) kelts in river, estuarine, and coastal habitat. ICES Journal of Marine Science 65; 1626-1634.

Abstract:
The downstream migration of 30 Atlantic salmon (Salmo salar) kelts tagged with acoustic transmitters was monitored using 26 underwater receivers at eight locations from April to October 2006 in the LaHave River and Estuary. In all, 27 tags were detected as they left the coastal environment by the middle of May, 5 weeks after release, indicating a possible 90% kelt survival to coastal departure. Two missing tags and one dropped tag were assumed to be attributable to natural mortality in the estuary. Migration time from release to the outermost coastal receivers 24 km below the tide limit took an average of 14 d, but varied from 3 to 32 d. Some 40% of the kelts lingered and were active in the lower estuary. Five kelts monitored with depth transmitters migrated mostly at the surface in all habitats, with occasional brief descent to the bottom. A consecutive spawning salmon returned after 79 d outside the outermost array. The low rate of returns is consistent with the historical repeat spawning schedule for this river, and more precisely documents the temporal and spatial habitat use of migrating kelts.

Project No. C11 Status: Completed

Party or relevant jurisdiction	Canada Québec, MRNF University Laval, McGill, UQàRimouski, UQàMontreal, INRS, NGO (Atlantic Salmon Federation)/DFO collaboration
Title of project	**Integrated modelling of juvenile Atlantic salmon movement and physical habitat in fluvial and estuarine environments**
Objective of research project	(1) To develop an innovative geomatic approach capable of relating the behaviour of smolts during their migration to the characteristics of the physical habitat in rivers and estuaries. (2) To apply this approach to the analysis of the migration of smolts through the estuaries of the St. Jean, Dartmouth and York rivers and down the Baie de Gaspé. (3) In the case of aquaculture development planned in the Baie de Gaspé, to detect potential changes in the migration pattern of smolts in response to the presence of sea cages.
Brief description of research project	The spatial and temporal distribution of smolts was assessed by tagging smolts with coded transmitters during their downstream migration. The plan was to release 60 tagged smolts during years 1, 2 and 3. These smolts were monitored by (a) a boat-mounted directional hydrophone and receiver to track their migration in the estuaries (b) an array of fixed, GPS geo-referenced, hydrophones moored across the Baie de Gaspé. Particle image velocimetry and image analysis techniques and passive acoustic drifters were used to determine surface flow velocity fields within the estuaries and Baie de Gaspé.
Dates during which research took place	Spring/summer 2005 to 2008
Area in which research took place	York River and Baie de Gaspé, Québec, Canada
Estimated number and weight of salmon retained	50 smolts, tagged and released
Resources	
Estimated cost of the research project	Approx. £100 K for operations, salaries and acoustic tags Approx. £30 K for receiver arrays Approx. £20 K for smolt wheels **Total Approx £150 K per annum** **Principal Supporting Partners**: Atlantic Salmon Federation, Fred Whoriskey Centre Interuniversitaire de Recherche sur le Saumon Atlantique (CIRSA) Fédération Québécoise du Saumon Atlantique Fondation pour le saumon du Grand Gaspé Génivar Hydro-Québec Ministère des Ressources Naturelles et de la Faune BC Ministry of Sustainable Resource Management, Information Services Division, Evert Kenk **Principal investigators**

	Normand Bergeron, INRS-Eau, Terre et Environnement. Deputy leader Thomas Buffin-Bélanger, Université du Québec à Rimouski François Caron, Ministère des Ressources naturelles et de la Faune Michael Church, University of British-Columbia Stuart Lane, University of Leeds, UK Michel Lapointe, McGill University
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Julian Dodson julian.dodson@bio.ulaval.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Small boats (less than 20 feet in length) Chartered fishing vessel (approx. 35 feet) for gear deployment
Type and amount of gear and other equipment used	Up to 50 VR 2 acoustic receivers 50 acoustic tags
Details of any collaborating countries	Canadian and UK collaboration (University of Leeds)

Summary of Findings:

Publication: **Hedger, R. D; F. Martin, D. Hatin, F. Caron, F. G. Whoriskey, and J. J. Dodson. 2008. Active migration of wild Atlantic salmon *Salmo salar* smolt through a coastal embayment. Marine Ecology Progress Series Vol. 355: 235-246.**

Abstract: Migration patterns of wild Atlantic salmon Salmo salar smolt were examined in a coastal embayment in the Gaspe peninsula of Quebec, Canada. Twenty-four smolt in 2005 and 30 in 2006 were tagged with coded ultrasonic transmitters, and their migration throughout the bay was monitored using an array of fixed VR2 hydrophone receivers. Migration patterns were complex, with some smolt taking a direct route through the coastal embayment and others repeatedly changing direction over short spatial and temporal scales. Migration was mainly an active process with an overall outward (seaward) migration in the face of an inward residual circulation. Swimming direction was mainly outward during nocturnal inflowing currents but was more dispersed during daytime and nocturnal outflowing currents; swimming speed was greater during daytime than during night-time. This pattern was consistent with smolt migrating offshore nocturnally and using daytime for prey detection and predator avoidance. Salinity had a strong effect: exposure to more saline waters caused increased swimming speeds. These observations are consistent with the hypothesis that smolt exploit an innate compass to maintain a preferred bearing and that the speed and direction of swimming is controlled by salinity and the diurnal cycle.

Project No. C12 Status: Completed

Party or relevant jurisdiction	Canada (Fisheries and Oceans Canada – Newfoundland Region)
Title of project	**Estuary acoustic tracking of Atlantic salmon (*Salmo salar*) smolts and kelts – Conne River, Little River, and Bay d'Espoir, Newfoundland**
Objective of research project	1) To tag and track migratory behaviour of Atlantic salmon smolts and kelts as they leave the Conne River, Newfoundland; 2) To determine the movements and migration patterns throughout the Bay d'Espoir fjord; 3) To provide insight into the initial survival and residency of smolts and kelts migrating through the fjord.
Brief description of research project	The population of Atlantic salmon in the Conne River on the south coast of Newfoundland has, with few exceptions, been in decline since the early 1990s and continues to remain at relatively low levels of adult abundance. Marine survival has fallen from 7 - 10% estimated in the mid-to-late 1980s, to 3-4% during much of the past decade. Reasons for the decline in marine survival are not known. Fifteen (15) kelts and 49 smolts were captured and implanted with the Vemco acoustic tags as they migrated out of the Conne River in the spring of 2006. Twenty-one (21) VR2 Vemco receivers were deployed throughout Bay d'Espoir to track migrating fish. Manual tracking in nearshore areas was also carried out to complement the arrays of acoustic receivers. This project was expanded in 2007 whereby 38 receivers (2 subsequently lost) were placed throughout the Bay d'Espoir fiord, with 30 kelt and 62 smolt tagged and released from Conne River. In addition, the Miawpukek (Conne River) First Nation provided funding and participated with the tagging and tracking of twenty (20) smolts that were released from Little River, another system in the Bay d'Espoir area. In 2008, an additional 30 smolts and 8 kelt were tagged at Conne River with 20 smolts released from Little River. A total of 28 Vemco VR2 receivers were again positioned at various locations throughout Bay d'Espoir. This year several receivers were located in more distant areas outside of the Bay d'Espoir fiord extending tracking coverage upwards of 65 km from the point of release.
Dates during which research took place	2006 - 2008
Area in which research took place	Conne River, and estuary, Little River, and the Bay d'Espoir fjord, south coast Newfoundland, SFA 11.
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£15 K per annum. Project funded by Fisheries and Oceans Canada, the Miapukek First Nation, and is also a joint initiative between the Experimental Sciences Section and Salmonid Research Section.

Number of participating scientists	This project involved several scientists and technical staff with expertise in salmonid research and telemetry investigations and staff from the Miawpukek First Nation.
Name and e-mail address of coordinating scientists in charge of project	J. Brian Dempson dempsonb@dfo-mpo.gc.ca Keith Clarke clarkekd@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	Vemco VR2 receivers, V7-2L and V9-6L transmitters
Details of any collaborating countries	N/A

Summary of Findings:

Publication:

Dempson, J.B., Robertson, M.J., Pennell, C.J., Furey, G., Bloom, M., Shears, M., Ollerhead, L.M.N., Clarke, K.D., Hinks, R., and Robertson, G. 2011. Residency time, migration route and survival of Atlantic salmon *Salmo salar* smolts in a Canadian fjord. Journal of Fish Biology 78: 1976-1992.

Atlantic salmon *Salmo salar* smolts (n = 181) from two rivers were surgically implanted with acoustic transmitters and released to determine migration route, residency time and survival in a 50 km long estuarine fjord located on the south coast of Newfoundland, Canada. Data obtained from automated receivers placed throughout the Bay d'Espoir fjord indicated that migrating smolts used different routes to reach the outer areas of the fjord. The duration of time that smolts spent in the immediate estuary zone also differed between the two localities (7 and 17 days) although the total time smolts were resident in the fjord was similar and extensive (40 days). Many smolts were resident for periods of 4-8 weeks moving back and forth in the outer part of the fjord where maximum water depths range from 300 to 700 m. Survival in the estuary zone was greater for smolts with prolonged residency in estuarine habitat. Overall smolt survival to the fjord exit was moderately high (54-85%), indicating that the initial phase of migration did not coincide with a period of unusually high mortality.

No. C13 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Spatio-temporal distribution of Atlantic salmon stocks and the impact of the West Greenland fishery**
Objective of research project	Provide knowledge about the river origin of the salmon catch in the commercial fishery, particularly at West Greenland.
Brief description of research project	To evaluate the spatio-temporal distribution of North American Atlantic salmon on the coast of West Greenland, tissue samples were obtained as part of the international salmon monitoring initiative. Tissue will be analysed and population origins assigned to reference populations from Québec, the Maritimes and Maine, using 13 microsatellites markers. The impacts of fishing will then be estimated by evaluating the contribution of each of these base populations to the annual landings in Greenland. The project is a research thesis for a Masters program.
Dates during which research took place	2006 – 2008 (samples collected in 2006 and 2007).
Area in which research took place	Samples from West Greenland, analysis at Laval University, Quebec, Canada
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£15 K per annum. Project funded by research grants to Université de Laval (Bernatchez). Salaries for a sampler were provided by Quebec MNRF. Travel expenses for samplers to collect data were provided by Fisheries and Oceans Canada.
Number of participating scientists	2
Name and e-mail address of coordinating scientists in charge of project	Louis Bernatchez (Supervisor); Tim King (Co-supervisor) louis.bernatchez@bio.ulaval.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	N/A
Summary of Findings: Samples were collected from the West Greenland fishery in August and September, 2006 and 2007 and were compared to historical samples. Analyses for genetic characterization were completed. Results show that the Southern Québec, Labrador and New-Brunswick regions contributed significantly more than the other regions of North America to the West Greenland Fishery. Regional contribution to the fishery was correlated with the regional MSW production.	

Publication:
Gauthier-Ouellet M, Dionne M, Caron F, King TL, Bernatchez L. 2009. Spatio-temporal dynamics of the Atlantic salmon Greenland fishery inferred from mixed-stock analysis. Canadian Journal of Fisheries and Aquatic Sciences, 66 : 2040-2051.

Project No. C14 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Genetic population structure of Atlantic salmon in Eastern Canada and its implication for conservation**
Objective of research project	This project aims at elucidating the genetic population structure of Atlantic salmon from a small (river) to a large (Eastern Atlantic coast) spatial scale and proposing conservation units for the Canadian distribution range.
Brief description of research project	Samples from over 55 rivers in Quebec with additional sampling from rivers in the southern Gulf of St. Lawrence and Labrador were obtained and their characteristics evaluated at multiple microsatellite loci. Further work was conducted on the variability in major histo-compatability complexes and its association with exposure to pathogens.
Dates during which research took place	2004 - 2008
Area in which research took place	Rivers from Québec, Canada
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£60 K. Project funded by research grants to Université de Laval (Bernatchez and Dionne) with support from Quebec MNRF. About £20 K per annum
Number of participating scientists	2
Name and e-mail address of coordinating scientists in charge of project	Louis Bernatchez louis.bernatchez@bio.ulaval.ca Mélanie Dionne melanie.dionne@mffp.gouv.qc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

This project aimed at elucidating the genetic population structure of Atlantic salmon from a small (river) to a large spatial scale (Eastern Atlantic coast) and proposing conservation units for the Canadian distribution range. Results showed that most rivers are genetically differentiated from one another (mean $F_{st} = 0.05$, $p < 0.001$), suggested that in general each river in Eastern Canada represents a distinct population. However, genetic differentiation is also found within certain river systems such as the Moisie, Romaine and Restigouche, suggesting that populations can be identified at the tributary level. At a large spatial scale, seven genetic regions are identified in Eastern Canada. Genetic differentiation is found to be associated with temperature regime conditions, suggesting local adaptation in Atlantic salmon. Analyses of an immunocompetence gene (MHC class II) suggest spatial diversity is associated with local adaptation to pathogen diversity and temperature regime. Evidence also suggest genetic diversity at MHC influences mate choice and subsequent juvenile survival.

Publications:

Dionne, M ; Miller, K. M; Dodson, J. J; Caron, F.; Bernatchez, L. 2007. Clinal variation in mhc diversity with temperature: evidence for the role of host-pathogen interaction on local adaptation in Atlantic salmon. Evolution Vol. 61(9): 2154-2164.

Dionne. M., F. Caron, J. J. Dodson, and L. Bernatchez. 2008. Landscape genetics and hierarchical genetic structure in Atlantic salmon: the interaction of gene flow and local adaptation. Molecular Ecology 17: 2382–2396.

Dionne. M., F. Caron, J. J. Dodson, and L. Bernatchez. 2009. Comparative survey of within-river genetic structure in Atlantic salmon; relevance for management and conservation. Conserv. Genet. 10: 869–879.

Dionne M, Miller KM, Dodson JJ, Bernatchez L. 2009. MHC standing genetic variation and pathogen resistance in wild Atlantic salmon. *Philosophical Transactions of the Royal Society of London B*, 364: 1555-1565.

Evans, M.L., M. Dionne, K. Miller et L. Bernatchez. 2011. Mate choice for major histocompatibility complex genetic divergence as a bet-hedging strategy in the Atlantic salmon (*Salmo salar*). *Proceedings of the Royal Society B*, 278 (1715): 1-8.

Project No.   C15   Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Pelagic ecosystem survey of the Northwest Atlantic**
Objective of research project	A marine pelagic trawl survey was conducted to sample the upper pelagic ecosystem during the period corresponding to the early postsmolt phase of Atlantic salmon (August and September). The survey design addressed hypotheses of post-smolt distribution (mixing of stocks, mixing of maturing and non-maturing components) and oceanographic features. Catches of post-smolts provided information on distribution and relative abundance of salmon at selected locations and times along the hypothesized ocean migration route. Data on relative abundance of other species, including macroplankton aggregations, provided information on the role of salmon within this larger pelagic ecosystem. Oceanographic conditions would be examined relative to smolt catches.
Brief description of research project	A Fisheries and Oceans Canada research vessel was used to the ecosystem components within the upper 20 m of the water column. Surface gillnets were deployed to assess size-selective catchability of the pelagic trawl and to validate trawl catchability. Catches of salmon were examined relative to geographic (latitude, longitude) and oceanographic (fronts, temperature, salinity) characteristics. These data will provide information on preferences and/or selection of the physical characteristics by salmon size / age groups. Catches and relative abundance of other species, including macroplankton aggregations, will provide information on the role of salmon within this larger pelagic ecosystem.
Dates during which research will take place	Research surveys were conducted during August 2008 and September 2009. Data analysis and publication in 2010-2011.
Area in which research will take place	In 2008, in the northwest Atlantic from just south of 49°N to 56°N, 49°W to 55°W. In 2009 in the northwest Atlantic between 56°N to 58°N, 45°W to 60°W
Estimated number and weight of salmon to be retained	In 2008, 15 post smolts, total weight = 3.5 kg. In 2009, catch of 63 post smolts and 22 non-maturing salmon, total weight = 85 kg.
Resources	
Estimated cost of the research project	<u>For 2008:</u> Total estimated cost excluding any analysis: **£350 K** £230 K. Fisheries and Oceans Canada Research vessel cost excluding science personnel (23 days @ £10 K) Science personnel costs (salary, overtime, operations) £70 K Fisheries and Oceans Canada £10 K MFFP Province of Québec (Canada) £40 K US NOAA <u>For 2009:</u> Total estimated cost excluding any analysis: **£350 K** £230 K. Fisheries and Oceans Canada Research vessel cost excluding science personnel (23 days @ £10 K)

	Science personnel costs (salary, overtime, operations) £70 K Fisheries and Oceans Canada £10 K MRNF Province of Québec (Canada) £40 K US NOAA For 2010 Analysis of samples collected in 2008 and 2009. Costing unknown to date For 2011 Results of several aspects of the program will be presented at the "Salmon Summit" conference, Oct. 11-13, 2011 in LaRochelle (France). No costing is available.
Number of participating scientists	6 scientists Five from Atlantic DFO regions (Gulf, Maritimes, Newfoundland and Labrador), one from US NOAA
Name and e-mail address of coordinating scientist in charge of project	Gerald Chaput Gerald.chaput@ dfo-mpo.gc.ca Dave Reddin Reddind@dfo-mpo.gc.ca Tim Sheehan tsheehan@mercury.wh.whoi.edu
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	US NOAA

Summary of Findings:

During August 8 to 21, 2008, 46 stations were sampled with the pelagic surface trawl. The survey covered an area extending from just south of 49°N to 56°N, 49°W to 55°W. Very few (N=15) Atlantic salmon postsmolts were captured. Atlantic salmon were captured at 8 of the 46 stations (17%) and the majority (14 of 15 fish) were captured at stations north of 52°N. The stations with salmon catches were characterized by a wide range of water depths (about 250 m to >3,000m depth) and temperatures (less than 10°C to over 13°C). Salmon were only captured during the daytime. The salmon ranged in size from 23 to 31 cm.

For 2009, 21 sets were made in the Labrador Sea between 55 ^{0} N and 58 ^{0} N. Fourteen tows were made with the surface trawl and eight post smolt salmon were caught with the aquarium attached. No postsmolts were caught during tows without the aquarium. Different fishing techniques including adjustments to warp length, vessel speed, length of tow time and time of fishing were tried. Two night tows were done and 5 postsmolts caught. Two tows and one gillnet set were made in the colder water of the Labrador Current with no salmon caught. Seven drift net sets of 42 to 48 nets of varying mesh size (2.5-5 inch) were completed in the Labrador Sea. Eighty four salmon (61 post smolt, 23 adults) were caught with an average time of each set being approximately 16 hours. CTDs and plankton tows were done at stations where salmon were successfully captured.

In spite of the poor weather for fishing surface trawl and gillnets, the SALSEA program objectives of sampling the ecosystem components within the upper 20 m of the water column were achieved. The salmon that were intensively sampled when analysed will define the characteristics, origin, age, health, and diet of the salmon population in the northern Labrador Sea area. Stable isotope analysis will define the salmon's place trophically in the ecosystem. Other accomplishments were showing that salmon could be caught in the surface trawl at night and the high productivity and species diversity of the upper portion of the water column in the Labrador Sea. No salmon were caught in sets on the shelf area influenced by the Labrador Current versus fishing sets in mid-Labrador Sea where salmon were commonly caught. Species caught during surface trawling included salmon, lumpfish, myctophids, jellyfish, amphipods, barracudina, squid, redfish, Atlantic saury, redfish and Greenland halibut. Most abundant species were lumpfish, myctophids, redfish, salmon and squid.

For 2010, various activities related to tissue processing and data analysis were undertaken.

For 2011, results of some analyses of samples (stable isotopes, feeding, ecosystem components) were presented as scientific papers at the "Salmon Summit" conference in La Rochelle (France).

<u>Summary of publications to date:</u>

Chaput, G., and Sheehan, T. 2009. SALSEA North America: Summary of pelagic ecosystem survey – August 2008. Summary report provided to NASCO for IASRB.

Sheehan, T. F., Reddin, D. G., Chaput, G., and Renkawitz, M. D. 2012. SALSEA North America: a pelagic ecosystem survey targeting Atlantic salmon in the Northwest Atlantic. – ICES Journal of Marine Science 69: 1580-1588. doi:10.1093/icesjms/fss052.

Project No. C16 Status: Ongoing

Party or relevant jurisdiction	Canada
	Joint project of the Miramichi Salmon Association (MSA), Atlantic Salmon Federation (ASF), Restigouche River Watershed Management Committee (RRWMC), Cascapédia Society, Gespe'gewaq Mi'gmaq Resource Council (GMRC)
Title of project	**Miramichi River and Restigouche River kelt movements and survival**
Objective of research project	Document the spring movements and survival of post-spawning kelts from the Miramichi River and Restigouche River systems as they return to the sea, and on their subsequent return as repeat spawners. To determine the locations and causes of kelt mortalities in the marine environment.
Brief description of research project	Sonic telemetry and pop-up satellite tags will be used to document the movements and survival of salmon kelts as they move back to the ocean and across the Gulf of St. Lawrence.
Dates during which research will take place	April 2008 to present –sonic telemetry and satellite tags
Area in which research will take place	Miramichi River and estuary, Restigouche River and estuary, Gulf of St. Lawrence, Atlantic Ocean
Estimated number and weight of salmon to be retained	In the Miramichi River: - 2008-2011: 50 kelts per year - 2012: 25 acoustic, 10 pop-up satellite archival (PSAT) - 2013: 5 acoustic, 11 PSAT - 2014: 10 acoustic and 11 PSAT - 2015: 13 acoustic, 11 PSAT - 2016: 26 acoustic - 2017: 8 acoustic In the Restigouche River: - 2013: 25 acoustic - 2014: 17 acoustic - 2015: 25 acoustic - 2016: 15 acoustic, 10 PSAT - 2017: 17 acoustic Plans for 2018 are to tag 25 kelts in each of the Miramichi, Restigouche, and Cascapedia Rivers.
Resources	
Estimated cost of the research project	£78 K annually – operations, salaries, acoustic and satellite tags £80 K – receiver arrays £125 K – receiver arrays (Ocean Tracking Network contribution: receivers and operational costs) Annual cost - £108 K Principle Supporting Partners: ASF, MSA, RRWMC, GMRC, Cascapédia Society, OTN
Number of participating scientists	4
Name and e-mail address	Jon Carr jcarr@asf.ca

of coordinating scientist in charge of project	
Details of research vessels	na
Type and amount of gear and other equipment to be used	Sonic telemetry arrays and charter/coastal vessels as described in Canada ongoing project C18 *Atlantic salmon smolt migration and survival within Canadian rivers, estuaries and during the marine life stage*
Details of any collaborating countries	

Summary of Progress:

Atlantic salmon kelts have been tracked in the Northwest Miramichi River since 2008 and in the Restigouche River since 2013. Acoustic technology has been predominantly used, however pop-up satellite archival tags (PSATs) have been used in both rivers. PSAT-tagged fish were also implanted with small acoustic tags to increase data on movement within the river during the seaward migration as well during the return to river of consecutive spawners. Acoustic receiver gates are placed along the freshwater and estuarine portions of the migration as well as at the exits of the Gulf of St. Lawrence to the North Atlantic at the Strait of Belle Isle and Cabot Strait. The Cabot Strait line is owned and operated by the Ocean Tracking Network, the other receivers are owned and operated by the Atlantic Salmon Federation.

Salmon from both rivers can exhibit either consecutive or alternate spawning strategies. Consecutive spawners return to the river in the same year that they leave, thus spawning in consecutive years. Alternate spawners spend a winter at sea between spawning years.

Between 2008 and 2017, between 0% and 17% of fish were recorded as consecutive spawners, with an average of 9% exhibiting the behaviour. Restigouche fish were detected as consecutives in 50% of the tagging year with 4% and 16% of the fish exhibiting the behaviour. Fish were classified as such when they were detected returning to and ascending the river. Fish classified as alternate spawners are those that were detected leaving the Gulf of St. Lawrence via the Strat of Belle Isle of the Cabot Strait. Miramichi kelts were detected leaving the Gulf in six out of ten years of tagging with the number of individuals detected during those years ranging from 2% to 38%. Restigouche River kelts were recorded passing out of the Gulf of St. Lawrence in all years tagged and the number of individuals detected each year ranged from 4% to 71% of tagged kelts.

Tags used on acoustic-only kelts last approximately three years, therefore some fish are detected in following years from when they were tagged. All years of the project showed detections of tags from that or previous years.

PSAT-tagged fish were tagged from 2012 to 2015 in the Northwest Miramichi and in 2016 in the Restigouche River. Data was gathered from 66% of tags, either from transmissions or tag recovery. Eight of the 53 tags reached their programmed due date for pop-off at the ends of either August, September or October. Twenty-four of the tags popped off due to the constant pressure mechanism which suggest mortality of the tagged fish.

Full results of the 2012-2015 Miramichi PSAT tagging are available in:

Strøm, J. F., Thorstad, E. B., Chafe, G., Sørbye, S. H., Righton, D., Rikardsen, A. H. and Carr, J. Ocean migration of pop-up satellite archival tagged Atlantic salmon from the Miramichi River in Canada. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsw220.

<ins>Abstract:</ins> The ocean migration of 16 post-spawned adult Atlantic salmon [Salmo salar L.] from the Miramichi River, Canada, tagged concurrently with pop-up satellite archival tags and acoustic transmitters was reconstructed using a Hidden Markov Model. Individuals exclusively utilized areas

within the Gulf of St Lawrence and the Labrador Sea, and showed little overlap with known distributions of European stocks. During the migration, individuals were generally associated with surface waters and spent >67% of the time in the upper 10 m of the water column. The Atlantic salmon occupied greater depths and showed more diving activity during the day than during the night, with a few exceptions. Although residing in the Gulf of St Lawrence, individuals used different geographical areas and displayed frequent dives to shallow depths (10–30 m). All fish that entered the Labrador Sea (n¼8) migrated through the Strait of Belle Isle (767 km from the river mouth), after spending 41–60 d in the Gulf of St Lawrence. After exiting the Gulf of St Lawrence, individuals utilized different areas in the Labrador Sea, and overlaps in spatial distributions among the individuals were largely limited to the Labrador Coast. This variation in area use was accompanied by individual differences in diving behaviour, with maximum depths recorded for individuals ranging from 32 to 909 m. Dives to depths exceeding 150 m were only performed by four individuals and mainly restricted to the central Labrador Sea (areas with water depths >1000 m). Vertical movements were shallower and resembled those in the Gulf of St Lawrence when fish migrated through shallower coastal areas along the Labrador Shelf. In conclusion, the large overall variation in migration routes suggests that post-spawners from the Miramichi River encounter different habitats during their ocean migration and that the growth and survival of adults may depend on ecological conditions in multiple regions, both in the Gulf of St Lawrence and in the Labrador Sea.

Project No. C17 Status: Ongoing

Party or relevant jurisdiction	Canada
Title of project	**Marine survival of Canadian Atlantic salmon stocks: long-term monitoring**
Objective of research project	Smolt production and adult return estimates are available for many salmon populations in Canada, from rivers (wild) and from hatcheries. In some cases, these time series extend to +40 years. Spatial and temporal trends in freshwater smolt production and in marine survival are monitored at the following sites.
Brief description of research project	*Newfoundland:* Five (5) facilities: Campbellton River; Rocky River; Conne River; Garnish River; and Western Arm Brook. Smolt and adult Atlantic salmon abundance is monitored by fish-counting fences or mark-recapture (Conne River smolts). Survival is determined both for smolt to small (< 63 cm) and MSW adult salmon returns. Biological characteristics (e.g. length, weight, condition, age, etc.) of both life-stage components are collected along with additional information on run timing and environmental conditions. These data are periodically examined in relation to patterns of annual variation in marine survival of wild smolts. = *Maritimes:* Smolts and return rates are monitored at four locations: Nashwaak River, Mactaquac Dam on Saint John River, Big Salmon River and LaHave River (wild, and hatchery up to 2005). Continuation of a +40-year time series of marine survival for hatchery smolts released to the Saint John River (Mactaquac). Continuation of 19-year data series for wild smolt survival on Nashwaak River and 14-year data series for the Big Salmon River. Previous marine survival for hatchery origin smolts (25-year time series), and continuation of wild origin smolts (19-year time series) also exists for the LaHave River. The information collected for these populations provides data for age-structured life history models, which when combined with information about freshwater productivity, are being used to assess persistence and recovery strategies for these stocks. *Gulf:* Four facilities on the Restigouche River (Restigouche, Upsalquitch, Matapedia, and Kedgwick rivers). Smolt production is obtained from the Restigouche River overall and two tributaries. Biological characteristics are described including size of smolts, age, and sex ratios. *Quebec:* Provincial government operates three (3) facilities. Abundance, condition as well as freshwater and marine survival are monitored on Rivière de la Trinité (North Shore) and Rivière St-Jean (Gaspé) since over 30 years while those information are collected on Rivière du Vieux-Fort since 2014. Smolt trap are used to estimate smolt run by mark-recapture. Adult returns are count in a fishway (de la Trinité),

	through a counting fence (du Vieux-Fort) or by snorkelling (St-Jean). Characteristics of adult returns are notably obtained using recreational catch
Dates during which research will take place	April – November, annually
Area in which research will take place	On Canadian rivers named in 'objectives' section
Estimated number and weight of salmon to be retained	Generally not applicable, although in some studies a few smolts are retained (less than 500 overall per sampling location) for biological sampling
Resources	
Estimated cost of the research project	Newfoundland (£325 K sub-total): DFO - £300 K per year, including overheads NGO Partners - £25 K per year Maritimes (£50 K sub-total): DFO - £30 K per year, including overheads NGO Partners - £10 K per year Gulf (£60 K sub-total): DFO - £30 K per year (includes DFO operating costs, capital investment and salaries, incl overheads) Partners: £35 K by NGO partners (Miramichi Salmon Association, Atlantic Salmon Federation, Northumberland Salmon Protection Association, First Nations) for capital acquisitions, and O&M for assistance. Same level of support anticipated annually. Quebec (£225 K sub-total): MRNF - £150 K per year, incl overheads Hydro Quebec – £75 K0 per year **Canada Total - £660 K per year**
Number of participating scientists	Newfoundland (4), Maritimes (2), Gulf (3), Quebec (2)
Name and e-mail address of coordinating scientist in charge of project	For information, contact: Carole.Grant@dfo-mpo.gc.ca; Ross.A.Jones@dfo-mpo.gc.ca; Michel.biron@dfo-mpo.gc.ca; Julien.april@mffp.gouv.qc.ca
Details of research vessels	N/A
Type and amount of gear and other equipment to be used	Smolt and adult traps in fishways and fences, trap nets, rotary screw smolt traps.
Details of any collaborating countries	

Summary of Progress:

Publications:

April J., W. Cayer-Blais, et V. Cauchon. 2017. Travaux de recherche sur le saumon atlantique de la rivière du Vieux-Fort en 2016, Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Direction de l'expertise sur la faune aquatique, 27 p.

April J., W. Cayer-Blais, et V. Cauchon. 2016. Travaux de recherche sur le saumon atlantique de la rivière du Vieux-Fort en 2015, Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Direction de l'expertise sur la faune aquatique, 27 p.

April J., W. Cayer-Blais, et V. Cauchon. 2015. Travaux de recherche sur le saumon atlantique de la rivière du Vieux-Fort en 2014, Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Direction de l'expertise sur la faune aquatique, 27 p.

Bowlby, H.D., Gibson, A.J.F., and Levy, A. 2013. Recovery Potential Assessment for Southern Upland Atlantic Salmon: Status, Past and Present Abundance, Life History and Trends. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/005. v + 72 p.

Cauchon, V., et J. April. 2017. Écologie et évolution des populations témoins de saumon atlantique au Québec : rapport de recherche 2016, Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Direction de l'expertise sur la faune aquatique, 71 p.

Cauchon, V., et J. April. 2017. *Écologie et évolution des populations témoins de saumons atlantiques au Québec : rapport de recherche 2016*, Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Direction de l'expertise sur la faune aquatique, 61 p.

Cauchon, V. et J. April. 2018. Suivi des populations témoins de saumon atlantique au Québec : rapport scientifique 2017, Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Direction de l'expertise sur la faune aquatique, 54 p.

Dionne et al. 2015. Écologie et évolution des populations témoins de saumon atlantique au Québec : rapport de recherche 2014. Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de l'expertise sur la faune et ses habitats, Direction de la faune aquatique, 86p.

Dionne, M., Cauchon, V., et Harnois, N. 2014. Écologie et évolution des populations témoins de saumon atlantique au Québec : rapport de recherche 2013, Québec, ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Direction générale de l'expertise sur la faune et ses habitats, Direction de la faune aquatique, 82 p.

Dionne, M., Cauchon, V., et Harnois, N. 2013. Écologie et évolution des populations témoins de saumon atlantique au Québec : rapport de recherche 2012, Québec, ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Direction générale de l'expertise sur la faune et ses habitats, Direction de la faune aquatique, 82 p.

Dionne M, Fournier D et Cauchon V. 2012. Écologie et évolution des populations témoins de saumon atlantique au Québec. Ministère des Ressources naturelles et de la Faune du Québec, Direction de la Faune Aquatique, 78 pp.

DFO. 2012. Stock Assessment of Newfoundland and Labrador Atlantic Salmon - 2011. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/077.

DFO 2012. Stock status of Atlantic salmon (*Salmo salar*) in DFO Gulf Region (Salmon Fishing Areas 15 to 18). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/040.

DFO. 2012. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/014.

DFO. 2013. Status of Atlantic salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/013.

DFO. 2014. Stock status of Atlantic salmon (*Salmo salar*) in DFO Gulf Region (Salmon Fishing Areas 15 to 18) to 2013. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/057.

DFO. 2014. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/037.

DFO. 2015. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/021.

DFO. 2015. Atlantic Salmon (*Salmo Salar*) Stock Status Update in Newfoundland and Labrador for 2014. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/023 (Erratum: December 2015).

DFO. 2016. Update of stock status of Atlantic Salmon (*Salmo salar*) in DFO Gulf Region (Salmon Fishing Areas 15 to 18) for 2015. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/018.

DFO. 2016. Atlantic Salmon (*Salmo salar*) Stock Status Update in Newfoundland and Labrador for 2015. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/020.

DFO. 2016. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/029.

DFO. 2017. Update of indicators of Atlantic Salmon (*Salmo salar*) in DFO Gulf Region Salmon Fishing Areas 15 - 18 for 2016. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/013.

DFO. 2017. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/020.

DFO. 2017. Stock Assessment of Newfoundland and Labrador Atlantic Salmon – 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/035.

DFO. 2018. Update of indicators of Atlantic Salmon (*Salmo salar*) in DFO Gulf Region Salmon Fishing Areas 15 - 18 for 2017. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/017.

Gibson, A.J.F., and Bowlby, H.D. 2013. Recovery Potential Assessment for Southern Upland Atlantic Salmon: Population Dynamics and Viability. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/142. iv + 129 p.

Jones, R.A., L. Anderson, and C.N. Clarke. 2014. Assessment of the Recovery Potential for the Outer Bay of Fundy Population of Atlantic Salmon (*Salmo salar*): Status, Trends, Distribution, Life History Characteristics, and Recovery Targets. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/008.

Lavallée, C., Cauchon, V., Gagné, N., Cayer-Blais, W. et J. April. 2018. Suivi de la population de saumon atlantique de la rivière du Vieux Fort, saison 2017. Québec, ministère des Forêts, de la Faune et des Parcs, Direction de la gestion de la faune Côte-Nord et Direction de l’expertise sur la faune aquatique, 32 p.

Pépin Labbé, A., M., Dionne, V. Cauchon, et J. April. 2016. Écologie et évolution des populations témoins de saumon atlantique au Québec : rapport de recherche 2015, Québec, ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, Direction de l’expertise sur la faune aquatique, 61 p.

Project No. C18 Status: Ongoing

Party or relevant jurisdiction	Canada NGO (Atlantic Salmon Federation; Ocean Tracking Network), DFO (Gulf and Newfoundland Regions) and Province of Québec collaboration
Title of project	**Atlantic salmon smolt migration and survival within Canadian rivers, estuaries and during the marine life stage**
Objective of research project	Provide a time series of stage-specific estimates of mortality rates for smolts and post-smolts at various points of their at-sea migration, including for their transitions through fresh water, the estuary and to various points in the ocean. Examine the relation between biological characteristics of the fish and survival rates to attempt to isolate mortality causes. Document the migration pathways and speeds of smolts from different rivers.
Brief description of research project	Smolts are captured in smolt wheels in fresh water and fitted with acoustic tags. Acoustic receiving arrays are positioned in rivers, at the head of tide, and at the exit of the estuary and in the Strait of Belle Isle. Additional receivers are placed at points of opportunity. In October 2011, the acoustic line was completed between Cabot Strait from Cape North, Cape Breton to Cape Ray, Newfoundland. This line is funded by the Ocean Tracking Network (OTN) based out of Dalhousie University. The receiver line at the Strait of Belle Isle was twinned in 2015 to 2017 to permit estimation of survival rates through the Gulf of St. Lawrence.
Dates during which research will take place	2003 – present (spring/summer)
Area in which research will take place	Miramichi River and estuary; Restigouche River and Baie des Chaleurs; Cascapedia River and estuary; St-Jean (Côte-Nord) River and estuary; Strait of Belle Isle, Cabot Strait, Labrador.
Estimated number and weight of salmon to be retained	~ 275 smolts, tagged and released annually. No fish retained.
Resources	
Estimated cost of the research project	Approx. £130 K for operations, salaries and acoustic tags Approx. £80 K for receiver arrays Approx. £100 K for smolt wheels (Partner contribution: 8 wheels and their operation) Approx. £125 K for receiver arrays (OTN contribution: receivers and operational costs) **Total Approx. £435 K per annum** Principal Supporting Partners: Miramichi Salmon Association Restigouche River Watershed Management Committee Cascapédia Society OTN DFO First Nations

	US NOAA Fisheries
Number of participating scientists	8
Name and e-mail address of coordinating scientist in charge of project	Jonathan Carr: jcarr@asf.ca
Details of research vessels,	Small boats (20 feet in length) Chartered fishing vessel (approx 35 feet) for gear deployment
Type and amount of gear and other equipment to be used	Up to 200 VR 2 acoustic receivers ~ 275 acoustic tags per year
Details of any collaborating countries	

Summary of Progress:

A manuscript describing the results of 14 years of acoustic telemetry data is in the final stages of preparation for submission to the ICES journal of Marine Science. Atlantic salmon smolts from four river populations in eastern Canada covering the period of 2003 to 2016 were implanted with small acoustic transmitters during the spring seaward migration and monitored at fixed stations near the head of tide, at the exit to the Gulf of St. Lawrence and at exit to the Labrador Sea, a migration covering a period of up to two months at sea and offshore marine distances of 800 km. The observations of detections processed in a state-space formulation of the Cormar-Jolly-Seber hierarchical model provide inferences on apparent survival rates of tagged smolts through the sequential environments. Apparent survival is positively associated with size of smolts at tagging, which is accounted for in the model. Apparent survivals through the estuarine and nearshore waters were estimated to be 0.5 to 0.9 for two neighbouring river stocks from Chaleur Bay in contrast to lower values of 0.25 to 0.7, with a declining temporal trend, in two neighbouring stocks in Miramichi Bay. Apparent survivals through the Gulf of St. Lawrence, a transit of 800 km over a period of 30 to 50 days are variable but high among years and rivers, ranging from 0.96 to 0.99 per day. This same model was updated to include this past years (2017) data. Similar trends to those of 2003 to 2016 were observed for 2017, however, the median estimate for the cumulative apparent survival to the entrance of the Gulf of St. Lawrence was estimated to be 0.08 for NW Miramichi River smolts. This marks the lowest apparent survival on record throughout the time series for this river.

Project No. C19 Status: Completed

Party or relevant jurisdiction	Canada, US
Title of project	**Stable isotope ratios to infer trophic structure and condition of Atlantic salmon during their life at sea**
Objective of research project	Marine ecology of these fish could be advanced through studies of trophic state and condition. The questions to be addressed include: 1. Are trophic states of 1SW non-maturing fish similar between NAC and NEAC origin salmon? 2. Are trophic states of 1SW non-maturing fish different from that of 1SW maturing of the same cohort? Can this tell us anything about when these different maturity groups separate in the North Atlantic? 3. Has there been a trophic state change between West Greenland and when these fish finally return to home rivers as 2SW salmon? 4. How do current measures of trophic status compare with measures of trophic status obtainable from archival scale samples and do differences indicate significant changes have occurred.
Brief description of research project	A complete cohort of Atlantic salmon will be tracked from the time they leave the rivers to their return to rivers two years later as 2SW salmon. Smolts will be sampled from the broad geographic range of rivers in eastern North America to characterize their stable isotope signatures as they enter the sea. Stable isotope signatures will be characterized from post-smolts from the marine surveys followed by 1SW maturing and non-maturing salmon as they return to rivers or during their feeding migrations at West Greenland. This will be followed by sampling 2SW salmon upon their return to home waters. The present sampling program at West Greenland includes the purchase of whole fish specifically for disease sampling. Additional tissue sampling of these fish would be conducted including muscle, liver and caudal fin punches. Liver and muscle samples would be analysed for lipid and stable isotope ratios. Caudal punches would be analysed for stable isotope ratios. Caudal punches can be collected without lethal sampling and would therefore be collected from sacrificed fish to permit calibration to the other tissues to allow sampling of survivors of 1SW and 2SW salmon back in home waters.
Dates during which research will take place	Tissue samples from smolts collected in spring 2008. Post-smolts were sampled in the Labrador Sea in August 2008. West Greenland samples collected in August and September 2009, 2010 and 2011. 1SW maturing samples collected in 2009. 2SW salmon samples were collected in 2010. Data and sample analyses 2011/2014. All samples delivered to University of Waterloo by the end of 2012. Stable isotope analysis for 2009 and 2010 samples from West

	Greenland completed for chosen tissues. 2011 samples in the process of being completed.
Area in which research will take place	Sampling occurred at West Greenland and from salmon returning to the index rivers of eastern Canada
Estimated number and weight of salmon to be retained	Sampling program at West Greenland includes the purchase of whole fish specifically for disease sampling. Additional tissue sampling of these fish would be conducted and therefore no additional fish are to be retained. Tissue samples from 1SW and 2SW salmon in the Miramichi will be collected preferentially from First Nations food fisheries. Target sample size for tissue sampling is 50 fish per age group.
Resources	
Estimated cost of the research project	Purchase of fish at West Greenland accounted for in ongoing project D1 (Denmark) Laboratory analysis in winter 2010/2011: Smolt tissue sample analyses: **£18 K**, funded by International Atlantic Salmon Research Board will cover a portion of total expected analytical costs, restricting analysis to include only 2009 West Greenland samples. Samples processed at cost at U. of Waterloo, Canada Data and sample analyses 2011/2014: Analyses and draft scientific manuscript, in-kind
Number of participating scientists	Heather Dixon, PhD Candidate, University of Waterloo Michael Power U. of Waterloo (Canada) Brian Dempson, Gerald Chaput (DFO Canada) Tim Sheehan (US NOAA)
Name and e-mail address of coordinating scientist in charge of project	Brian Dempson : Brian.dempson@dfo-mpo.gc.ca Tim Sheehan : Tim.Sheehan@noaa.gov
Details of research vessels	Not applicable
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	Denmark (in respect of the Faroe Islands and Greenland)

Summary of Findings:

Smolts were collected from 15 index rivers in eastern Canada in May and June 2008: LaHave, Margaree (Nova Scotia), Nashwaak, Southwest Miramichi, Little Southwest Miramichi, Kedgwick, Upsalquitch (New Brunswick), Saint-Jean, de la Trinité (Québec), Conne, Rocky, Campbellton, Exploits, Western Arm Brook (Newfoundland), Sand Hill River (Labrador). Scale and adipose tissue samples from 1SW fish returning to13 of these rivers were obtained in 2009, and the same two tissue types were taken 2SW fish returning to 6 of these rivers in 2010. Tissues for all Canadian river smolts and adults have been dried and processed at the University of Waterloo laboratory in winter of 2010. Data on C and N ratios are currently undergoing statistical analyses, with some analyses to be completed pending abilities to acquire additional funds for the analysis of 2010 and 2011 West Greenland samples. Similar tissues from the 15 post-smolts captured in August 2008 have been processed as above. Similar tissues (liver, dorsal muscle, adipose, caudal fin, scales) from the 63 post-smolts and 22 adult salmon captured in September 2009 were collected and analysed. The extended sampling program at West Greenland collected similar tissues from 412 non-maturing 1SW-4SW salmon from in 2009 and 358 non-maturing 1SW-3SW salmon in 2010 The 2009 West Greenland samples have been analysed, while the 2010 samples are about to be processed. A summary of initial results was prepared and presented at the “Salmon Summit” conference Oct. 11-13, 2011, La Rochelle (France). A manuscript was subsequently prepared and published by ICES Journal of Marine Science as part of the symposium proceedings.

The extended sampling programme at West Greenland collected similar tissues as for previous years from 430 1SW-3SW salmon. Adipose, scale and dorsal muscles samples for 2010 West Greenland salmon of North American origin have been run for stable isotope analysis. The same tissues from 2011 salmon of North American origin are in the process of being run. Gut content analysis has been completed for stomachs from West Greenland fish caught during the 2009-2011 enhanced sampling programme, with the contents currently being processed and run for stable isotope analysis and bomb calorimetry.

A scale methods paper has recently been published by Fisheries Research. An extensive analysis of the gut contents of the West Greenland fish has also been undertaken, and is currently in the process of being linked to the stable isotope data from both the salmon themselves and the prey items. The analysis of the gut content data from the West Greenland salmon was presented at the 2013 ArcticNet meeting in Halifax, NS. All stable isotope analyses for the West Greenland Atlantic salmon and their prey items have now been run. Work planned for 2014 included writing up papers on the diet of West Greenland salmon, and possible differences in stable isotope values in different salmon tissues over time. A presentation further detailing stable isotope analysis of West Greenland Atlantic salmon was given at the 2014 Arctic Change conference in Ottawa, ON, with another presentation to be given at the 2015 NoWPaS workshop in Gallway, Ireland.

The paper analysing gut contents and stable isotope data has been submitted. The scale paper examined the use of fish scales in stable isotope ecology studies, which is becoming increasingly prevalent, especially for rare species where non-lethal sampling methods are preferable. In studies of Atlantic salmon ecology, scale samples have been used to assess trophic interactions and migrations. The use of scales is complicated by their architecture and growth, with later overplating layers covering the lower older layers and biasing their isotope values. Despite the increase in scale use, there is no consensus as to what part of the scale should be used for stable isotope studies. The stable isotope values for the marine growth zone of scales and its constituent growth zones (1st summer, 1st winter, 2nd summer) from non-maturing 1SW Atlantic salmon were investigated. Significant differences were found between the different sections of the marine growth zone, which, although small, were comparable to differences interpreted as biologically significant by other stable isotope studies. A mathematical model assuming isometric growth was used to correct for the biasing effect of later overplating. The method facilitates calculation of the “pure” stable isotope values for the different marine growth zones, and a “pure” value for the whole marine growth zone. Appropriate accounting for the differences between measured and “pure” values will assist in minimising the ecological inferential errors associated with the use of stable isotope analysis. Given the similarity between the measured and “pure” whole marine growth zone values, the measured whole marine growth zone can be used as a proxy for average marine feeding while the commonly used 2nd summer growth zone was found not to be representative of earlier marine feeding.

The gut contents/stable isotope paper investigated Atlantic salmon diet, which has been poorly studied in the Northwest Atlantic when compared with information available from the Northeast Atlantic. Climate change induced changes to food webs in the marine feeding areas for Atlantic salmon have been noted, along with an increase in Atlantic salmon mortality despite a cessation in most ocean fishing activities. Since forage success may be hampering salmon survival, it was important that this knowledge gap be addressed. Accordingly, Atlantic salmon were sampled at three communities on the West Greenland coast (Sisimiut, Nuuk and Qaqortoq) across three years, in 2009-2011. Conventional gut content analyses were combined with stable isotope methods to assess spatial and temporal differences in salmon feeding. Capelin (*Mallotus villosus*) was found to be the dominant prey species overall, with hyperiid amphipods (*Themisto* spp.), boreoatlantic armhook squid (*Gonatus fabricii*) and sand lance (*Ammodytes* spp.) also featuring heavily. Significant differences were found among years and communities for both gut contents analysis and stable isotope analysis, along with differences evident across larger spatial and temporal scales. Results showed that Atlantic salmon diets have changed over the last 40 years, particularly with the emergence of squid as a prey item. When compared to information from salmon diets in the Northeast Atlantic, Atlantic salmon feeding at West Greenland were found to have broadly similar preferences for fish, crustaceans, and squid, although the species present were significantly different. Capelin was the most important prey item in Atlantic salmon diets at Nuuk and Qaqortoq, while at Sisimiut squid were more important. Evidence of specialisation on these prey items at these communities was apparent. By gaining an understanding of Atlantic salmon diets and the variation thereof, an insight can be gained into the possible effects of food web changes on this species.

Publications to date:

Dixon, H.J., Power, M., Dempson, J.B., Sheehan, T.F., and Chaput, G. 2012. Characterizing the trophic position shift in Atlantic salmon (*Salmo salar*) from freshwater to marine life-cycle phases using stable isotopes. ICES Journal of Marine Science 69: 1646–1655.

Dixon, H.J., Dempson, J.B., and Power, M. 2015. Assessing the use of different marine growth zones of adult Atlantic salmon scales for studying marine trophic ecology with stable isotope analysis. Fisheries Research, 164: 112–119.

Dixon, H.J., Dempson, J.B., Sheehan, T.F., Renkawitz, M.D., and Power, M. 2017 Assessing the diet of Atlantic salmon (*Salmo salar* L.) off the West Greenland coast using gut content and stable isotope analyses. Fisheries Oceanography 26: 555–568.

Other Significant Project-related Presentations:

Dixon, H., Dempson, J. B. and Power, M. 2014. Characterising differences in the trophic ecology of North American Atlantic salmon (*Salmo salar* l.) along the West Greenland coast using stable isotopes. ArcticNet 10th Annual Scientific Meeting: Arctic Change 2014, December 8-12, Ottawa, Ontario.

Dixon, H. J., Dempson, J. B., Sheehan, T. F., Renkawitz, M. D. and Power, M. Assessing trophic ecology of migrating Atlantic salmon (*Salmo salar* l.) caught off the West Greenland coast. ArcticNet 9th Annual Scientific Meeting, Dec 9-13, 2013, Halifax, NS, Canada

Project No. C20 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Identification of essential habitat for repeat spawning Atlantic salmon of Inner Bay of Fundy origin**
Objective of research project	To identify the freshwater and marine habitats used by post-spawning Atlantic salmon of Bay of Fundy (BoF) origin for reconditioning, and identify the sites and times of mortality.
Brief description of research project	The project is part of an overall strategy to use telemetry to identify the marine habitat used by BoF salmon (the most obvious data gap). Tagged salmon kelts were monitored in rivers of the BoF and at sea from 2008 to 2011 to obtain information on migration, distribution, habitat, and mortality. Acoustic were attached on salmon before spawning and fish were monitored until river exit (2-6 months in freshwater). Pop-up satellite archival tags (PSATs) were attached to kelts after spawning just before river exit to monitor marine migration (4-6 months at sea).
Dates during which research will take place	September 2008 – March 2013
Area in which research will take place	Big Salmon and Gaspereau rivers (inner BoF fall and spring migrants) and Hammond River (outer BoF – Saint John River system spring migrants).
Estimated number and weight of salmon to be retained	None
Resources	
Estimated cost of the research project	Expenditures to date and for 2009-2011: **£100 K** Fisheries and Oceans Canada: Tags, personnel, and operating costs. In-kind contributions from Fort Folly First Nation. For 2012: data analysis complete and one manuscript submitted for publication with a second manuscript in progress. For 2013: Complete second manuscript and submit for publication.
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	Dr. Gilles Lacroix Gilles.Lacroix@dfo-mpo.gc.ca Ross Jones Ross.A.Jones@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Seine nets, angling gear and Rotary Screw trap Acoustic receivers and tags (freshwater component) Satellite tags (marine component)
Details of any collaborating countries	None to date

Summary of Findings:

Between 2007 and 2011, about 60 adult Atlantic salmon were tagged with acoustic transmitters and monitored in the Big Salmon River in the Bay of Fundy from September until river exit. This was done to determine essential freshwater habitat for this endangered population as needed in the Recovery Strategy for inner Bay of Fundy salmon. It also provided the timing of river exit so that migrating kelts could be tagged with pop-up satellite archival tags (PSATs) as they left the river. All telemetry data have been recovered and summarized.

Publication

Lacroix, G.L. 2013. Population-specific ranges of oceanic migration for adult Atlantic salmon (Salmo salar) documented using pop-up satellite archival tags. Can. J. Fish. Aquat. Sci. 70: 1011-1030.

Abstract: Pop-up satellite archival tags identified differences in oceanic migration of Atlantic salmon (*Salmo salar*) kelts from three distinct Canadian populations. Kelts from two endangered populations were restricted to coastal areas near home rivers, whereas kelts from a persisting nearby population migrated to the Labrador Sea and towards the Flemish Cap. Kelts spent most time near the surface (0–5 m), but coastal migrants undertook repeated daytime dives (10–40 m), associated with feeding, upon marine entry and progress was slow (8–23 km·day−1). Distant migrants moved rapidly along the continental shelf (10–50 km·day−1) against prevailing ocean currents, remaining near the surface, except for deep dives (100–1000 m) when crossing ocean channels and at the shelf edge. Home range water temperatures (0–15 °C) indicated that kelts avoided warmer adjacent areas in summer. Kelts did not avoid cold coastal habitat (0–5 °C) in winter, but avoided the surface layers. Kelt migration mimicked that of postsmolts of similar origins, with water temperature acting as a directive or controlling factor. Containment of kelts from endangered populations in coastal habitat was probably responsible for the disappearance of repeat spawners.

Lacroix, G.L. 2014. Large pelagic predators could jeopardize the recovery of endangered Atlantic salmon. Can. J. Fish. Aquat. Sci. 71: 343–350 dx.doi.org/10.1139/cjfas-2013-0458

Abstract: Long-term population viability of Bay of Fundy Atlantic salmon (Salmo salar) is threatened by high levels of marine mortality during migration. Pop-up satellite archival tags on repeat spawners provide direct evidence of extensive natural mortality of migrating salmon in coastal zones attributed to predation by large pelagic fish and no evidence of fishing mortality. Ingested tags show that salmon with a coastal migration are eaten by porbeagle shark (Lamna nasus) inside the Bay of Fundy, whereas distant migrants are consumed by Atlantic bluefin tuna (Thunnus thynnus) and other apex predators along the Scotian Shelf. Mortality is clustered in a few zones because of similar predator–prey habitat preferences and overlapping migration paths. The extent of predation in salmon populations with different migration strategies can account for observed decline rates in neighbouring populations with different life histories. The impact on endangered salmon populations that rely on multiple repeat spawners for population stability may be sufficient to hamper ongoing recovery efforts.

Project No. C21 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Genomic basis of adaptive divergence and marine survival among Atlantic salmon populations**
Objective of research project	Elucidate the genetic basis of adaptive divergence and marine survival in Atlantic salmon populations from eastern Canada. Contribute to the identification of management units.
Brief description of research project	This project aim at creating a genetic database across eastern Canada populations by resolving the genetic structure of populations using the same genetic markers across the study area. Moreover, with the use of recent genomic resources developed for Atlantic salmon, it will identify genes under selection and environmental factors responsible for the genetic divergence between populations. Finally, these resources will help identify the genetic basis of high marine mortality during the first years at sea.
Dates during which research will take place	2010 – 2014
Area in which research will take place	Eastern Canada: Québec, Maritimes, Newfoundland and Labrador
Estimated number and weight of salmon to be retained	Salmon samples have already been collected through another project
Resources	
Estimated cost of the research project	£194 K. Funded by the Natural Sciences Engineering Research Council of Canada (NSERC), the Ministère de la Forêt, de la Faune et des Parc (MFFP) and the Réseau Aquaculture Québec (RAQ)
Number of participating scientists	3
Name and e-mail address of coordinating scientist in charge of project	Louis Bernatchez, supervisor, Louis.Bernatchez@bio.ulaval.ca Mélanie Dionne, co-supervisor, Melanie.Dionne@mrnf.gouv.qc.ca Patrick O'Reilly, coordinator, OReillyP@mar.dfo-mpo.gc.ca Vincent Bourret, PhD student, vincent.bourret.1@ulaval.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	Norway: the centre for integrative genetic (CIGENE) developed some of the genomic resource that will be used in this project USA: tissue samples from Greenland fisheries

Summary of Findings:

Samples of salmon over the entire range in eastern North America have been obtained and laboratory analyses of relevant microsatellite loci has been completed and integrated into a continent wide database. The database is now being used in a number of studies looking at stock identification in mixed stock fisheries and population structuring. Adaptive genetic differences between the different regions in Québec and potential environmental factors responsible for the genetic divergence observed were identified. Genetic basis associated with marine mortality during the first year at sea have been assessed in the two Quebec index rivers.

Publications:

Bourret, V., O'Reilly, P.T., Carr, J.W., Berg, P.R., & Bernatchez, L. 2011. Temporal change in genetic integrity suggests loss of local adaptation in a wild Atlantic salmon (*Salmo salar*) population following introgression by farmed escapees. *Heredity*, 106: 500–510.

Bourret, V., Kent, M.P., Primmer, C.R., Vasemägi, A., Karlsson, S., Hindar, K., McGinnity, P., Verspoor, E., Bernatchez, L., & Lien, S. 2013. SNP-array reveals genome wide patterns of geographical and potential adaptive divergence across the natural range of Atlantic salmon (*Salmo salar*). *Molecular Ecology*, 22: 532-551.

Bourret, V., Dionne, M., Kent, M.P., Lien, S., & Bernatchez, L. 2013. Landscape Genomics in Atlantic Salmon (*Salmo salar*): searching for gene-environment interactions driving local adaptation. *Evolution*, 67: 3469-3487.

Bourret, V., Dionne, M., & Bernatchez, L. 2014. Detecting genotypic changes associated with selective mortality at sea in Atlantic salmon : polygenic multilocus analysis surpass genome scan. Molecular Ecology 23: 4444-4457.

Bradbury, I.R., Hamilton, L.C., Robertson, M.J., Bourgeois, C.E., Mansour, A., and Dempson, J.B. 2014. Landscape structure and climatic variation determine Atlantic salmon genetic connectivity in the northwest Atlantic. Can. J. Fish. Aquat. Sci. **71**(2): 246-258.

Moore, J.-S., Bourret, V., Dionne, M., Bradbury, I., O'Reilly, P., Kent, M., Chaput, G., and Bernatchez, L. 2014. Conservation genomics of anadromous Atlantic salmon across its North American range: outlier loci identify the same patterns of population structure as neutral loci. Molecular Ecology 23: 5680–5697.

Bradbury, I.R., Hamilton, L.C., Rafferty, S., Meerburg, D., Poole, R., Dempson, J.B., Robertson, M.J., Reddin, D.G., Bourret, V., Dionne, M., Chaput, G., Sheehan, T.S., King, T.L., Candy, J.R., and Bernatchez, L. 2015. Genetic evidence of local exploitation of Atlantic salmon in a coastal subsistence fishery in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 72: 83-95.

Project No. C22 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**River and extended estuary acoustic tracking of Atlantic salmon (*Salmo salar*) smolts in Southern Uplands rivers**
Objective of research project	To estimate mortality rates, assess the spatio-temporal dynamics of natural mortality and examine migratory behaviour during the fresh to saltwater transition of wild Atlantic salmon *Salmo salar* smolts from four river systems in an area of Nova Scotia, Canada known as the Southern Upland.
Brief description of research project	Wild salmon smolts from the Southern Upland were implanted with acoustic tags and their movements tracked as they exited their natal rivers, migrated though estuaries and along the coast. Active tracking (via mobile receiver) supplemented passive (moored) receivers and permitted assigning each fish to an assumed fate (e.g. died and remained on bottom, removed from water, etc). Simultaneous visual surveys of potential smolt predators permitted an estimate of total predator abundance, which is currently being analysed.
Dates during which research took place	2008 - 2010.
Area in which research took place	LaHave River, St. Mary's River, Gold River, and West River (Sheet Harbour), Nova Scotia, Canada.
Estimated number and weight of salmon retained	N/A. All tagged salmon were released.
Resources	
Estimated cost of the research project	£30 K per annum (2008 & 2009), £116 K (2010). Project was funded by Fisheries and Oceans Canada, the Nova Scotia Salmon Association, the Atlantic salmon Federation, the Ocean Tracking Network, NSERC, LaHave River Salmon Association, St. Mary's River Association, Donner Foundation Canada, Atlantic salmon Conservation Foundation and others (see publications).
Number of participating scientists	Two scientists from DFO Maritimes Region. Led by Eddie Halfyard, PhD student / scientist from Dalhousie University, Halifax, Nova Scotia, Canada. Also, two scientists from Dalhousie University / the Ocean Tracking Network and one scientist from Acadia University, Wolfville, Nova Scotia, Canada.
Name and e-mail address of coordinating scientist in charge of project	E. Halfyard eahalfyard@dal.ca A Jamie F. Gibson Jamie.Gibson@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	Vemco VR2, VR2w and VR100 receivers, Vemco V9-6L transmitters
Details of any collaborating countries	N/A

Summary of Findings:

Publications:

Halfyard, E.A., Gibson, A.J.F., Ruzzante, D.E., Stokesbury, M.J.W., and Whoriskey, F.G. 2012. Estuarine survival and migratory behaviour of Atlantic salmon *Salmo salar* smolts. Journal of Fish Biology 81, 1626–1645

Abstract: To estimate mortality rates, assess the spatio-temporal dynamics of natural mortality and examine migratory behaviour during the fresh to saltwater transition, 185 wild Atlantic salmon Salmo salar smolts were implanted with coded acoustic transmitters. Seaward migration of tagged S. salar from four river systems in an area of Nova Scotia, Canada known as the Southern Upland was monitored using fixed receivers and active telemetry over 3 years. Cumulative survival through the river, inner estuary, outer estuary and bay habitats averaged 59·6% (range = 39·4–73·5%). When standardized to distance travelled, survival rates followed two patterns: (1) constant rates of survival independent of habitat or (2) low survival most frequently associated with inner estuary habitats. In rivers where survival was independent of habitat, residency periods were also independent of habitat, post-smolts exhibited few upstream movements, took a more direct route to the ocean and reached the ocean rapidly. Alternatively, in rivers where survival was habitat specific, residency was also habitat specific with overall increased residency, more frequent upstream movements and delayed arrival to the open ocean. The sudden disappearance of most (75–100%) smolts and post-smolts assumed dead during the course of this study warrants further examination into the role of avian predators as a mortality vector.

Halfyard, E.A., Gibson, A.J.F., Stokesbury, M.J.W., Ruzzante, D.E. and Whoriskey, F.G. 2013. Correlates of estuarine survival of Atlantic salmon post-smolts from the Southern Upland, Nova Scotia, Canada. Canadian Journal of Fisheries and Aquatic Sciences. 70: 452-460.

Abstract: Acoustic telemetry is a useful tool to monitor the estuarine survival and behaviour of Atlantic salmon postsmolts. Most frequently, survival is reported as the static fraction of tagged postsmolts detected, and while the timing or location of mortality may be reported, covariates of survival or the relationship between migratory behaviour and survival are less often described. In this study, we used acoustic telemetry to follow Atlantic salmon smolts migrating to sea from four rivers in Nova Scotia, Canada. Further, we tested the relationship between migratory behaviour and survival and used mark–recapture models to examine the role of body length and tag-to-body mass as survival covariates. Survival was most heavily impacted in estuarine habitats closest to head-of-tide. Survival was affected by body length at three of four sites. The shape and spatial variability of the body length – survival relationship provided insight on mortality vectors, highlighting the potential roles of predation and osmotic stress. Survival was not influenced by repeated landward-seaward migratory movements; however, there was a significant correlation between residency and survival.

Project No. C23 Status: Completed

Party or relevant jurisdiction	Canada
Title of project	**Effects of early captive exposure on measures of fitness later in life for Inner Bay of Fundy (IBoF) Atlantic Salmon**
Objective of research project	To assess the effects of standard and novel conservation rearing strategies on measures of fitness important for the recovery of IBoF salmon.
Brief description of research project	We assessed two long-standing standard strategies of releasing juvenile salmon (age 0+ unfed fry and ~5 month old feeding fall parr) for effects on fitness at multiple stages later in life and for viability of offspring in the next generation. Captive hatched juveniles were released to the wild as either fry or parr and a portion re-captured 1-3 years later as smolts during their natural migration to the Bay of Fundy. The captured sample of 2010 Upper Salmon River smolts was individually tagged (PIT) and reared during the natural 18 month 1SW marine phase in a marine captive environment in modified commercial net pens in the Bay of Fundy. Following the marine phase, a sample of mature fry and parr-origin fish were artificially spawned within treatment groups to determine effect of parental captive exposure (fry or parr release stage) on offspring viability. Smolt age and size, growth and survival during the marine phase, and offspring viability for both fry and parr release origin fish were reported.
Dates during which research took place	2010 – 2012- field work 2013 – 2014 analyses and reporting 2014 - 2015 – completed MSc thesis
Area in which research took place	Upper Salmon River (Fundy National Park),
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	~£100 K per annum. Cash and In-kind funding from Fisheries and Oceans Canada, Parks Canada, The Atlantic Salmon Federation, The Atlantic Canada Fish Farmers Association and Fort Folly First Nation.
Number of participating scientists	One scientist from DFO Maritimes Region, Parks Canada, Concordia University and one graduate student and two scientists from Memorial University, St. John's, Newfoundland
Name and e-mail address of coordinating scientist in charge of project	Corey Clarke: corey.clarke@pc.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Local fishing vessels chartered for moving fish
Type and amount of gear and other equipment used	Helicopter time (to release juveniles), Rotary screw trap (to capture smolts), dive gear, net seines, commercial sea cages, hatchery

	facilities, small motorized boats, light trucks, fish transport trucks, fishing boats, acoustic tags , acoustic receivers, PIT tags (2000)
Details of any collaborating countries	N/A

Summary of Findings:

Publications:

Clarke, C.N., Fraser, D.J., and Purchase, C.F. 2016. Life-long and carry-over effects of early captive exposure in a recovery program for Atlantic salmon. Anim. Conserv. 19: 350-359.

Abstract: A full lifecycle understanding of how different captive rearing strategies affect wild fitness is needed for many species of conservation concern. Over the lifecycle of endangered Atlantic salmon, we measured the effects on wild fitness of two widely applied conservation captive rearing strategies. One strategy releases juveniles before the onset of feeding (reduced exposure), the other after five months of captive feeding (extended exposure). Fish were released to the wild and monitored 1-3 years later as seaward migrating juveniles. A sample of migrating fish from both rearing strategies was held captive in the ocean until mature, and artificially bred to monitor offspring viability. Extended early captive exposure resulted in smaller size-at-stage throughout life, shorter generation time, and reduced offspring viability. Our results demonstrate how seemingly brief alterations in early captive exposure can generate long-term and transgenerational effects on fitness and life history traits that likely accelerate domestication effects, and hence provide insight for effective recovery strategy design.

Project No. C24 Status: Ongoing

Party or relevant jurisdiction	Canada
Title of project	**Genomic stock identification techniques provide distribution information of regional groups of Atlantic salmon from eastern North America and estimates of exploitation in mixed stock marine fisheries**
Objective of research project	Identify to regional groups the origin of salmon from mixed stock fisheries of Labrador (Canada), Saint-Pierre & Miquelon, and at West Greenland, estimate total catch by regional group and examine region specific variations in distribution at sea and availability of Atlantic salmon in marine fisheries.
Brief description of research project	The recently developed North American genetic database for Atlantic salmon is used to identify regional groups of salmon populations. These regional group characteristics are used to assign the origin of salmon sampled from mixed stock fisheries in Labrador, Saint-Pierre & Miquelon and at West Greenland. Additional historical scale samples from the Faroes fishery of the 1990s are being examined to determine the origin of salmon identified as being of North American source. The West Greenland samples will cover the period 2011 to 2014, the Labrador fishery samples the period 2006 to 2017, and the Saint-Pierre & Miquelon samples from 2011, 2013 to 2017. These results will be presented at the ICES Working Group meeting and subsequently the annual NASCO meetings.
Dates during which research will take place	2013 – 2019
Area in which research will take place	Eastern North America and samples from West Greenland
Estimated number and weight of salmon to be retained	Salmon samples are collected from existing marine salmon fisheries
Resources	
Estimated cost of the research project	£123 K DFO International Governance Strategy: 2014/2019: £60 K DFO GRDI program: 2014/2018: £19 K DFO Inkind (salary of Bradbury, Hamilton) – £28 K Other sources of Funds US NOAA – £16 K
Number of participating scientists	1
Name and e-mail address of coordinating scientist in charge of project	Ian Bradbury, DFO Canada ian.bradbury@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	

Details of any collaborating countries	Ifremer – samples from the SPM fishery NASCO International Sampling Program: tissue samples from Greenland fisheries

Summary of Findings:

Analysis of stock origin in mixed stock fisheries at Labrador, St. Pierre & Miquelon, and West Greenland.

Publications:

Bradbury, I.R., Hamilton, L.C., Rafferty, S., Meerburg, D., Poole, R., Dempson, J.B., Robertson, M.J., Reddin, D.G., Bourret, V., Dionne, M., Chaput, G., Sheehan, T.S., King, T.L., Candy, J.R., and Bernatchez, L. 2015. Genetic evidence of local exploitation of Atlantic salmon in a coastal subsistence fishery in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 72: 83-95.

Bradbury, I. R., Hamilton, L. C., Chaput, G., Robertson, M. J., Goraguer, H., Walsh, A., Morris, V., et al. 2016. Genetic mixed stock analysis of an interceptory Atlantic salmon fishery in the Northwest Atlantic. Fisheries Research, 174: 234-244. (St. Pierre & Miquelon analysis).

Bradbury, I.R., Hamilton, L.C., Sheehan, T.S., Chaput, G., Robertson, M.J., Dempson, J.B., Reddin, D.G., Moris, V., King, T., and Bernatchez, L. 2016. Genetic mixed-stock analysis disentangles spatial and temporal variation in composition of the West Greenland Atlantic Salmon fishery. ICES Journal of Marine Science; doi:10.1093/icesjms/fsw072.

Project No. C25 Status: Ongoing

Party or relevant jurisdiction	Canada
Title of project	**Rearing wild-origin IBoF Salmon smolts in marine netpens for release as adults to supplement stocking of Fundy National Park (FNP) Rivers.**
Objective of research project	Experimentally supplement FNP spawning adult salmon populations to effective population size for one salmon generation (4-5years) and produce cohorts of naturally spawned and captive-free migrating smolts.
Brief description of research project	For approximately 5 years beginning in 2015, we intend to collect smolts or age 1+ parr from the wild in FNP and rear to maturity in specialized marine net pens operated by the New Brunswick Aquaculture industry in the Bay of Fundy. Fish will then be released back to their respective rivers as adults to spawn generations of migrating smolts which will be free of captive exposure and the known compromises to fitness in the wild. Throughout the program, annual collections will be planned to meet adult release targets of estimated minimum viable effective population size in both FNP rivers (n_e=375-450 adults). Independent research will be conducted by the University of New Brunswick (K.Samways lead) focused on monitoring the in-river movements (via RF tag and tracking) of released adult salmon as well as the effects of the released salmon on river food web productivity. Additional research began in 2016 by Dalhousie University (J. Grant Lead) focused on characterizing salmon habitat in Fundy National Park with 3-dimensional spatial data collected from a drone. Once characterized, the data will be used with UNB data on observed fish locations to produce a habitat use model. *Of note, similar methods are being carried out on the Petitcodiac River salmon population by project collaborators at Fort Folly First Nations (T. Robinson lead) with support from the Department of Fisheries and Oceans, Parks Canada and local project partners.
Dates during which research took place	2014-2019
Area in which research took place	Upper Salmon River, Point Wolfe River(Fundy National Park) *Petitcodiac
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	~£100 K per annum. Cash and In-kind funding from Fisheries and Oceans Canada, Parks Canada, Members of The Atlantic Canada Fish Farmers Association and Fort Folly First Nation.
Number of participating scientists	One scientist from Parks Canada, University of New Brunswick and Dalhousie University, other collaborating research institutes include, DFO, and Concordia University

Name and e-mail address of coordinating scientist in charge of project	Corey Clarke: corey.clarke@pc.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	na
Type and amount of gear and other equipment used	Helicopter time (to release adults), rotary screw trap and electrofisher (to capture juveniles), dive gear, net seines, commercial sea cages, hatchery facilities, small motorized boats, light trucks, fish transport trucks, fishing boats, acoustic/PIT/VHF tags, acoustic/PIT/VHF receivers.
Details of any collaborating countries	N/A

Summary of Progress:

In 2015 the province of New Brunswick dedicated the first known aquaculture marine farm dedicated solely to rearing wild salmon for conservation purposes. This farm is located in Grand Manan NB Canada, operated and equipped by Cooke Aquaculture, and rears exclusively wild Inner Bay of Fundy smolts to maturity for release to participating Petitcodiac and Fundy National Park rivers as part of this project.

Fundy National Park wild-origin adult Salmon Releases:
Oct 14, 2015: n=426, all to Upper Salmon River, all Pit tagged, 20 VHF tagged.
Oct. 12, 2016: n=850, all to Upper Salmon River, all Pit tagged, 48 VHF tagged
Oct 12, 2017: n=971, all to Upper Salmon River, all PIT tagged, 20 VHF tagged

UNB researchers:
- Maintained an array near mouth of the river to remotely detect PIT tag identification of each crossing fish in 2015, 2016, and 2017
- Collected data on aquatic productivity prior to and following release of adult salmon in 2015, 2016, and 2017.
- Actively tracked radio-tagged fish weekly from October until mid December in 2015, 2016, and 2017.
- Operated a DIDSON sonar camera near river mouth to observe all migrating salmon in 2016 and 2017.

University of Dalhousie researchers collected 3-D spatial data on the entire Upper Salmon river accessible salmon habitat.

Project No. C26 **Status: Ongoing**

Party or relevant jurisdiction	Canada
	Unama'ki Institute of Natural Resources (UINR)
Title of project	**Smolt monitoring on Middle River, Cape Breton, Nova Scotia, Canada**
Objective of research project	The objectives of the research project are: • to estimate run size, age structure and phenology of Atlantic Salmon smolts from the Middle River, Nova Scotia • to allow estimation of survival in the marine environment from smolt to adult life phases • to allow collection of smolts for other research projects and collaborations (e.g. behavioural tagging studies) • to contribute information to inform recovery planning and traditional ecological knowledge
Brief description of research project	A rotary screw trap (RST) is used to capture smolts for biological sampling and to estimate smolt abundance. Run size is estimated using Petersen mark-recapture methods, and scales are aged to estimate age structure. Smolt run size estimates will be combined with adult population estimates (obtained through separate adult surveys) to estimate return rates for 1SW and 2SW salmon.
Dates during which research will take place	2011 – 2016 (May and June) Funding requested for continuation into 2017-2019.
Area in which research will take place	Middle River, Cape Breton, Nova Scotia
Estimated number and weight of salmon to be retained	100 to 600 smolts have been marked (via a caudal fin clip) on an annual basis for the mark-recapture experiment. No smolts are retained.
Resources	
Estimated cost of the research project	Approx. £15 K for smolt wheel Approx. £11 K for annual Operation and Maintenance Costs
Number of participating scientists	5 in total, joint project conducted by Dalhousie University (2), Cape Breton University (1), Ocean Tracking Network (1), and Unama'ki Institute of Natural Resources (1).
Name and e-mail address of coordinating scientist in charge of project	Shelley Denny, shelley.denny@uinr.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	NA
Type and amount of gear and other equipment to be used	One Rotary Screw Trap
Details of any collaborating countries	

Summary of Progress:
Smolt population estimates have been obtained for 2012-2016. Population estimates have been published in annual newsletters and shared with DFO Science for inclusion in their annual Science Response:

DFO. 2014. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/037.

DFO. 2015. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/021.

DFO. 2016. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/029.

DFO. 2017. Stock Status Update of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/020.

Atlantic salmon smolt tagging occurred on Middle River in 2012 (n=16), 2013 (n=50), 2014 (n=30), and 2016 (n=50). Smolt tracking has provided estimates of survival, habitat utilization and timing, and information on physiological conditions influencing migration.

Project No. C27 Status: Ongoing

Party or relevant jurisdiction	Canada
	Unama'ki Institute of Natural Resources (UINR)
Title of project	Tracking the migration behaviour of Atlantic salmon smolts (Middle River) and kelts (Middle and Baddeck rivers), through a unique inland brackish sea of Cape Breton, Canada
Objective of research project	To evaluate marine life history and habitat utilisation of Middle River smolts (e.g., use of Bras d'Or Lakes versus Atlantic Ocean); and to study life history variation, habitat use patterns and underlying physiology of Atlantic salmon kelts from Middle and Baddeck rivers as well as to evaluate management practices associated with broodstock collection program on these rivers.
Brief description of research project	Acoustic telemetry used to track migratory behaviour of Atlantic Salmon smolts (captured via smolt wheel) from Middle River, and kelts from Middle and Baddeck rivers (captured via seining and angling).
Dates during which research will take place	Smolt Acoustic Tagging: 2012, 2013,2014, and 2016, May – June Kelt Acoustic Tagging: 2014 and 2015, November – December Smolt and Kelt Tracking: 2012-2017
Area in which research will take place	Middle and Baddeck rivers, Cape Breton, Nova Scotia. Tracking of tagged fish will occur via acoustic receiver arrays in Middle and Baddeck rivers, Bras d'Or Lakes, Cabot Strait, Strait of Belle Isle and OTN Wave Glider.
Estimated number and weight of salmon to be retained	No salmon will be retained.
Resources	
Estimated cost of the research project	Total per year (including overhead): Approx. £19.4K • Dalhousie University (OTN): Approx. £19.4K • Cape Breton University: Approx. £NA • UINR: Approx. £NA
Number of participating scientists	5 in total, joint project conducted by Dalhousie University (2), Cape Breton University (1), Ocean Tracking Network (1), and Unama'ki Institute of Natural Resources (1).
Name and e-mail address of coordinating scientist in charge of project	Glenn Crossin, gtc@dal.ca Xavier Bordeleau, xavier.bordeleau@dal.ca Bruce Hatcher, bruce_hatcher@cbu.ca Fred Whoriskey, fwhoriskey@dal.ca Shelley Denny, shelley.denny@uinr.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	NA
Type and amount of gear and other equipment to be used	Rotary screw trap, VEMCO acoustic tags, OTN Wave Glider, and acoustic receiver arrays in Middle and Baddeck rivers, Bras d'Or Lakes, Cabot Strait, and Strait of Belle Isle
Details of any collaborating countries	

Summary of Progress:

Atlantic salmon populations originating from the Bras d'Or Lakes (BdOL) watershed occupy a unique ecological niche. This brackish-water inland sea offers alternative possibilities for out-migrating salmon smolts, and could serve as an important reconditioning habitat for kelts.

Atlantic salmon smolt tagging occurred on Middle River in 2012 (n=16), 2013 (n=50), 2014 (n=30), and 2016 (n=50). Smolt tracking has provided estimates of survival, habitat utilization and timing, and information on physiological conditions influencing migration (see Crossin et al. 2016). In addition, we combined energetic modelling using Dynamic Energy Budget (DEB) theory with acoustic telemetry to mechanistically link smolt bioenergetics to their migration strategy. Results suggest that smolts requiring more food were more likely to exit the Bras d'Or during the observation period due to their higher energy requirements, and that increased lake temperature would result in faster depletion of smolt energy reserves, which is predicted to favour smolts migrating to the ocean sooner in order to reach better food resources. (Strople et al. 2018, in revision).

Kelt tagging occurred on Middle (n= 13 in 2014, and n = 33 in 2015) and Baddeck (n= 8 in 2014, and n = 7 in 2015) rivers. Despite limited knowledge on the kelt life stage, post-spawning condition is believed to influence decisions about migration timing and strategy, with implications for longer-term survival. To test this hypothesis, and to evaluate the role of the BdOL in Atlantic salmon life-cycle, a total of 61 kelts were surgically implanted with acoustic transmitters and bio-sampled for indicators of their physiological state. Results suggest the implication of individual's condition (i.e. nutritional state) on migratory timing, with repercussion on longer-term survival. Furthermore, BdOL residency periods of up to 191 days (Nov to June) have been observed, but permanent residency remains speculative (study currently in writing). In addition, tagging both hatchery-spawned and wild-spawned kelts allowed us to evaluate the consequences of hatchery practices on the physiology (stress and immune states), migratory behaviour, and longer-term survival of these fish. Compared to wild-spawned counterparts, hatchery-spawned kelts had significantly higher stress levels and potentially altered immune states, and exhibited earlier freshwater-exit and elevated estuarine mortality. Furthermore, survival to repeat-spawning was 0% (0/30) and 6.5% (2/31) for hatchery-spawned and wild-spawned kelts, respectively. Given that female repeat-spawners are generally large and have high fecundity, our findings suggest that a reduction in iteroparity as a result of hatchery practices could have population-level consequences in some jurisdiction. These repercussions should be considered in current conservation and management practices in iteroparous salmonid species (Bordeleau et al. 2018, in revision).

Publications:

Crossin GT, Hatcher BG, Denny S, Whoriskey K, Orr M, Penney A, Whoriskey FG. Condition-dependent migratory behaviour of endangered Atlantic salmon smolts moving through an inland sea. *Conserv Physiol* 4(1): cow018; doi:10.1093/conphys/cow018.
Abstract: The Bras d'Or Lake watershed of Cape Breton Island, Nova Scotia, Canada is a unique inland sea ecosystem, UNESCO Biosphere Reserve and home to a group of regionally distinct Atlantic salmon (*Salmo salar*) populations. Recent population decreases in this region have raised concern about their long-term persistence. We used acoustic telemetry to track the migrations of juvenile salmon (smolts) from the Middle River into the Bras d'Or Lake and, subsequently, into the Atlantic Ocean. Roughly half of the tagged smolts transited the Bras d'Or Lakes to the Atlantic Ocean, using a migration route that took them through the Gulf of St Lawrence's northern exit at the Strait of Belle Isle (~650 km from the home river) towards feeding areas in the Labrador Sea and Greenland. However, a significant fraction spent >70 days in the Lakes, suggesting that this

population has an alternative resident form, in which smolts limit their migrations within the Bras d'Or. Smolts in good relative condition (as determined from length-to-mass relationships) tended to be residents, whereas fish in poorer condition were ocean migrants. We also found a covarying effect of river temperature that helped to predict residence vs. ocean migration. We discuss these results relative to their bioenergetic implications and provide suggestions for future studies aimed at the conservation of declining salmon populations in Canada.

Bordeleau X, Hatcher BG, Denny S, Fast MD, Whoriskey FG, Patterson DA, Crossin GT (2018) Increased physiological stress, altered migratory behaviour, and reduced survival of hatchery-spawned versus wild-spawned Atlantic salmon kelts. Biological Conservation. In revision.

Strople LC, Filgueira R, Hatcher BG, Denney S, Bordeleau X, Whoriskey FG, Crossin GT (2018) Modelling the effect of environmental conditions on the migration of Atlantic salmon smolts (Salmo salar) through an inland sea. Environmental Biology of Fishes. In revision.

Project No. C28 Status: Completed

Party or relevant jurisdiction	Canada
	Fisheries and Oceans Canada
Title of project	**Evaluating the role of bottom-up effects of prey availability on the survival or local abundance of repeat spawning Atlantic salmon between two ecosystems**
Objective of research project	The objectives of the research project are: Contrary to the overall pattern of declining survival of maiden Atlantic salmon, survival of Miramichi River (Gulf of St. Lawrence, GSL) consecutive MSWS has increased and appears to be linked with local forage fish abundance (Chaput and Benoît, 2012). This project contrast the links with forage fish abundance and environmental factors in the GSL, to the patterns observed in the Bay of Fundy ecosystem where the survival of repeat spawning salmon is considerably lower. The project aims to provide evidence of the importance of forage fish in affecting population dynamics of these highly migratory species by confirming their likely prey using stable isotopes and by contrasting responses among multiple ecosystems and for two salmon spawner groups (local reconditioning vs high seas reconditioning).
Brief description of research project	Stable isotope (C, N) signatures will be extracted from the repeat spawning portion of salmon scales on a second spawning migration, sampled from the Miramichi River and the Nashwaak River. The salmon scale samples are available from the annual monitoring programs in these rivers. Isotopic signatures were derived from a suite of potential prey samples of reconditioning Atlantic salmon obtained during multispecies trawl surveys in the Gulf of St. Lawrence, Bay of Fundy and Scotian-Shelf, and the Labrador Sea. Mixture models were used to estimate the probable prey composition in each ecosystem by repeat spawner group. Scale samples were taken from the most recent available sampling years.
Dates during which research will take place	2014 – 2017
Area in which research will take place	Nashwaak River (Bay of Fundy), Miramichi River (Gulf of St. Lawrence), Bay of Fundy, Scotian Shelf, Gulf of St. Lawrewnce, Labrador Sea
Estimated number and weight of salmon to be retained	None
Resources	
Estimated cost of the research project	Overall: £62 K from DFO International Governance Strategy £30 K Inkind
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Hugues Benoît, DFO (Hugues.benoit@dfo-mpo.gc.ca) Gérald Chaput DFO (Gerald.chaput@dfo-mpo.gc.ca) Ross Jones DFO (Ross.A.Jones@dfo-mpo.gc.ca) Michael Power, University of Waterloo (m3power@uwaterloo.ca)
Details of research vessels, e.g. name,	NA

registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Elemental Analyser, mass spectrometer
Details of any collaborating countries	

Summary of Progress:

Kelly, B., Benoît, H., Chaput, G., Jones, R., and Power, M. 2017 (submitted). Spawning strategy dependent diets in two populations of Atlantic salmon (*Salmo salar*).

Abstract: The diet of Atlantic salmon (*Salmo salar*) was investigated using carbon and nitrogen stable isotope values from scales. Isotope values for consecutive and alternate repeat spawning Atlantic salmon were compared between and within the Miramichi and Nashwaak Rivers, New Brunswick, Canada, and a Bayesian mixing model was used to infer dietary contributions from potential prey items. Significant differences in the stable isotope values were found among spawning strategies and between rivers, indicating differences in diet and feeding area. The range and variance in $\delta^{15}N$ values were indicative of a higher extent of omnivory or a wider feeding range by Nashwaak River alternate repeat spawners. Mixing model results infer that the main prey items consumed during marine feeding by Atlantic salmon from the two rivers were euphausiids, hyperiid amphipods, sandlace (*Ammodytes* sp.), mackerel (*Scomber scombrus*) and capelin (*Mallotus villosus*), with proportional contributions differing among feeding areas, and sometimes between spawning strategies within feeding area. The inferred dietary proportions corresponded well with published Atlantic salmon gut content analysis. These results provide information on the diversity of inferred feeding regimes of Atlantic salmon in the Northwest Atlantic ocean.

Project No. C29 Status: Completed

Party or relevant jurisdiction	Canada
	Memorial University of Newfoundland
Title of project	**Movements and survival rates of acoustic tagged smolts from Campbellton River, Newfoundland**
Objective of research project	The objectives of the research project are: • Study migration rates, habitat use and early phase marine survival of salmon smolts from a northeast coast Newfoundland river.
Brief description of research project	Smolts were captured at a counting fence. Acoustic tags were placed in 26 smolts in 2014. Receivers were placed throughout Notre Dame Bay.
Dates during which research will take place	2014 – 2017
Area in which research will take place	Campbellton River, Newfoundland
Estimated number and weight of salmon to be retained	26 smolts tagged in 2014. No smolts are retained.
Resources	
Estimated cost of the research project	-
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	Kristin Boee - kristinboee@gmail.com
Details of research vessels, e.g. name, registration, call sign and description of vessel	NA
Type and amount of gear and other equipment to be used	Counting fence, acoustic receivers
Details of any collaborating countries	

Summary of Progress:

Analyses are ongoing.
Out of the 26 smolts that were tagged in Campbellton River in spring 2014, every fish was detected at least once in the marine environment. The 24 smolt detections in zone 5 gives a minimum survival rate of 92 % from the river to the outer coast, or 96 % if including the smolt that was last detected at the eastern part of the array. It took on average 29 days from the date of release till the smolts were first detected in zone 5 (+/- 6.6 days). The majority of the smolts were last detected on the Eastern side of Exploits Island when leaving zone 5. Only 5 smolt were detected outside Notre Dame Bay/Exploits Bay. Two smolts were detected in Triton, 44 and 47 days after release respectively. Three smolts were detected Northeast of Twillinggate, 39, 45 and 47 days after release. The estimated tag life was 61 days meaning that further detections became less likely as the smolt migration progressed further away from Notre Dame Bay/Bay of Exploits.

Project No. C30 Status: Ongoing

Party or relevant jurisdiction	Canada
	Atlantic Salmon Federation, Vemco/Amirix
Title of project	**Predation events on Atlantic salmon smolts in the Miramichi estuary**
Objective of research project	The objectives of the research project are: • To identify the extent of bias introduced to acoustic telemetry data as result of predation on tagged individuals and their subsequent detection within the study area
Brief description of research project	Smolts captured by rotary screw traps in Miramichi and tagged with new V5 180 kHz predator detection tags. Receivers were placed in tidal estuary waters of the Northwest and mainstem Miramichi River
Dates during which research will take place	2017 (spring/summer)
Area in which research will take place	Northwest Miramichi River, New Brunswick, Canada
Estimated number and weight of salmon to be retained	50 smolts tagged in 2017.
Resources	
Estimated cost of the research project	£20 K Transmitters £20 K Receivers £30 K Labour
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	Jonathan Carr, Atlantic Salmon Federation: jcarr@asf.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Small boats (20 feet in length)
Type and amount of gear and other equipment to be used	Rotary screw traps, acoustic tags and receivers
Details of any collaborating countries	

Summary of Progress:

Recently developed predator tags were surgically implanted into 50 smolts in the NW Miramichi River this past season to quantify predation in more empirical way compared to previous behavioural based models. Smolts were randomly selected for tagging throughout the duration of the spring smolt run. This differs from our typical smolt tagging activities in that we are not selecting for larger and potentially more fit individuals and we are not tagging at discrete points within the duration of the smolt run. This allows for a more representative sample of the population to base our inferences. Of the 50 tags only 41 were detected within the estuary, of which, five were detected only as predated. In total, 59% of the smolts were detected as predated. Most of the post-predation detections for each tag occurred at a single array leaving us without any behavioural attributes to make informed predictions on the type of predator responsible. 22% of detected tags, however, were detected across multiple arrays post-predation, suggesting piscine predators were responsible. Due to the relatively coarse resolution of the data and the lack of post-predation behavioural attributes we opted to focus our attention on identifying the extent of predation bias in these data (i.e. the difference between 'true' and perceived estimates of survival, for example). With acoustically telemetered salmonids, researchers often make inferences on migration timing, behaviour, and survival. Using the predator tag data, we quantified the survival and timing bias introduced, through predation, spatially. The greatest amount of bias was present in the survival estimates within the upper 12 km of NW Miramichi estuary. The bias introduced here resulted in an approximately 10% over estimation in the probability of survival. A manuscript is currently in preparation and is expected to be submitted by the fall of this year.

Project No. C31 Status: Ongoing

Party or relevant jurisdiction	Canada
	Fisheries and Oceans Canada
Title of project	**Research into factors of early marine phase postsmolt mortality using acoustic predator-detection tags**
Objective of research project	The objectives of the research project are: • to assess the extent to which predation explains the loss of acoustically tagged Atlantic salmon smolts during the early phase of migration • to assess how run timing modifies predation and loss rates
Brief description of research project	Smolts captured rotary screw traps in Stewiacke River and tagged with new V5 120 kHz predator detection tags. Receivers will be placed in river and tidal estuary waters of Minas Basin
Dates during which research will take place	2017 +
Area in which research will take place	Stewiacke River, Inner Bay of Fundy, Nova Scotia, Canada
Estimated number and weight of salmon to be retained	50 smolts to be tagged in 201
Resources	
Estimated cost of the research project	£73 K Approx.
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	David Hardie, Fisheries and Oceans Canada¶ david.hardie@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	NA
Type and amount of gear and other equipment to be used	Rotary screw traps, acoustic receivers (20), small-medium (<20’) vessels, active tracking acoustic hydrophones
Details of any collaborating countries	

Summary of Progress:

Field preparation and research design ongoing and planned gear deployment and tagging for May-June 2017

Project No.   C32   Status: Ongoing

Party or relevant jurisdiction	Canada
	Fisheries and Oceans Canada
Title of project	**Migration, distribution, survival of smolts from Nashwaak River**
Objective of research project	The objectives of the research project are: 1. assess riverine, estuarine, near and distant marine migration and survival of Nashwaak River smolts 2. assess the survival of pre-smolts tagged and released in river and in laboratory. 3. Compare the migration and survival of smolts tagged the preceding fall as pre-smolts and recently tagged smolts.
Brief description of research project	1. Track RST-captured smolts (N=50, spring 2017) throughout Nashwaak and St. John River and past estuarine and oceanic hydroacoustic infrastructure (e.g. OTN lines etc…) 2. Tag electrofished pre-smolts to be released in-river (50) and held in captivity (dummy-tagged N=25). Monitor over-winter survival and tag retention of dummy-tagged smolt. Track/monitor overwinter survival of tagged in-river pre-smolts. 3. Tag RST-captured smolts (N=50, spring 2018) to track river and estuarine migration and survival compared to surviving smolts tagged as pre-smolts the preceding fall (objective 2).
Dates during which research will take place	May 2017, Fall 2017, May 2018
Area in which research will take place	Nashwaak River, Saint John River.
Estimated number and weight of salmon to be retained	Nil
Resources	
Estimated cost of the research project	£76 K
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	David Hardie David.Hardie@dfo-mpo.gc.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Small vessels (<20 foot)
Type and amount of gear and other equipment to be used	Hydroacoustic tags and dummy tags in pre-smolts and smolts. Hydroacoustic receivers in river and estuary. Active tracking from small-medium vessels in river and estuary.
Details of any collaborating countries	

Summary of Progress:

Tags and some receivers for 2017 spring smolt deployment funded/ordered. Liaison with Canadian Rivers Institute for acoustic array design/supplementation ongoing. Funding for tagging/tracking in spring 2017 and balance of proposed 2017-18 tags and fieldwork not yet funded (proposal in prep and/or pending).

Project No. C33 Status: Ongoing

Party or relevant jurisdiction	Canada
	Fisheries and Oceans Canada Ministère des Forêts, de la Faune et des Parcs du Québec
Title of project	**Early marine phase migration, and survival of post-smolts from salmon populations of Quebec**
Objective of research project	The objectives of the research project are: - to study migrations, distribution and post-smolt survival of Atlantic salmon smolts as they leave rivers to travel in the Gulf of St. Lawrence to the Strait of Belle Isle
Brief description of research project	Atlantic salmon smolts from monitored rivers in the province of Quebec were intercepted during their migrations to the sea and tagged with acoustic transmitters. Their movements and early phase marine survival was studied by tracking in tidal areas, nearshore and at the receiver arrays at the 2 exits of the Gulf of St. Lawrence. In 2014, MFFP tagged 50 smolts with acoustic transmitters in the Vieux-Fort River (Lower North Shore). In 2017, MFFP and DFO tagged with acoustic transmitters a total of 188 smolts from Vieux-Fort River and Jacques Cartier River (50 km West of Québec City). The Jacques-Cartier River smolts, a reintroduced population, were tagged at Pont-Rouge hydrofacility dam. Post-smolt migrations from both rivers were monitored at the exit of the Gulf of St. Lawrence (Strait of Belle Isles). Also in 2017, the CIRSA (Université Laval) started a smolt survival program with PIT-tags in the Ste Marguerite North East River (Saguenay); monitoring of returning salmon will start in 2018.
Dates during which research will take place	Started in 2014 and to be continued.
Area in which research will take place	Gulf of St. Lawrence, eastern Canada
Estimated number and weight of salmon to be retained	Nil
Resources	
Estimated cost of the research project	Quebec: MFFP - approx. £80 K per year DFO - approx. £80 K for one year Université Laval - approx. £25 K per year
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Martin Castonguay: martin.castonguay@dfo-mpo.gc.ca Julien April : julien.april@mffp.gouv.qc.ca Normand Bergeron : normand.bergeron@ete.inrs.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Small vessels (<20 foot)
Type and amount of gear and other equipment to be used	Acoustic tags in smolts. Acoustic receivers in river and estuary.

Details of any collaborating countries	
Summary of Progress: 2014: 50 tags and some receivers deployed. 2017: 188 tags and some receivers deployed. 2018: No tracking will be carried out in 2018. Low survival results of 2017 need to be analysed and data exchange between participants must be specified in a collaboration agreement.	

Project No. C34 Status: Ongoing

Party or relevant jurisdiction	Canada
	Nova Scotia Salmon Association
Title of project	**West River Acid Rain Mitigation Project**
Objective of research project	Evaluate the efficacy of acid rain mitigation techniques, including lime dosing, catchment liming and additional supporting restoration techniques (e.g. physical habitat restoration, the creation of artificial spring habitats)
Brief description of research project	Acid rain has been greatly reduced relative to the 1980s, however along the Atlantic coast of Nova Scotia and northeastern Maine, USA, a legacy of acid rain persists; impacting soil, forest, and the aquatic ecosystem health. The Atlantic Salmon, *Salmo salar*, is a species which has been particularly negatively impacted with total abundance reduced by 88-99% along Nova Scotia's Atlantic coast and a suspected 2/3rds of the known populations now extirpated. Beginning in 2005, the not-for-profit Nova Scotia Salmon Association initiated a demonstration acid mitigation project on a small coastal river 80 km northeast of Halifax. An automated lime doser continuously administers powdered limestone to the acidic river water in an effort to raise pH, reduce the concentration of toxic monomeric (labile) aluminum, and ultimately, increase the survival and abundance of Atlantic Salmon and other acid-sensitive aquatic species. Scientific monitoring during the initial 2005-2015 period consisted of a short-term intensive project 2005-2007 in support of a MSc project. This monitoring followed a "Before-After-Control-Impact" (BACI) experimental design which contrasted several ecological parameters in limed and unlimed areas for 1 year prior to liming and for 1.5 years post-liming (i.e. spring 2005 through summer 2007). The parameters examined during the BACI study included; stream pH, periphyton (algae), aquatic invertebrates (insects) and fish abundance determined *via* electrofishing surveys. Post-2006, it was determined that further monitoring should occur. In general, there was a lack of rigorous scientific planning and resources for monitoring were limited. Sporadic electrofishing continued between 2007-2015 at six sites. Smolt production in the limed WRSH and the Little River tributary (unlimed) was estimated between 2007-2014 using a 'smolt wheel' and fyke nets. Continuous spring-summer-fall monitoring of stream pH was reinstated in 2013. Beginning in 2015, returning adult salmon have been counted in both the limed WRSH and Little River using a novel resistance board weir and a traditional 'picket-style' weir.
Dates during which research will take place	June 2016 – April 2019
Area in which research will take place	Nova Scotia Southern Upland

Estimated number and weight of salmon to be retained	80 smolts
Resources	
Estimated cost of the research project	£1,770 K over 3 years
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	Dr. Eddie Halfyard eahalfyard@hotmail.com
Details of research vessels, e.g. name, registration, call sign and description of vessel	*n/a*
Type and amount of gear and other equipment to be used	Rotary screw trap, resistance board weir, electrofishing, fyke nets
Details of any collaborating countries	
Summary of Progress: Project results are presently being analysed and a publication is expected in 2018.	

Project No. C35 Status: New Entry (Ongoing)

Party or relevant jurisdiction	Canada
	Dalhousie University, Halifax, NS
Title of project	**Atlantic Salmon Research Joint Venture – Life History Modelling Project for Wild Atlantic salmon**
Objective of research project	The objectives of the research project are: • To update a 1998 review on Atlantic salmon life history variability throughout the species geographical range • To develop detailed time-series data within selected Canadian populations for key life-history traits • To undertake population viability analyses for Atlantic salmon populations at different spatial scales, ranging from very large scales (e.g. across species range) to increasingly small scales (e.g., regional, river-by-river, where appropriate) • To undertake elasticity and sensitivity analyses of the life history model at different spatial scales, ranging from very large scales (e.g. across species range) to increasingly small scales (e.g., regional, river-by-river, where appropriate)
Brief description of research project	Many populations of Atlantic salmon that range in North America from the Connecticut River, USA to Kapisillit River, Greenland are currently experiencing high levels of natural mortality. Several populations are listed as endangered or threatened. Extraordinary losses occur in the estuarine and marine environment but the causes, locations, and timing of the various sources of mortality and stage in the life history are largely unknown. In order to identify and quantify factors responsible for mortality it is necessary to look at options or possibilities for project planning that may lead to mitigation or cessation of those causative factors, i.e. threats. The objective of this planned work is to develop a stochastic, dynamic life history model that can be used to further explore the factors affecting the survival of Atlantic salmon. The work will involve, but not be limited to, analyses of per capita population growth, life-history elasticity, model sensitivity, and patterns of density dependence (including Allee effects) at different spatio-temporal scales. The model parameters will be based on a review of data throughout the geographic range of the species, updating one undertaken in 1998. The over-arching goal of the project is to apply the model to address fundamental questions pertaining to population viability of Atlantic salmon.
Dates during which research will take place	May 2017 to March 2019
Area in which research will take place	North Atlantic
Estimated number and weight of salmon to be retained	Nil
Resources	

Estimated cost of the research project	£40 K per year Total over 2 years: £80 K (£37.5 Atlantic Salmon Conservation Fund; £37.5 K DFO Atlantic Salmon Research Joint Venture; £5 K Killam Chair Dalhousie University)
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	Dr. Jeff Hutchings jeff.hutchings@dal.ca Dr. Sebastian Pardo spardo@dal.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	NA
Type and amount of gear and other equipment to be used	NA
Details of any collaborating countries	NA

Summary of Progress in 2017/2018:

Datasets analysed:
Spatial and temporal trends of biological characteristics (river age, sea age, grilse length, large salmon length) for Newfoundland Rivers (English River, Paradise River, Muddy Bay Brook, Sand Hill River, Exploits River, Campbellton River, Middle Brook, Terra Nova River, Northwest River, Rocky River, Little River, Conne River, Highlands River, Crabbes River, M. Barachois River, Robinsons River, Fischells River, Flat Bay Brook, Harry's River, Pinchgut Brook, Torrent River, Western Arm Brook). Also looked at the available return data (small and large salmon) for all Canadian rivers combined. This has served mostly as "dummy" data to test the modeling approach described below.

Developed inverse matrix approach:
The inverse matrix approach aims to estimate the life history parameters estimates, such as smolt-to-grilse survival (marine survival) and egg-to-smolt survival (freshwater survival), that result in the population trends we measure directly (i.e. adult returns) for individual rivers across time. This is achieved using a Sampling Importance Resampling (SIR) algorithm, which can be thought of as a bootstrapping approach which is weighted using a likelihood function based on how well each set of parameters matches the observed abundance estimates. This approach allows for exploring how life history traits, particularly survival, have changed in each river across time, as well as assessing whether their variability changed over time.

Project No. C36 Status: New Entry

Party or relevant jurisdiction	Canada
	Atlantic Salmon Federation, St. Andrews, NB
Title of project	**Atlantic Salmon Research Joint Venture – Atlantic Salmon Post-smolt Trawl and Troll Survey in the Strait of Belle Isle**
Objective of research project	The objectives of the research project are: 1. Determine the feasibility of capturing Atlantic salmon post-smolts (unharmed) as they migrate through the Strait of Belle Isle (SoBI). 2. Record presence of other fish species (predator and prey) at SoBI at the same time post-smolts are passing through. 3. Lethally sample a subset (N=100) post-smolts for fish health, growth (scales, otoliths), genetic analysis (population structure and sex), and stomach contents.
Brief description of research project	For reasons not fully understood, mortality rates for Atlantic salmon at sea are double those of the 1970s and 1980s (Bowlby et al. 2013). To understand and identify the reasons for mortality, involves an in-depth investigation of the Atlantic salmon from the time it enters the marine habitat as a smolt to its return to freshwater as a mature adult. Since 2003, the Atlantic Salmon Federation has been working with several partners to tag and track smolt from several Gulf of St. Lawrence (GoSL) rivers. Post-smolts from several regions within the GoSL use SoBI as a migration corridor to the Labrador Sea. This migration occurs over a ten-day window (early-mid July) annually. By the time post-smolts arrive at SoBI we would expect them to have increased from 12-15 cm smolt size to near 25 cm or larger. Based on trawl surveys in the Labrador Sea the mean post-smolt fork lengths were 26.8 cm ± 2.4 SD in mid-August 2008, and 34.8 cm ± 1.0 SD in mid-September 2009 (Sheehan et al. 2012). Thus, SoBI may be a suitable area for future tagging of post-smolt as they move into Labrador Sea. Other advantages of collecting post-smolt at SoBI are to sample for presence of pathogens, population structure (genetics), prey choice (diet and lipid analysis), condition factor, parasite load, and growth rates (scale analysis). Custom trawl surveys with live boxes have been successfully carried out by commercial fishermen and NOAA scientists in the Penobscot Bay (up to 5 knots of current) since 2012 (J Stevens, NOAA Fisheries Biologist 2017, pers. comm.). All post-smolts (about 400) were collected unharmed in the live boxes during those surveys. Micro trolling has successfully been used on the west coast of Canada to capture and tag chinook salmon as part of the Salish Sea Marine Survival Program (Pearsall and Riddell, 2016).
Dates during which research will take place	July 2017 to March 2019
Area in which research will take place	Strait of Belle Isle, Canada
Estimated number and weight of salmon to be retained	< 100 post smolts (< 30 kg)

Resources	
Estimated cost of the research project	2017: £94 K (£58 K DFO Atlantic Salmon Research Joint Venture; £35 K Atlantic Salmon Federation) 2018: £50 K (gear, tags, contractual vessel time, genetics, fish health screening, salary, etc)
Number of participating scientists	1
Name and e-mail address of coordinating scientist in charge of project	Jonathan Carr, Atlantic Salmon Federation jcarr@asf.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	Local fishing vessel
Type and amount of gear and other equipment to be used	custom pelagic surface trawl net with a custom made live box at the cod end
Details of any collaborating countries	NOAA Fisheries Service, USA

Summary of Progress in 2017/2018:

Throughout July 2017, three gear types for capturing post-smolt salmon were assessed: 1) Top water trawl; 2) gillnets; 3) traditional trolling with rod and reel. Gear was assessed for capture efficiencies and the relative damage it caused to fish captured. Locations within the strait were assessed for post-smolt presence by active sampling and deploying acoustic receivers to determine any areas where post-smolt may be holding before crossing the strait. New contacts and working relations were also established to continue efforts in future years.

From the data gathered, it had been determined that to increase capture efficiencies the top-water trawl net would need modifications to sample a larger area. Gillnets proved successful in capturing post-smolt, however, these caused large amounts of damage and were therefore deemed only suitable for lethal sampling. Trolling with rod and reel were unsuccessful and were recommended to be omitted from future sampling protocols. From acoustic receiver data, it was determined post-smolt may be congregating within L'Anse L'Amour and that future sampling should aim to explore this area more. Passive gears such as floating trap or fyke nets were also recommended to be tested in future years.

From recommendations provided from the 2017 sampling season, alterations to sampling gear and methodologies have been developed for the 2018 sampling season. The top water trawl net has been enlarged so twice the amount of area is fished. This modified trawl will be tested in the spring of 2018 to ensure equipment would perform as expected during the field season. Two fyke nets have also been purchased that will be used within L'Anse L'Amour. Additional receivers have also been purchased to be placed throughout L'Anse L'Amour to detect acoustically tagged smolts emigrating from the Gulf of St. Lawrence rivers. Up to 40 postsmolt will be acoustically tagged in 2018.

Project No. C37 Status: New Entry

Party or relevant jurisdiction	Canada
	Atlantic Salmon Federation, St. Andrews, NB
Title of project	**Atlantic Salmon Research Joint Venture – Current status of knowledge, data, and research efforts on Atlantic salmon at Greenland: what do we have, what do we need, and what should we do moving forward?**
Objective of research project	The objectives of the research project are: 1. review historical/current state of knowledge (literature review and data inventory) of Atlantic salmon at the summer feeding area off the coast of West Greenland; 2. review current research efforts on Atlantic salmon at the summer feeding area off the coast of West Greenland; 3. compile future data needs and gaps; 4. review inventory of archived databases (sampling database, genetic assignment database, etc.) and samples (scales, tissue, etc.) available from Atlantic salmon collected at the summer feeding area of the coast of West Greenland; 5. develop recommendations for improving future fishery sampling efforts; 6. develop short list of research themes/projects to address future data needs and gaps; 7. develop protocols for providing access to database(s) and archived samples for collaborating researchers; 8. develop a guide for interpreting the sampling database that considers the non-random sampling conducted in some years.
Brief description of research project	Annual sampling of the West Greenland Atlantic salmon fishery has occurred since 1968 except for 1993 and 1994. Presently there are approximately 60K records detailing sampling date, location (NAFO Division), size (mainly fork length (cm) and gutted weight (kg)), river/sea age, presence of spawning marks, and continent of origin for the sampled individuals. In addition, individual scale and tissue samples (tissue samples since 1999) are also available for the sampled individuals. The sampling approach has varied over time, from random sampling by research vessel fishing to samples from the commercial landings, to random samples from local markets, other vendors, and factories from individual communities. The resulting database and associated samples represent a rich resource of information that can be used to evaluate the marine dynamics and ecosystem drivers of Atlantic salmon marine survival for these 1SW non-maturing fish. Decades of research have been undertaken with these data and samples and the results from these studies are not widely known or understood. In addition, numerous other studies have been conducted in association with the sampling program as well as outside of the sampling program and these data and results are also not widely known or understood. The West Greenland fishery sampling program provides an excellent opportunity to conduct studies to further understanding of this critical life stage. Before proceeding further, it would be prudent to review the

	past and ongoing studies to inform the development of an efficient future research plan based on data needs and gaps. It is also important to develop protocols for historic data and sample use to ensure their availability into the future as many new sampling techniques are sometimes destructive. If access is not properly managed, this important data resource could be lost.
Dates during which research will take place	May 2017 to March 2018
Area in which research will take place	NA
Estimated number and weight of salmon to be retained	NA
Resources	
Estimated cost of the research project	£38 K (£18 K DFO Atlantic Salmon Research Joint Venture; £20 K inkind from various contributors)
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Timothy Sheehan: Tim.Sheehan@noaa.gov Niall Ó Maoiléidigh: niall.omaoileidigh@marine.ie Rasmus Nygaard: rany@natur.gl Jonathan Carr: jcarr@asf.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	NA
Type and amount of gear and other equipment to be used	NA
Details of any collaborating countries	Canada, USA, Greenland, Ireland, European Union

Summary of Progress in 2017/2018:

A workshop was convened in Halifax, NS Canada during 7-9 December, 2017. A total of 18 attendees from North America and Europe participated covering a wide range of experience and interests with the West Greenland sampling program. Some participants are currently involved in the sampling program, some individuals have been involved in research projects utilizing the data and samples collected, and some individuals were selected to provide advice on best future use of collected data and samples as well as future data needs, gaps, and research plans. The Workshop was organized to address each of the specific objectives in turn. The draft workshop report provides an overview of discussions, conclusions, and recommendation which occurred under each objective and is currently under revision by participants.

Project No. C38 Status: New Entry

Party or relevant jurisdiction	Canada
	Oceans Tracking Network, Dalhousie University, Halifax, NS
Title of project	**Atlantic Salmon Research Joint Venture – Development of Acoustic Tracking Capabilities for Drifter Buoys**
Objective of research project	The objectives of the research project are: 1. Support the scientific community's work acoustic telemetry work following the movements and survival of Atlantic salmon in the Northwest Atlantic Ocean by conducting the engineering and integration work needed to couple a Vemco VR2C underwater, cabled acoustic receiver to the MetOcean SVP drifting buoy. 2. Design the prototype so that it becomes a low-cost, add-on option (target < £ 3 K per unit) to the purchase price of the MetOcean buoy (current cost £3 K), enabling NASCO members and other partners to contribute to high seas research of Atlantic salmon through modest, incremental contributions to the purchase prices of meteorological buoys which national authorities intend to buy and launch annually. 3. Build, test, and refine a prototype of the buoy.
Brief description of research project	Covering the offshore with acoustic telemetry poses a large challenge. Offshore moorings are expensive to purchase and can cost up to $1M/year/mooring to maintain. In addition, moorings with surface floats can be an obstacle to shipping, and any mooring placed in fishing areas can cause friction with fishing communities. Additional acoustic receiver coverage can be provided to the offshore by mounting receiver units on mobile assets such as bioprobes (e.g., grey seals), or marine autonomous vehicles (e.g., Slocum and Wave Gliders). Seals tend to remain coastal, and while the numbers of autonomous vehicles deployed in the North Atlantic Ocean are growing at present they are not numerous. A third solution is to attach acoustic receivers to disposable, affordable (existing buoy price without acoustic capacity approximately $5K ea), passively drifting buoys such as those used in the Global Surface Drifter buoy array These buoys are designed to measure and report Georeferenced (GPS), real-time data oceanographic data such as sea temperature and salinity to assist the World Meteorological Organization via satellite link. Hundreds of drifter buoys are deployed annually by multiple countries including Canada, and each buoy has the battery power and physical resilience to waves and biofouling to be active for approximately two years. The MetOcean SVP buoy is the workhorse of the drifting buoy world. The Global Drifter Center, located in Miami Florida, maintains an array of at least 1,250 buoys at all times in the world's oceans. If the buoys of the Drifter Network are modified to include acoustic receiver technology reporting detections of acoustically tagged animals in real-time, they could become a valuable asset to the scientific community interested in tracking salmon and other species in the offshore. Halifax-based Vemco currently has a proven cabled acoustic receiver (VR2C) that can has been adapted to integrate with and report real-time data from fixed

	moorings, marine autonomous vehicles, and cabled ocean observatories. The MetOcean buoy is designed to easily communicate to, or integrate with, the user's top-side unit or surface hub. Development work will be carried out in Halifax, where the industry partners MetOcean and VEMCO have their research and development capabilities, and where the OTN has access to test facilities. The work involves integrating an existing VEMCO cabled acoustic receiver into the MetOcean SVP Drifter buoy. This buoy is compact and easy to deploy from virtually any sized vessel. OTN will take possession of the prototype, and deploy it locally off Halifax for testing. This will include range testing to determine detection efficiency for a variety of models of acoustic tags. Following this, feedback will be provided to the companies so that necessary modifications to address identified deficiencies can be addressed, and the final version will be developed. Assuming the final prototype is ready for October 2017, a field trial will be conducted in the Miramichi estuary in October where a quantity of striped bass carrying acoustic tags return to the river in the fall and project partners could very readily deploy and retrieve the unit within this small geographic area.
Dates during which research will take place	May 2017 to March 2018
Area in which research will take place	NA
Estimated number and weight of salmon to be retained	NA
Resources	
Estimated cost of the research project	£58 K in 2017-2018 (£38 K DFO Atlantic Salmon Research Joint Venture; £20 K Oceans Tracking Network)
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Dr. Fred Whoriskey, Executive Director, Ocean Tracking Network, Dalhousie University fwhoriskey@dal.ca
Details of research vessels, e.g. name, registration, call sign and description of vessel	NA
Type and amount of gear and other equipment to be used	NA
Details of any collaborating countries	Canada, USA
Summary of Progress in 2017/2018: Participating companies (Vemco, MetOcean) have met, signed necessary non-disclosure agreements, and have agreed upon their work contributions. Scoping meetings have been conducted with MetOcean to discuss design, engineering, and cost constraints to guide the work. Parameters for the project including packaging tag-detection information into the regularly scheduled communications programming for the MetOcean buoys are close to being finalized. The software development for this will be a rate-limiting step in the project. Timelines for the engineering and development work will now carry us into autumn of 2018 at the earliest.	

2. DENMARK (IN RESPECT OF THE FAROE ISLANDS AND GREENLAND)

Faroe Islands

The Faroese Fisheries Laboratory is collaborating in a number of projects detailed in the returns made by other Parties.

Greenland

Project No. D1 Status: Ongoing

Party or relevant jurisdiction	Greenland
Title of project	**West Greenland Salmon Fishery Sampling Programme**
Objective of research project	1. Continue the time series of data (beginning 1969) on the continent of origin and biological characteristics of the salmon in the West Greenland Fishery; 2. Provide data on mean weight, length and continent of origin for input to the North American and European run-reconstruction models; 3. Collect information on the recovery of internal and external tags; 4. Collect other additional biological samples as required.
Brief description of research project	One of the key data inputs to international stock assessments of Atlantic salmon is the origin of Atlantic salmon harvested in mixed stock fisheries. The Parties to the West Greenland Commission of NASCO have, therefore, worked cooperatively over the past three decades to collect biological data on Atlantic salmon harvested at West Greenland. The sampling programme collects biological data, scale and tissue samples, and information on tags and marks from Atlantic salmon caught in the commercial fishery at West Greenland. Under the NASCO 2017 West Greenland Sampling Agreement (WGC(17)8), Parties to the NASCO West Greenland Commission agreed to provide staff to sample catches of Atlantic salmon in the West Greenland fishery during the 2017 fishing season. The sampling programme collects: • Biological characteristics data including lengths and weights of landed fish; • Information on tags, fin clips and other marks; • Scale samples to be used for age and growth analyses; • Tissue samples to be used for genetic analyses; • Other biological data requested by the ICES scientists and NASCO co-operators.

Dates during which research will take place	Annually during the fishing season, approximately August – October
Area in which research will take place	Sisimiut, Maniitsoq, Paamiut, and Qaqortoq
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	Greenland - approximately £9,000 per annum Canada - £7,000 per annum (excludes costs of scale ageing, genetic origin determination, and data analyses) EU (United Kingdom England & Wales) - £15,000 per annum EU (United Kingdom Scotland) - £15,000 per annum EU (Ireland) - £17,400 per annum USA - £30,000 per annum Total - £93,400
Number of participating scientists	1 scientist from Greenland working with scientists from Canada (1), USA(1), EU-UK (2) and EU-Ireland (2)
Name and e-mail address of coordinating scientist in charge of project	Helle Siegstad helle@natur.gl
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	Standard sampling equipment Standard genetics laboratory equipment
Details of any collaborating countries	Collaborative project with investigators from US (T. Sheehan), the United Kingdom (P. Davison, K. Hanslip, I. Russell, G. Smith, and L. Talks), Ireland (C. Gallagher and N. Ó Maoiléidigh), and Canada (G. Chaput). The work is coordinated via NASCO and is reported to ICES (Working Group on North Atlantic Salmon).

Summary of Progress:

In 2017, the sampling program included sampling teams from Greenland, United States, Canada, Scotland, England and Wales, and Ireland. Teams were in place shortly after the start of the fishery on 15 August and continued through October. In total, approximately 1,400 specimens were sampled for presence of tags, fork length, weight, scales, and tissue samples for DNA analysis. Samples were obtained from four landing sites (Sisimiut (NAFO Division 1B), Maniitsoq (1C), Paamuit (1E) and Qaqortoq (1F)). Collected scale samples will be aged and tissue analysis for continent of origin determination will be conducted by Canadian collaborators.

Results from the 2016 sampling program are currently in press as a NOAA NEFSC Laboratory Reference Document (citation below). A similar report will be pursued for the 2017 sampling programme results.

Sheehan, T.F., Deschamps, D., Downie, H., Hawkes, J., McAuliffe, M., Millane, M., Sims, K., Nygaard, R., Lubinski, B., Robertson, M.J., and Ó Maoiléidigh, N. *in press*. The International Sampling Program: Continent of Origin and Biological Characteristics of Atlantic Salmon Collected at West Greenland in 2016. US Dept Commer, Northeast Fish Sci Cent Ref Doc. ##-##; ## p.

3. EUROPEAN UNION

Project No. E1 Status: Completed

Party or relevant jurisdiction	European Union
Title of project	**SALMODEL Concerted Action - A co-ordinated approach towards the development of a scientific basis for management of wild Atlantic salmon in the North-East Atlantic**
Objectives of research project	- To improve our ability to set salmon conservation limits (CLs); addressing transportability and dynamic change issues, also taking into account underlying stock structure, and; - To examine methods of estimating pre-fishery abundance (PFA) for north-east Atlantic (NEAC) salmon stocks and to determine whether and how PFA estimates can be used to give catch advice.
Brief description of research project *(Note: only the PFA/marine side of the project is reported here)*	Development of catch advice for NEAC salmon in distant water fisheries depends critically on availability of methods of assessing stock status in advance of fishing and relating this to conservation requirements in rivers of origin. SALMODEL aimed to provide improvements to the existing interim methods of developing catch advice at ICES (which do not have predictive capability for NEAC stocks) and to explore and evaluate options for developing fully predicative PFA models. Two workpackages addressed these areas: Workpackage 4: - examined current models used to estimate PFA, including that used by ICES - valuated the quality of historic data used to run the ICES PFA model - assessed sensitivity of the model to data types and variation, and tested assumptions of incorporation of natural mortality “m” into PFA models -evaluated the basis of the NEAC stock groupings being used in the catch advice process. Workpackage 5: -evaluated options for developing a predictive PFA model from the historic time series employing environmental and other data, producing for the first time forecasts of PFA of southern European stocks at West Greenland -investigated forward-running predictive PFA models based on smolt production estimates/indices for the NEAC area -examined approaches for model validation -examined scales at which the various model types can be applied

Dates during which research took place	2000-2002. Project completed 31/12/02, draft final report sent to European Commission March 2003.
Area in which research took place	Work was progressed via formal meetings, topic-specific workshops and co-operative studies; no field studies were involved.
Estimated number and weight of salmon retained	Not applicable
Resources	
Estimated cost of the research project	£500,000 in total
Number of participating scientists	17 European members; 2 Canadian participants; + invited external experts
Name of coordinating scientist in charge of project	Dr Walter Crozier
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	UK (E&W; Scotland, N. Ireland); France; Ireland; Norway; Sweden; Finland; Iceland; Canada

Summary of Findings:

This will be provided as a separate document to NASCO (CNL(03)9). Briefly, SALMODEL has:

- examined current models used to estimate PFA, including that used by ICES
- assessed sensitivity of the ICES model to data types and variation, and tested assumptions of incorporation of natural mortality "m" into PFA models, this resulting in a change to the default value of "m" used at ICES
- SALMODEL also evaluated the basis of the NEAC stock groupings being used in the catch advice process
- evaluated options for developing a predictive PFA model from the historic time series employing environmental and other data, producing for the first time forecasts of PFA of southern European stocks at West Greenland
- investigated predictive PFA models based on smolt production estimates/indices for the NEAC area
- examined approaches for model validation and examined scales at which the various model types can be applied

Project No. E2 Status: Completed

Party or relevant jurisdiction	European Union - (consortium of 20 partners)
Title of project	**SALSEA-Merge - Advancing understanding of Atlantic salmon at sea: Merging genetics and ecology to resolve stock-specific migration and distribution patterns**
Objective of research project	The overall objective of SALSEA-Merge is, by merging genetic and ecological investigations, to advance understanding of stock specific migration and distribution patterns and overall ecology of the marine life of Atlantic salmon and gain an insight into the factors resulting in recent significant increases in marine mortality.
Brief description of research project	SALSEA-Merge comprises seven work packages including: development of genetic identification methodology; marine data acquisition through a series of marine surveys in the north-east Atlantic; genetic identification of stock origin of samples collected; biological analysis of samples including analysis of scale samples (historic and contemporary), diet analysis and assessment of condition; merging and analysis of genetic, biological and oceanographic data.
Dates during which research will take place	April 2008 – 31 October 2011 (marine surveys in 2008 and 2009)
Area in which research will take place	North- East Atlantic with marine surveys conducted west of Ireland and the UK, around the Faroes, the Norwegian Sea and western Barents Sea. Laboratory analysis of contemporary and historic samples.
Estimated number and weight of salmon to be retained	All salmon sampled during the marine surveys will be retained. Approximately 900 fish each year, predominantly postsmolts.
Resources	
Estimated cost of the research project	Euro 5.5million (£5.5million) over 3 years with Euro 3.5million (£3.5million) funded through the EU Seventh Research Framework Programme (FP7) and Euro 2million (£2million) contributed by the programmes scientific and private sector partners. The Atlantic Salmon Trust is funding the scientific coordinator's post £50,000 (Euro 50,000) per annum and the TOTAL Fondation is contributing Euro 100,000 (£100,000) to the Faroese marine surveys in both 2008 and 2009.
Number of participating scientists	
Name and e-mail address of coordinating scientist in charge of project	Scientific Coordinator - Jens Christian Holst jens.christian.holst@imr.no Project Coordinator – Merethe Flatseth merethef@IMR.no
Details of research vessels, e.g. name,	*RV* Celtic Explorer, *RV* Celtic Voyager, *RV* Magnus Heinason, *RV* Johan Hjort, *FV* Eros, *FV* Libas

registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Pelagic trawls, Pelagic Live Capture Trawls (Fish-Lift), CTD, plankton sampling equipment, genetic analysis.
Details of any collaborating countries	The SALSEA-Merge consortium comprises 20 partners as follows:

Participant No.	Organization Name.	Country.
1 (Co-ordinator).	Institute of Marine Research (IMR).	Norway.
2.	Marine Institute (MI).	Ireland.
3.	Fisheries Research Services (FRS) (now Marine Scotland Science).	UK.
4.	Norwegian Institute for Nature Research (NINA).	Norway.
5.	University of Exeter (UE).	UK.
6.	National University of Ireland, Cork (NUIC).	Ireland.
7.	Queen's University Belfast (QUB).	UK.
8.	University of Wales, Swansea (UWS).	UK.
9.	Danish Institute for Fisheries Research (DIFRES).	Denmark.
10.	Institute of Freshwater Fisheries (IFL).	Iceland.
11.	University of Turku (UT).	Finland.
12.	University of Oviedo (UO).	Spain.
13.	Geneindex (GENI).	France.
14.	Finnish Game and Fisheries Research Institute (FGFRI).	Finland.
15.	*Faroese Fisheries Laboratory (FFL).	Faroes.
16.	*Atlantic Salmon Trust (AST).	UK.
17.	* NASCO’s International Atlantic Salmon Research Board (IASRB).	UK.
18.	*Total Foundation (TOTAL).	France.
19.	*Conservatoire National du Saumon Sauvage (CNSS).	France.
20.	*Loughs Agency.	UK.

* Non-contracting Partners

Summary of Findings:

2008:

SALSEA-Merge as an EU FP-7 project, formally commenced on 1 April 2008, but before that, in February 2008, an international SALSEA-SALMAN II Genetics Symposium and Workshop was arranged by IASRB in Paris with sponsorship from the Total Foundation. The symposium reviewed the state of the art within the field of salmon genetics and the possibilities of developing genetic techniques to support the SALSEA-Merge project. The workshop went into the planning of the project and strategies were developed with regard to the work both on the genetic baseline of European salmon stocks, the construction of a common European genetic salmon database, the optimisation of the standardised set of genetic markers to be used by the labs involved and the first preliminary organising of the seagoing sampling.

In March, the marine data acquisition group met in Copenhagen to plan the marine surveys and sampling strategies in detail. The meeting developed a common plan for the four surveys focusing on intercepting the high concentrations of north-ward migrating post-smolts along the strong currents on the shelf edge The plan developed in Copenhagen was later followed in detail by the vessels.

RV Celtic Voyager carried out the first survey during May 10-15 and sampled the areas west off Ireland and Scotland between 55°N and 57°N. The survey was very successful with 76 post-smolts caught.

The SALSEA-Merge launch meeting was held in Sligo, Ireland, during 14-15 May. The second survey, by *RV* Celtic Explorer, was launched from Killibegs 16 May which also promoted the official launch of the SALSEA-Merge seagoing activities with participation by the Deputy Prime Minister and broad media coverage. The *RV* Celtic Explorer surveyed the shelf edge current west off the British Isles from 56°N to almost 62°N during the period 16–24 May The total catch was 358 post-smolts.

The Faroese survey by *RV* Magnus Heinason was the third survey, and it took place during the period 2-16 July in the areas around 65°N-69°N along and north of the Vøring plateau in the Norwegian Sea. This is an area of high post-smolt abundance because of a very narrow migration corridor. The vessel caught 363 salmon, further underlining the success of the sampling strategy put out in Copenhagen.

The Norwegian *FV* Eros left Longyeartown in Spitzbergen on 26 July and surveyed the northern Norwegian Sea from 77°N south to Tromsø at 70°N on 9 August. In these northern areas the concentrated transport migration phase in the shelf edge current is over and the fish spread out over a vast area. This leads to much lower concentrations which are reflected in the lower catch of 88 post-smolts despite a large trawling effort.

In August, a genetic planning and strategy meeting was held at Stansted, London. The meeting focused in particular on choosing the genetic markers to be used in SALSEA-Merge and on different aspects of the future genetic work. The planning of the database was advanced, as was the work on the common European genetic salmon baseline.

In September, a workshop on scale reading was organised in Trondheim, Norway. The focus of the meeting was training and standardising the measuring and reading technique to be used by the SALSEA-Merge partners.

2009:

The 2009 General Assembly was held in Bergen 5-7 March, combined with internal planning meetings for the Genetics and Sea groups.

The survey activities continued in 2009, with 2 Irish, one Faroese and two Norwegian surveys. The first survey was carried out by the *RV* Celtic Voyager during 9 -12 May on the shelf edge off western Ireland and western Scotland. The survey was severely hampered by bad weather and only 9 post-smolts were caught in 9 hauls.

The second survey by the *RV* Celtic Explorer took place during 23 June - 2 July on the western edge of the Voering plateau at about 67-68°N, 2°E. During a hectic four day period 15 trawl hauls were made and in total 465 salmon were caught under very good weather conditions.

The third survey was carried out by the Faroese *RV* Magnus Heinasson in the Norwegian Sea between 66-69 °N, 1°W to 4 °E during the period 1-5 July. This survey also took place under very favourable conditions and in total 342 salmon were caught.

The fourth and fifth surveys were carried out by the Norwegian vessels *FV* Libas and *FV* Eros during the period 15 July - 6 August. Eros made experiments with the 'Continuous video trawl' system (CVT) and did not catch salmon while *FV* Libas caught 87 salmon in total.

2010:

The seagoing sampling of SALSEA-Merge was finalized with the two Norwegian surveys in August 2009. In total the SALSEA-Merge surveys collected 1,732 post-smolts plus 37 adult salmon from 55°N to 78° N. All fish were sampled for a large number of parameters including various tissue samples. The sampling for the trans-European genetic river baseline was also more or less completed during this period. In total 326 rivers were sampled at 589 locations, yielding 32,002 fish. Each fish has since been scored for the 14 common agreed alleles totaling 896,056 allele scores. Overall 4,179 marine samples were available for SALSEA-Merge. These samples originated from the SALSEA-Merge surveys, a Scottish survey and several Norwegian surveys during the periods 1996-2004. From this point onwards the various labs have put tremendous work into analysing the various datasets e.g. stomach content, scale analysis and genetic assignments of the fish caught at sea.

A Consortium meeting/ General Assembly was held in Dublin during 6-7 October 2010. For co-ordination of the scientific work and various management matters there was 2 Steering Group meetings in 2010, during 7-9 the April in Bergen and the 8th October back to back with the General Assembly in Dublin. In addition WP 4 held a working meeting in Bergen 27-28 April in Bergen and WP 5 a video conference 9th December.

2011:

2011 was the final year of SALSEA-Merge and after application the project got an extension of 7 months meaning it would run until 31st October 2011 when the formal scientific activities stopped. After this date focus was on producing the Final Report and also the second Periodic Report. The Final Report was delivered to the EU 24nd February 2012. All reports, deliveries and the SALSEA-Merge DoW can be found at http://www.nasco.int/sas/salseamerge_documents.htm.

In 2011, the SALSEA-Merge scientists have been busy analyzing the various data, combining results and preparing the different outputs to emerge from SALSEA-Merge. There was a Steering Group meeting in Bergen 3rd April and a genetic work meeting in WP1 and WP3 during 6-10 April in Geilo, Norway and Merge meetings in WP 5 February 4th and 11-15 April, both in Bergen. The various meetings in 2011 were in particular important with respect to planning the production of the final report, the presentations to be made at the Salmon Summit and the final publications.
SALSEA-Merge presented a total of 15 contributions, 8 speeches and 7 posters, to the ICES-NASCO symposium 'Salmon at Sea: Scientific Advances and their Implications for Management' in La Rochelle, France, 11-13 October 2011. All documents related to the Salmon Summit, including the various speeches is found at http://www.nasco.int/sas/salmonsummit.htm. Following peer review, the scientific papers submitted for inclusion in the proceedings will be published in a symposium issue of the ICES Journal of Marine Science. This volume is due to be published in November 2012 and will contain several SALSEA-Merge publications.

On 13th December 2011, 6 SALSEA-Merge talks were given at the Ocean-Silver conference organised by the Atlantic Salmon Trust in London. While the Salmon Summit was a traditional scientific meeting, the Ocean-Silver conference was a dialogue meeting with fish managers, bringing the SALSEA-Merge results out to the end users. More on the conference is found at http://www.atlanticsalmontrust.org/oceansilver/conference-programme.html.

Project No. E3 Status: Completed

Party or relevant jurisdiction	ECOKNOWS Consortium (see below)
Title of project	**ECOKNOWS (Effective Use of Ecosystem and Biological Knowledge in Fisheries): Improving fisheries assessment methods by integrating new sources of biological knowledge** Case study under Workpackage 4.2 “Salmon in the Atlantic and Baltic: migration modelling and extensive biological data sets”
Objective of research project	• Improve the use of ecosystem and biological knowledge in fisheries science and management • Improve links between traditional fish biological knowledge (maturity, growth, fecundity, etc) and fish stock assessment, which have remained as relatively separate areas • Improve the use of large existing biological and environmental databases, published papers and survey data sets provided by EU data collection regulations and stored by ICES and EU member countries • Develop a computational learning approach that builds on the extensive data present in FishBase • Improve ways to find generic and understandable biological reference points, such as the required number of spawning times per fish, for use in management measures
Brief description of research project	The general aim of the ECOKNOWS project is to improve the use of biological knowledge in fisheries and management. The lack of appopriate calculus methods and fear of statistical overparameterisation has limited biological reality in fisheries models. This reduces biological credibility perceived by many stakeholders. We solve this technical estimation problem by using up-to-date methodology supporting more effective use of data. The models suggested will include important knowledge about biological processes and the applied statistical inference methods allow to integrate and update this knowledge in stock assessment. We will use the basic biological data (such as growth, maturity, fecundity, maximum age and recruitment data sets) to estimate general probabilistic dependencies in fish stock assessments. In particular, we will seek to improve the use of large existing biological and environmental databases, published papers and survey data sets provided by EU data collection regulations and stored by ICES and EU member countries. Bayesian inference will form the methodological backbone of the project and will enable realistic estimations of uncertainty. We developed a computational learning approach that builds on the extensie information present in FishBase (www.fishbase.org). The developed methodology will be of fundamental importance, especially for the implementation of the Ecosystem Approach to Fisheries Management. it has been a difficult challenge, even for target species with long data series, and now the same challenge is given for new and poorly studied

species. We will improve ways to find generic and understandable biological reference points, such as the required number of spawning times per fish, which also supports the management needs in the developing countries. ECOKNOWS applies decision analysis and bioeconomic methods to evaluate the validity and utility of improved information, helping to plan efficient EU data collection.

Work packages:
WP 1 Management
WP 2 Review of existing methods from the point of view of biological knowledge
WP 3 Development of new assessment methodology
WP 4 Case studies
WP 5 Biological and economic evaluation of the management impacts
WP 6 Creating online archive and learning systems for priors
WP 7 Dissemination

WP 1: The aim of the Management WP is to ensure that all deliverables are of high quality and are made available in an agreed time schedule. This WP will support the high motivation to publish good journal papers.

WP 2: To critically review and improve current model assumptions in fisheries by using current knowledge in ecology. Assumptions considered in thi s WP will include features of S/R models, assumption that natural mortality is constant and i ndependent of species biology etc. We will suggest improvements to the information flow from e cology and genetics to fisheries management.

WP 3: To provide tools that improve the credibility of fi sheries science by: 1) using probability distributions in historical data analysis and predi ctions, instead of point estimates that are always to some degree wrong when compared with what happened; 2) by including ecological and genetic knowledge in fisheries models; and 3) by using all available biological and ecological data to estimate the probabilistic S/R relationships. The i nference model developed to use the FishBase information can provide estimates for any set of tho se biological parameters with probabilistic dependencies, for example fecundity, growth, and S/ R parameters.

WP 3.1: To develop methods that utilise all relevant inform ation for short-term probabilistic prediction. The methodology developed in this sub-p ackage will use survey data sets and existing large, currently poorly utilized, effort data sets (log book data) in ICES.

WP 3.2: To develop methods for more effective learning. Thi s is based on the systematic use of prior information from data bases, updating them by each additional data in sequential analysis. This methodology for step wise learning will be dem onstrated for S/R

	relationship and the general productivity of species (growth, fecundity, natural mortality etc.). This methodological development is needed to serve the information needs of both da ta poor and data rich cases. WP 3.3: To make the use of priors and full probabilistic mod els an operational part of some European stock assessments. Two of the partners have successfully implemented a probabilistic methodology for salmon assessment. Here their experiences will be built upon, together with the experience of ICES, to expand the probabilistic methodology to S/R analysis of several ICES stocks. WP3.4: To improve computational efficiency. The aim is to improve the computational efficiency of Bayesian models so they can be more effectively applied, e.g. in fish stock assessment working groups. WP 4: To apply the methods to case studies, and to learn effectively from contrasts between areas and between stocks. We also take into account the different scientific and management traditions of regions, and utilize the diverse experiences of partners included in the proposal. We will apply the innovative methodology developed in WP 3 to a) the European Anchovy in the Western Mediterranean and the adjacent Atlantic; b) Atlantic and Baltic salmon stocks; c) clupeoids in the Baltic and North Sea; d) multispecies length-based models to be applied to evaluation of technical measures, both for the Baltic and the Mediterranean; e) Hake (*Merluccius merluccius*) in Division IIIa, Subareas IV, VI, and VII, and Divisions VIIIa,b,d (Northern stock); and f) Northern shrimp (*Pandalus borealis*) in Division IIIa and Division IVa East (Skagerrak and Norwegian Deep. The more sophisticated use of surveys and year class estimate correlations of geographically related populations will be reported in case study deliverables. WP 5.1: In WP 5, testing improved stock assessments in a risk averse decision making environment. For each case study we will construct a simulation model applying management rules that explicitly consider uncertainty in setting exploitation limits. ECOKNOWS will test the potential of wrong conclusions in management of les s studied species by mimicking different amounts of information. WP 5.2: In the economic analysis of Data Collection Framework (DCF, EC Council Regulation No199/2008, Commission Regulation No665/2008 and Commission Decision No949/2008) program, we use the Bothnian Sea Baltic herring as case study to link the real costs of data collection to the value-of-information analysis (ho w much the extra knowledge can provide in terms of higher expected catches). This will provide a supporting planning tool for EU Commission to decide about new and existing data collections.

	WP 6: To establish learning databases (prior–data analysis–posterior) to existing FishBase (www.fishbase.org) databases to effectively support the risk assessment in fisheries. We will provide an interactive web-based tool to help in the estimation of prior probabilities for S/R parameters. As a posterior probability distribution of one analysis can be potentially used as a prior for the next one, a database that supports the systematic use of Bayesian models offers also a systematic learning possibility for fisheries science (see Fig. 2). Moreover, basic biological knowledge can be used to decrease the uncertainty in population level interest variables (like using fecundity values in re-parameterized S/R models to include information from general knowledge of fish biology). WP 7: To disseminate the philosophy related to new ways of using scientific information to stakeholders, and especially to link this to common logic to improve the credibility. We provide also a significant input to academic teaching material which will be linked to FishBase to provide continuation of the learning after the project. Deliverables under salmon case study WP4.2: D4.7: Manuscript: harmonizing models Details the approaches of assessing Baltic and North-Atlantic salmon stocks, specifying similarities in biology, as a prerequisite to their harmonization for parallel inference and risk analysis, independent of scales, available data and management objectives. D4.8: WGBAST application / ICES Describes how the project outcomes contribute to the activities of the ICES Working Group of Baltic Salmon and Trout (WGBAST), reviewed by the Inter-benchmark Protocol for Baltic Salmon (IBPSalmon). Outcomes of IBP Salmon included: 1) inclusion in the assessment model of additional data on survival at sea of reared salmon, which is assumed to increase precision in estimates of relative abundance of wild and reared salmon, 2) updated correction factors for discard proportions, and for under-reporting of tag recaptures, catches and fishing effort, and 3) an updated assessment model where maturation rate is allowed to vary over time due to e.g. climate variation, which is assumed to improve estimates of salmon survival and abundance at sea. D4.9: WGNAS application / ICES The ECOKNOWS modelling methodology for Atlantic salmon was reviewed, compared with the current approach, and discussed in the ICES Working Group on North Atlantic Salmon (WGNAS). An integrated life cycle model is described that brings a substantial contribution to Atlantic salmon stock assessment at a broad ocean scale. The model has been developed in the Hierarchical Bayesian Modelling framework. The existing biological and ecological knowledge on A. salmon demography is integrated into an age- and

	stage-based life cycle population dynamic model, which explicitly separates the freshwater (egg to smolt) and marine phases (smolt-to-return), and incorporates the variability of life histories (river and sea ages). It accounts for natural and fishing mortality, and captures the sequential fisheries along the migration routes, including off shore, coastal, estuarine and freshwater fisheries. Comparing to the current approach used by the ICES WGNAS, the framework makes it easier to evaluate different demographic hypotheses and, offers multiple possibilities to extend the model with additional sources of knowledge and data. D4.10: Forecasting methods Describes the work carried out to improve the predictive abilities of life cycle models for Atlantic salmon. The work focuses on maturation rates of Atlantic salmon in the Baltic Sea.
Dates during which research will take place	Start Date: 01/09/2010 End Date: 31/08/2014
Area in which research will take place	North Atlantic
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	
Number of participating scientists	
Name and e-mail address of coordinating scientist in charge of project	
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	• UH: University of Helsinki, Finland, coordinator • FGFRI: Finnish Game and Fisheries Research Institute, Finland • ICES: International Council for the Exploration of the Sea, Denmark • FIN: FishBase Information and Research Group, Inc., Philippines

	• AUTH: Aristotle University, Greece • CSIC: Consejo Superior de Investigaciones Científicas, Spain • MI: Marine Institute, Ireland • Imperial: Imperial College London, UK • DFO: Department of Fisheries and Oceans, Canada • SBF: Swedish Board of Fisheries, Sweden • INRA: Institut National de la Recherche Agronomique, France • AGRO: Agrocampus OUEST, France IEO: Instituto Español de Oceanografía, Spain

Summary of Findings:

Final report summary of ECOKNOWS with focus on the salmon case study
ECOKNOWS Work Package 4 comprised of case studies, including "Salmon in the Atlantic and Baltic: migration modelling and extensive biological data sets (CS_salmo) WP 4.2"
The main objectives of this reporting period were to:

(i) finalize the development of integrated Bayesian life cycle models for Atlantic salmon and for harmonizing the stock assessments approaches used in the ICES WGBAST and WGNAS;
(ii) demonstrate as an alternative and, if deemed appropriate, to adopt the applications of the models for the Atlantic salmon stock-assessment currently used by ICES WGNAS and WGBAST; and
(iii) develop and report a method for improving salmon forecasting.

These objectives were more than fully achieved. All deliverables have been submitted. Results have been presented in a paper published in a peer reviewed journal, ICES reports and in several International Conferences. An integrated life cycle model for Atlantic salmon in the North Atlantic has been successfully developed, lead by the French National Institute for Agricultural Research and the Institute for Life, Food and Horticultural Sciences and Landscaping (AGROCAMPUS OUEST, France), with contribution from the University of Helsinki, the Marine Institute (Ireland) and Fisheries and Oceans (Canada) and support from Marine Scotland and CEFAS (UK)). The model has first been successfully applied to the Eastern Scotland stock unit, the largest regional component of the Southern European stock complex. The new model (Massiot-Granier et al., 2014, ICES J. Mar. Sci, doi:10.1093/icesjms/fst240) has been presented to the WGNAS in several working papers. In addition, a multi-regional extension of the integrated life cycle model has been developed; the model is described in a manuscript in prep. for submission to the Canadian Journal of Fisheries and Aquatic Science.
Methods to improve forecasting of returns in the Baltic Sea were developed by extending the Baltic stock assessment model to incorporate environmental covariates and, as a result, capture part of the variability of maturation rates (lead by partner 2, with some contribution from partners 1, 7 and 12). This method has been introduced, reviewed and adopted in ICES WGBAST salmon assessments. Forecasting at local scale has been studied and progress is being made for Irish salmon rivers (partner 7), including aspects of management based on river specific conservation limits. The outcomes of WP 4.2 have been fed to preparation of D3.10 and D5.2. WP4.2 products have been widely utilized also in dissemination (D7.1).

Deliverables:

D4.7 Manuscript. Combined model structures between the Northeast and Northwest Atlantic and the Baltic Sea.

D4.8 ICES working group (WGBAST) report. Application of a new assessment model framework in the Baltic salmon assessment by ICES.

D4.9 ICES working group (WGNAS) report. Application of a new assessment model framework in the Atlantic salmon assessment by ICES.

D4.10 Manuscript. A framework of forecasting the salmon post-smolt survival in the Atlantic Ocean and Baltic Sea.
D4.11 Reporting to the ICES salmon assessment working groups, WGNAS and WGBAST. Annually (March-April).

Project No. De1 Status: Completed

Party or relevant jurisdiction	European Union – Denmark
Title of project	**Estuarine migration of smolts in the River Skjern Å (North Sea) and River Guden Å**
Objective of research project	Assess the effect of restoration of habitat in the River Skjern Å on the smolt runs of salmon and sea trout, in particular with regard to predation by piscivorous birds. Investigate the migration of salmon smolts in the River Guden Å.
Brief description of research project	
Dates during which research will take place	2002 – 2003
Area in which research will take place	
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	
Number of participating scientists	
Name of coordinating scientist in charge of project	Gorm Rasmussen gr@dfu.min.dk
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	

Summary of Findings:

In Skjern Å estuary we have demonstrated very high smolt mortalities during two research seasons caused by cormorants (28 and 44%). European rivers and their floodplains are generally severely affected by human activity. As a consequence, both the water and the river habitat quality have been seriously degraded in numerous European rivers during the twentieth century. In Denmark less than 5% of the rivers have been left in a natural physical state. During the 1960s the lower part of River Skjern Å was regulated and adjacent bogs, ponds, marshes and meanders drained. In the beginning of the 1990s the Danish government decided to restore the River Skjern Å and its floodplain and in 2002 the River Skjern Nature Project was implemented. The project consisted of several parts, including returning the straight, regulated river back to its former meanders and introducing better hydraulic interaction between the river and its meadows. Before implementation of the restoration project the causes of mortality of wild salmon *Salmo salar* and trout *Salmo trutta* smolts in River Skjern Å and its estuary Ringkøbing Fjord were investigated in 2000. A follow-up comparable study was performed in the spring of 2002 after the majority of the project was implemented, aimed towards assessing the effect of the restoration project on the salmon and trout smolt runs. This study indicated that the river restoration had an indirect slightly negative effect on the smolt run, mediating bird predation within the river system. As also demonstrated in 2000, bird predation in the estuary had a major adverse effect on the smolt run and jointly the smolt mortality in the river and in the estuary may threaten a self-sustaining salmon population in River Skjern Å.

In the River Guden Å and its estuary the migration of salmon smolts was investigated in 2002 and 2003 by acoustic telemetry.

Project No. De2 Status: Completed

Party or relevant jurisdiction	European Union – Denmark
Title of project	**Mortality of Atlantic salmon smolts during estuary migration**
Objective of research project	The main objective of the research is to estimate mortality of salmon smolts during migration through estuaries and to compare the return ratio of wild, stocked ½- and one-yearlings.
Brief description of research project	Since 2001 all salmon stocked (30,000 ½- and 62,000 1-yearlings annually) in River Skjern Å are microtagged and adipose fin clipped, in order to distinguish between wild and hatchery-reared smolts in a planned study in 2005 (using rotary screw traps). Since 1996, the spawning run has been estimated yearly (mark-recapture method). Thus in the future it will be possible to distinguish between wild and hatchery-reared fish. A similar programme is planned in the River Storå in 2007. Previously high smolt mortalities during estuarine migration through the Skjern Å estuary have been demonstrated for both sea-trout and salmon by radio telemetry. The total mortality during estuarine migration will be estimated in 2005 by acoustic telemetry. In Guden Å estuary, a project has been started in 2002 where wild salmon smolts are caught in a trap, and tagged with acoustic transmitters and followed through the estuaries by data-loggers at fixed stations and manual tracking. The preliminary results are promising and the project will be continued and combined with feeding studies of post-smolt and DST (data storage tags) tagging of smolt and/or spent fish.
Dates during which research took place	April 2000 to December 2008
Area in which research took place	River Skjern Å and River Stor Å (North Sea) and River Guden Å (Kattegat) and their estuaries.
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	River Skjern Å: £143,184 (total in years 2005-08) River Guden Å: £152,594 (total in years 2005-08) River Stor Å: £104,350 (2008) Publications (i.e. three rivers): £30,000 (2008)
Number of participating scientists	4
Name of coordinating scientist in charge of project	Anders Koed (River Skjern Å and River Stor Å) ak@difres.dk Kim Aarestrup (River Guden Å) kaa@difres.dk
Details of research vessels, e.g. name,	N/A

registration, call sign and description of vessel	
Type and amount of gear and other equipment used	Rotary screw traps, radio and acoustic telemetry equipment
Details of any collaborating countries	None

Summary of Findings:

Year 2004. Salmon and sea trout smolts and mature eel were trapped and numbered in River Guden Å and tagged with acoustic transmitters and followed during their migration through the estuary to the Kattegat. The migration speed of salmon exceeded the speed of sea trout smolts. The project continues in 2005 when the salmon and sea trout smolt project in River Skjern Å and the Ringkøbing estuary commences.

Year 2005. The project continued in 2005 and the results are being analysed. A report and paper will be published in year 2008. A peer reviewed publication on the results is planned in 2010.

Year 2005 and 2006. In River Skjern Å salmon and sea trout smolts were caught in a rotary screw trap in the river and acoustic tagged and followed on their downstream migration in the river and through the estuary, i.e. the Ringkøbing Fjord. The total mortality of salmon smolts in river and estuary was 54 % and was caused by predation from pike and birds (mostly cormorants) in the river and cormorants in the fjord; that means that 46 % of the salmon smolts entered the North Sea. Because of the low wild salmon population in River Skjern Å, each year ½- and one-year-old parr are stocked (F1 offspring from wild salmon). In 2005 about 27,300 smolts migrated out from the river, of which about 30 % were wild smolts from spawning in the river and 70 % were from stocking. It is concluded that because of bird predation, mostly from cormorants, the natural wild salmon in River Skjern Å is threatened. The data also showed that relatively the ½- and one-year-old parr give the same number of smolts, but the reason is uncertain; maybe it has something to do with a longer stay in hatchery of the one-year-old parr and therefore less adaptability in the river after release.

The results was analyzed and published in 2006 (Research on the smolt run of Atlantic salmon from River Skjern Å and mortality during migration through Ringkøbing Fjord, DFU-rapport nr. 160-06, in Danish). A peer reviewed publication on the results is planned in 2010.

Year 2007. In River Stor Å salmon and sea trout smolts were caught in a rotary screw trap in the river and acoustic tagged and followed on their downstream migration in the river and through the estuary, i.e. the Nissum Fjord.(to the North Sea) . The salmon smolt production was about 17,800 smolts. The total mortality of salmon smolts in river and estuary was about 64 % and was caused by predation from pike and birds (mostly cormorants) in the river and cormorants in the fjord; that means that about 36 % of the salmon smolts entered the North Sea. The results was published in 2008 (Smolt run from River Stor Å in 2007 and smolt mortalities during migration through Felsted Kog and Nissum Fjord, DFU-rapport nr. 186-08, in Danish).

Project No. De3 Status: Ongoing

Party or relevant jurisdiction	European Union - Denmark
Title of project	**Salmon Rehabilitation Plan: monitoring numbers of spawners, spawning and nursery areas in four Atlantic salmon rivers and the achievement of the objective of self-reproduction**
Objective of research project	The Danish national salmon rehabilitation plan describes four rivers with natural wild salmon populations. In earlier years monitoring has estimated numbers of smolts and numbers of spawners in the River Skjern Å but the exact spawning areas are not known. In 2008 monitoring took place in River Skjern Å, in 2009 in River Ribe Å, in 2010 in River Storå, in 2011 in River Skjern Å. In 2012 River Ribe and Varde Å, in 2013 River Skjern Å and Storå, and in 2014 River Ribe Å and Varde Å and so forth. Collected fry from River Skjern Å 2008 and 2009, and juveniles from Ribe Å and Varde Å collected during the last decade, will be genetically analyzed by 20-25 microsatellites to identify the number of families at each spawning site. A large number of juveniles and many families would indicate proper functioning of spawning and nursery areas for many spawning fish while getting few families will indicate too scarce spawning fish and / or poor conditions in much of the spawning area. The results will be compared with ecological and environmental indicators to determine which of the described hypotheses are the most likely for the specific spawning areas. In this way the effect of the rehabilitation plan and the development of the populations is assessed (the goal is at least 1,000 spawners in each river to fulfill the plan). This study will allow estimates of marine mortality of salmon to be made. A socio-economic analysis of the value of the salmon sport fishery will be initiated in corporation with the National Anglers Association in order to stimulate the political interest in spending money for habitat restoration in Danish salmon rivers.
Brief description of research project	Every year about 100 spawners are radio tagged and a number of spawners are PIT tagged and followed by boat and listening stations during the spawning period. Spawning areas are determined and numbers of spawners estimated from tagged and untagged salmon caught by electrofishing and reports from anglers. All stocked F1 half-yearlings are fin clipped and all F1 one-year old are fin clipped and cw tagged; this enable to separate wild spawners from stocked spawners. From identified spawning areas salmon fry are collected and genetically analyzed (20 – 25 microsatellites) to identify numbers of families on the spawning areas. High numbers of fry and families indicate better areas versus few fry and spawners.

	The salmon in western Jutland has been the subject of support breeding for many years. There is no national or international evaluation of the impact of many generations of support farming (F1 fish) has on the amount of genetic variation and to what extent it leads to genetic adaptations to a life of farming. Using the analysis of thousands of markers in genes (SNPs) in available 19 time series from the West Jutland salmon will enable to assess whether support farming has led to genetic changes with adaptation significance. Compared to management this knowledge will be essential in order to evaluate the application of support farming in general and time scale and population size in the end.
Dates during which research will take place	Annually.
Area in which research will take place	River Skjern, River Ribe, River Storaa, River Varde and River Sneum. The rivers flow into the North Sea.
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	Annually about £14,000 for running costs (tags and chemicals) and £32,000 for the socio-economic analysis. The amount is indexed. Annually about 510 scientist hours and 720 technical assistant hours (field work) Total cost annually about £110,300 (DKK 995,000)
Number of participating scientists	Three (3)
Name and e-mail address of coordinating scientist in charge of project	Anders Koed, ak@aqua.dtu.dk Einar Eg Nielsen, én@aqua.dtu.dk Niels Jepsen, np@aqua.dtu.dk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Pit and radio tags, lab equipment
Details of any collaborating countries	
Summary of Progress: In 2014 the spawning run in River Varde was estimated to 1709 (± 183; 95 % CL). Total length between 51 and 107 cm. http://www.fiskepleje.dk/nyheder/2014/12/laks-varde-aa-2014?id=681d111b-e888-41ab-a574-2c822d2c7406	

In 2015, the spawning run in River Storaa was estimated to be 5,848 (± 2061; 95 % CL), with total lengths between 50 and 127cm, of which 57% were wild and 43% F1 stocked fish. http://www.fiskepleje.dk/Nyheder/Nyhed?id=a7b4fcca-9105-4bbc-b88f-e99f0536c571

In 2015, the spawning run in the River Sneum was estimated to be 1,108 (± 102; 95% CL), with total lengths between 50 and 127 cm. http://www.fiskepleje.dk/nyheder/2016/01/sneum-aa-laksebestand-2015?id=f143a225-03f0-40fa-a3fc-f1a35454976b

In 2016, the spawning run in River Storaa was estimated to be 3,434 (± 417; 95% CL), of which 53% were wild and 47% F1 stocked fish. http://www.fiskepleje.dk/nyheder/2017/01/laks-i-skjern-aa-2016?id=20643d3e-f9a9-462c-b350-7f8838479539

In 2016, the spawning run in River Varde was estimated to be 3,389 (± 323; 95 % CL), of which 53% were wild and 47% F1 stocked fish. http://www.fiskepleje.dk/Nyheder/Nyhed?id=a7b4fcca-9105-4bbc-b88f-e99f0536c571

A report of spawning and nursery areas in River Ribe was published in 2016 (DTU Aqua report Nr. 313-2016 Laksebestanden i Ribe Å 2014. In Danish with a summary in English. The results show that as habitat improvements are implemented, salmon extended its abundance and spawning in the system.

A report of the value of the local recreational salmon fishery in River Skjern was published in 2014 (DTU Aqua Report: Nr. 287-2014 Den lokaløkonomiske værdi af laksefiskeriet i Skjern Å. In Danish.

Project No. De4 Status: Ongoing

Party or relevant jurisdiction	European Union - Denmark
Title of project	**Marine behaviour of Atlantic salmon**
Objective of research project	The last years of development of the Danish salmon stocks have been a success. This has been achieved through deliberate management focus on removing the limitations identified in freshwater and coastal areas and a change in stocking policy. One of the major challenges for continued successful management is knowledge of the salmon's marine life. The information about Danish salmon's marine phase consists of recaptured Carlin tagged fish from the North Atlantic, which probably gives an idea about the place of residence at the time of capture, but not about their specific behavior, timing of migration or survival. These factors are totally unknown.¶The overall aim is thus to obtain more knowledge about this part of the salmon’s life. The project will contribute scientific information but also knowledge to inform management. So far, it has not been possible to undertake more specific behavioral studies of Danish salmon’s marine life for two reasons: there have been too few salmon, and there has not been sophisticated technology to obtain behavioral data from the fish. Developments in electronic fish tags, particularly ‘data storage tags’ (DST) and ‘pop-up satellite tags’ (PSAT) now allow for a more detailed picture of the migration pattern and living places. The DST tag is a passive tag which records information about the fish's environment and saves them for reading at recapture. The tag is assigned an address and information can be returned after capture. PSAT tags are essentially the same tag, but also contain a satellite device that can send the recorded data to the ARGOS satellite system and a liberation mechanism. The tag is released from the fish at a predetermined time, rises to the surface and sends information to the satellite. These new types of tag allow information to be recorded about the fish’s surrounding environment with an unprecedented accuracy and both types of tags have large scope options (Neuenfeldt *et al* 2009, Aarestrup *et al* 2009). The limitation is currently the size of the transmitters and tagging method. Yet both types of tags are too big to tag smolts so kelts will be the most obvious group of salmon to tag. This has previously been almost impossible, because until a few years ago there were very few salmon in the Danish salmon streams. This has changed markedly in recent years. Moreover, popular opinion was that there were hardly any reusable spawners among Danish salmon (and hence that kelts do not survive until the next spawning). This has proved to be incorrect because scale readings of salmon from the 2008 spawning season show a significant proportion of multiple spawners (Jepsen *et al* 2010). In the past few years, Norway has conducted experiments with this type of tagging of salmon and, in particular, a method of tagging has been developed to increase survival of salmon kelts with PSAT tags

	(Rikardsen *et al* In prep). We intend to use the Norwegian method which in brief includes catching kelts in the river (Skjern Å), keeping them (up to one week) in saline water and then tagging the fish below the dorsal fin. Another way to examine the salmon's movements in the ocean is to investigate the chemical fingerprints of fish scales (Svendsen *et al* 2009). The method is a consequence of the fact that a number of stable compounds from food items are incorporated in the fish scales and otoliths. By analyzing the fish's scales or otoliths we get a "chemical fingerprint" depending on where the fish has been and what they have eaten. It has previously been shown feasible to use chemical fingerprints to distinguish between salmon from the Baltic Sea and the Atlantic. By taking scale samples from the tagged fish, we get a fingerprint that can be related to their behavior and, therefore, can be tested with other salmon populations to indicate whether they have the same behavior and migration behavior. These analyses are made in cooperation with Aalborg University.
Brief description of research project	See above
Dates during which research will take place	2010 to 2017
Area in which research will take place	River Skjern Å and River Storå
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£35,000 per annum
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Kim Aarestrup; kaa@aqua.dtu.dk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	

Summary of Progress:

In the spring of 2011, a total of 12 spent salmon (> 75 cm) from the Skjern Å river were rehabilitated in salt water at the Danish Salmon Production Farm (DCV) and tagged with pop-up satellite DST tags and released outside the estuary Ringkøbing Fjord directly in the North Sea. During 2011, 8 tags popped up at different localities in the Atlantic between Norway and Greenland. The data from the tags will in combination with other Atlantic data (temperature and current) allow the precise migration route of salmon from the Skjern Å river to be estimated.

In the spring of 2012, a total of 12 spent salmon (> 75 cm) from the Skjern Å river were rehabilitated in salt water at the Danish Salmon Production Farm (DCV) and tagged with pop-up satellite DST tags and released outside the estuary Ringkøbing Fjord directly in the North Sea. During 2012 10 tags popped up at different localities in the Atlantic between Norway and Greenland.

In 2013, 10 spent salmon (> 75 cm) from the Varde Å river were tagged and released at the outlet to the Waddensea (North Sea). This shall be repeated in 2014.

Scales, muscles samples and otoliths from fish similar to the tagged salmon has been collected from river Skjern Å, a south western Irish river has been collected but are still not analysed because of manpower problems at Aalborg University. The idea is to compare the results from these analyses with the tagged fish because these tagged fish gives the true migrating routes. Samples from river Alta (Norway) will be collected and included in the analysis. This part of the project has been postponed because of manpower problems at Aalborg University.

Project No. De5 Status: Ongoing

Party or relevant jurisdiction	European Union - Denmark
Title of project	**Strengthen the Danish Atlantic Salmon Populations (SDPAS)**
Objective of research project	The vision of the project is to strengthen Danish Atlantic salmon populations towards a state where the populations are completely self-sustainable and can be exploited under a dynamic catch quota approach. In the beginning of the 1980'ies indigenous Danish salmon populations were close to extinction due to habitat degradation, construction of barriers and stocking with non-native strains. However, a variety of conservation efforts carried out in collaboration among anglers, fishery managers and researchers, supported by national and local political administrations, led to a resurge of the populations in western Jutland. In contrast to Danish populations, other European and North American populations have generally undergone severe population decreases in the same time period. Conservation activities in Denmark have primarily comprised fisheries regulations, river restoration including barrier removal and implementation of a supportive breeding program based on native brood-stock. In response to these activities salmon populations developed positively, allowing annual catches by anglers of up to ca. 2.500.
Brief description of research project	The project consists of 7 work packages (WPs): **WP1. Limiting factors for fry production in Danish lowland rivers** In this project we will 1) estimate and compare spawning activity in different types of habitats in the River Skjern system, 2) evaluate the influence of various environmental factors (e.g., sediment infiltration and ochre content) on the egg to fry survival using *in situ* incubation chambers, and 3) investigate dispersal and habitat selection of salmon fry. Three reports documenting the results of this WP will be produced. (see also the Gantt diagram below): Report on spawning habitat, September 2017. Report on egg and fry survival, June 2018. Report on dispersal and habitat selection of fry, December 2018. The findings of the project are expected to vastly improve our understanding of environmental factors that may limit the fry production in the River Skjern, and the overarching goal is to develop practical guidelines that enable watercourse managers to optimize salmon fry production in Danish lowland rivers. On basis of the results, a specific plan for habitat restoration and releases of fry in River Skjern will be developed and implemented in collaboration with the authorities (the local municipalities). This plan will be ready ultimo 2019/primo 2020. In addition the results will be incorporated into the National Management Plan for Salmon in Denmark. The success criteria will ultimately be a documented higher fry production in the river.

	WP2. Limiting factors for smolt and pre-smolt run and survival Here we will estimate the size of the juvenile run, i.e. the smolt and presmolt run, calculate the fractions coming from wild and stocked fish, respectively and identify mortality factors during seaward migration. The findings of the project will reveal the sources and scale of mortality that limit smolt and pre-smolt output from River Skjern. On basis of the results, a specific target plan aiming at alleviating identified mortality sources (e.g. predatory birds or fishery in the fjord). This will be developed and implemented in collaboration with the authorities (the Ministry of Food and Fisheries). The plan will be prepared ultimo 2019. In addition the results will be incorporated into the National Management Plan for Salmon in Denmark. The success criteria will ultimately be a documented higher smolt output from the river. **WP3. Genetic status and spawning run size** This WP will provide a status of the genetic quality of individual salmon populations and will estimate the number of returning salmon. Differences in ocean survival between wild and stocked salmon will be identified. The findings of the project will elucidate the genetic status of salmon in the Skjern River with respect to inbreeding, level of genetic variability and genetic adaptations to the farmed environment. In addition the spawning run size (number of ascending spawning fish) will be estimated. The result will be used to develop and implement a plan for future supportive breeding of salmon in the Skjern River, including breeding and stocking practices. E.g. numbers of breeders, crossing schemes and recommendations on when to terminate the stocking programme in order to assure long term viability and protection of wild genetic resources. The plan will be ready medio 2020. **WP4. Limiting factors for kelt survival** Here we will examine river, fjord and ocean survival of spent adult salmon (kelts) and correlate energy content, morphological traits and health status with individual survival. The findings of the project will reveal the sources and scale of mortality that limit kelt survival in the River Skjern and estuary. On basis of the results, a specific target plan aiming at alleviating identified mortality sources (e.g. angling in the river or net fishery in the fjord). This will be developed and implemented in collaboration with the authorities (the Ministry of Food and Fisheries). This plan will be ready medio 2020. In addition, the results will be incorporated into the National Management Plan for Salmon in Denmark. The success criteria will ultimately be a documented higher kelt survival and return.

	WP5. Improving quality and post-release survival of stocked salmon Here we will (1) assess the timing and prevalence of operculum shortening in hatchery-reared salmon, (2) identify potential causes of shortened operculum in the rearing environment, and (3) investigate whether and to what extend shortened operculum influences the post-release survival of stocked fish. The findings of the project will identify factors responsible for operculum shortening in the hatchery and illuminate whether shortened operculum represents a survival bottleneck for the juvenile fish after release into nature. On basis of the results, the rearing procedures in the hatchery will be optimised in order to reduce the incidence and intensity of operculum shortening of the stocked fish. The rearing methods. The new guidelines will be implemented primo 2021. The success criteria will ultimately be a documented higher survival of hatcheryreared juvenile salmon following release. **WP6. Genetic background for age-at-maturation** The project will estimate the relative importance of environmental and genetic factors in determining the age at which the salmon return for breeding in the river. The results will form the basis for designing breeding plans in the hatchery in order to assure that the life history of released salmon mimics the original wild composition. I.e. the proportion of salmon returning after 1-3 years should remain stable over time. The results from this WP will be implemented in the management ultimo 2020/primo 2021. **WP7. Stakeholder communication and dissemination** In this WP the results from the WPs 1-6 will be presented, discussed and disseminated with the aim to implement the findings into specific management initiatives, as described above. Management activities combining conservation of salmon populations with the development of a profitable, sustainable recreational fishery have been greatly facilitated by a high degree of stakeholder awareness-building and engagement. Communication and dissemination of progress and scientific results is vital for further development of the salmon fishery and associated benefits to tourism in western Jutland.
Dates during which research will take place	1 February 2016 – 31 March 2020
Area in which research will take place	River Skjern, Denmark
Estimated number and weight of salmon to be retained	None

Resources	
Estimated cost of the research project	£2.5 million, £630,000 per annum. Public (PU): 1.2 million Private (PR): 1.3 million
Number of participating scientists	6
Name and e-mail address of coordinating scientist in charge of project	Anders Koed, ak@aqua.dtu.dk
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	2 fykenets, Electrofishing gear, PCR.
Details of any collaborating countries	Only Denmark

Summary of Progress:

WP2:

The the juvenile run from Skjern Å and its main tributary River Omme was estimated in spring 2016. The total run from River Skjer was estimated to 20.966 (17.142-24.791 95 % CL) and the run from River Omme to 2.483 (922 – 4.044, 95% CL). The smolt mortality in the estuary Ringkøbing Fjord was estimated by telemetry.

Project No. De6 Status: New Entry

Party or relevant jurisdiction	European Union - Denmark
Title of project	**Salmon Rehabilitation Plan: monitoring numbers of spawners, spawning and nursery areas in four Atlantic salmon rivers and the achievement of the objective of self-reproduction**
Objective of research project	The Danish national salmon rehabilitation plan describes four rivers with natural wild salmon populations. In earlier years monitoring has estimated numbers of smolts and numbers of spawners in the River Skjern Å but the exact spawning areas are not known. In 2008 monitoring took place in River Skjern Å, in 2009 in River Ribe Å, in 2010 in River Storå, in 2011 in River Skjern Å. In 2012 River Ribe and Varde Å, in 2013 River Skjern Å and Storå, and in 2014 River Ribe Å and Varde Å and so forth. Collected fry from River Skjern Å 2008 and 2009, and juveniles from Ribe Å and Varde Å collected during the last decade, have been analyzed by 20-25 microsatellites to identify the number of families at each spawning site. A large number of juveniles and many families would indicate proper functioning of spawning and nursery areas for many spawning fish while getting few families will indicate too scarce spawning fish and / or poor conditions in much of the spawning area. The results will be compared with ecological and environmental indicators to determine which of the described hypotheses are the most likely for the specific spawning areas. In this way the effect of the rehabilitation plan and the development of the populations is assessed (the goal is at least 1,000 spawners in each river to fulfill the plan). This study will allow estimates of marine mortality of salmon to be made. A socio-economic analysis of the value of the salmon sport fishery was organized and is published in 2016. The analysis documented that the salmon fishing provided a substantial revenue (2,4 M Euro) for the local community every year and that this would increase if the number of salmon available increased.
Brief description of research project	The salmon in western Jutland has been the subject of support breeding for many years. There is no national or international evaluation of the impact of many generations of support farming (F1 fish) has on the amount of genetic variation and to what extent it leads to genetic adaptations to a life of farming. Using the analysis of thousands of markers in genes (SNPs) in available 19 time series from the West Jutland salmon will enable to assess whether support farming has led to genetic changes with adaptation significance. Compared to management this knowledge will be essential in order to evaluate the application of support farming in general and time scale and population size in the end. All stocked F1 half-yearlings are fin clipped and all F1

	one-year old are fin clipped and cw tagged; this enable to separate wild spawners from stocked spawners. Every year an inventory of the run size is carried out in 2 rivers, by extensive electrofishing and PIT tagging followed by a second round of electrofishing weeks later, enabling us to estimate the run size with a known Standard Error. Based on large habitat surveys performed, compared with surveys of the density of wild and stocked salmon juveniles, the overall juvenile population and its relation to the potential (if all habitats were OK and freely accessible) is estimated. This has been done in Skjern, Ribe, Varde and Storå.
Dates during which research will take place	Annually.
Area in which research will take place	River Skjern, River Ribe, River Storaa, River Varde, Kongeå and River Sneum. The rivers flow into the North Sea.
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	Annually about £14,000 for running costs (tags and chemicals) and £32,000 for the socio-economic analysis. The amount is indexed. Annually about 510 scientist hours and 720 technical assistant hours (field work) Total cost annually about £110,300 (DKK 995,000)
Number of participating scientists	Three (3)
Name and e-mail address of coordinating scientist in charge of project	Anders Koed, ak@aqua.dtu.dk Einar Eg Nielsen, én@aqua.dtu.dk Niels Jepsen, np@aqua.dtu.dk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Pit and radio tags, lab equipment
Details of any collaborating countries	N/A
Summary of Progress: Annual runs have been estimated for Skjern (2016 and 2017), Kongeå, Ribe Å (2017). The development of the salmon stocks do continue to look good and the runs are of a good size, allowing harvest of more than 1000 fish annually. However, concern has been raised due to very low smolt counts measured in River Skjern 16 and 17. The expectations for the returning adults in 18 and 19 are rather poor. Only between 20-30,000 smolts (wild and stocked) were leaving Skjern in 16 and 17 and studies showed that only half of these reached the North Sea, so to achieve adult run sizes of 5000 (like we have seen recent years) marine survival must be about 50%. A continued high predation from cormorants seems to be the main reason for the low smolt-escapement.	

The river Storå (last run size: 5800) is the first river to have obtained status of self-reproducing, so all stocking has been terminated from 2018.

Project No. De7 Status: New Entry

Party or relevant jurisdiction	European Union – Denmark, UK, Ireland, Spain NASCO
Title of project	**SMOLTRACK**
Objective of research project	Marine mortality of salmon has long been acknowledged to play an important population regulating role. Marine mortality is usually defined as any mortality occurring from a smolt leaves the river until it returns as an adult spawner. Understanding the factors responsible for marine mortality is a tremendous task and will require different approaches adjusted to the specific areas and fish life stage investigated. There is evidence that the initial mortality in post-smolts moving into saltwater is very high (due to predation) and that this "point mortality" may explain most of the variation seen in return rates. Estuarine and near shore mortality may also be the part of the marine life cycle where management measures have the greatest chance of success. Hence, this project will explore the mortality of smolts and post-smolts during their migration through the lower rivers, estuaries/fiords and near-shore areas. It specifically addresses SALSEA-track priorities specified in the NASCO-IASRB Workshop on Telemetry report (recommendation SRBTW(14)7). Acoustic telemetry with wild salmon smolts is used to investigate and directly measure the mortality during the first days-to-weeks after leaving the river. Additionally, the project aims to act as a platform for EU-wide salmonid telemetry knowledge (facilitate the sharing of international best practice to EU members)/data/projects/bulk purchasers of technology, with the goal to establish an EU strategic salmon telemetry advisory group.
Brief description of research project	The SMOLTRACK project will use a similar telemetry approach in five different areas, where wild smolts will be caught in traps (gently), tagged with acoustic transmitters and then recorded when passing hydrophones (arrays) on their way from river to open sea. The projects covers six rivers in 5 countries, this will provide estimates of mortality rates, where and when this mortality occurs (dangerous areas) as well as general behaviour, speed of progression and reveal potential bottlenecks, both in time and space
Dates during which research will take place	2017 and 2018 (2019)
Area in which research will take place	Ireland – River Erriff Northern Ireland – River Bush England – River Tamar Spain – River Ulla & River Tea Denmark – River Skjern
Estimated number and weight of salmon to be retained	N/A

Resources	
Estimated cost of the research project	600,000 EUROs
Number of participating scientists	8
Name and e-mail address of coordinating scientist in charge of project	Niels Jepsen, nj@aqua.dtu.dk Kim Aarestrup, kaa@aqua.dtu.dk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Acoustic tags, hydrophones, Pit and radio tags, lab equipment
Details of any collaborating countries	Described on www.SMOLTRACK.eu

Summary of Progress:

Wild salmon smolts were caught and tagged in all rivers (2 in Spain, 1 in Ireland, one in Northern Ireland, one in UK and one in DK). In 2018, also a Swedish river will be included. The results demonstrated surprisingly high levels of smolt-loss during the lower river and estuary/coast and in 2018, radio-telemetry will be used to find the actual causes for the smolt loss.

Project No. Fi1 Status: Ongoing

Party or relevant jurisdiction	European Union - Finland
Title of project	**Long-term variation in population dynamics, life history characteristics, sea growth and origin (wild/reared) of salmon in the rivers Teno (Tana) and Näätämöjoki (Neidenelva)**
Objective of research project	Collect long-term data on variation in the stock components, life histories, sea growth and abundance of escaped farmed salmon in the salmon stocks of the rivers Teno and Näätämöjoki. Relate the population dynamics of the juvenile salmon and returning adult salmon in preceding and subsequent generations.
Brief description of research project	The wild Atlantic salmon stocks of the Rivers Teno (Tana) and Näätämöjoki (Neidenelva) have been subject to long-term monitoring programme since the 1970s in cooperation between Finnish and Norwegian research institutes and authorities. Catch statistics and samples have been collected in the freshwater salmon fisheries since 1972 covering all user groups, seasons and gear types. Typically, some 2,000-8,000 adult salmon scales have been collected yearly. Long-term electrofishing at permanent sampling sites has been carried out in the Teno since 1979 and in the Näätämöjoki since 1990.
Dates during which research will take place	Long-term ongoing programme
Area in which research will take place	Northern Finland and Norway
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£275,000 per annum
Number of participating scientists	5
Name/e-mail of coordinating scientist in charge of project	Dr. Jaakko Erkinaro jaakko.erkinaro@rktl.fi
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	Norway

Summary of Progress:

Long-term monitoring programmes. Analyses have indicated relationships between the yearly stock fluctuation and the environmental conditions, especially the Barents Sea temperatures. In addition, positive correlations between the catch fluctuations and the preceding and subsequent juvenile salmon production have been documented. Special emphasis has been allocated to the monitoring of possible escaped farmed salmon in the river catches of the Rivers Teno and Näätämöjoki.

Project No. Fi2 Status: Completed

Party or relevant jurisdiction	European Union - Finland
Title of project	**Joint use of high-throughput SNP assay infrastructure in Atlantic salmon**
Objective of research project	The key aims of the project include: I) A concerted effort to identify genomic regions that affect ecologically and economically important phenotypic traits in domesticated and wild Atlantic salmon; II)efficient joint utilization of a state-of-the-art Nordic genomics infrastructure to generate large-scale salmon SNP datasets;
Brief description of research project	Atlantic salmon is one of the most economically and scientifically important fish species world-wide and especially in the Nordic countries Atlantic salmon can be seen as a "flagship" species because of their vulnerability, attractiveness and broad influence in conservation biology as well as evolutionary, ecological and genomic research. In recent years, the ability to study biological processes from a whole genome perspective have opened unforeseen directions and opportunities but at the same time the resources required for high-throughput genomic projects are becoming prohibitively large for single research groups. Hence, there is an urgent need for collaborative effort for utilizing the latest genomic developments and it provides an ideal ground for joint use of Nordic infrastructures in merging evolutionary, ecological and genomic perspectives.
Dates during which research will take place	2009 -2010
Area in which research will take place	Norway and Finland
Estimated number and weight of salmon to be retained	-
Resources	
Estimated cost of the research project	Staff costs: - Travel: £2,000 Laboratory expenses: £98,000 Overheads: Total 2009-2010: £100,000 i.e. approximately £50,000 per annum
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Craig Primmer craig.primmer@utu.fi
Details of research vessels, e.g. name, registration, call sign and description of vessel	-
Type and amount of gear and other equipment to be used	-

Details of any collaborating countries	Department of Biology, University of Turku, Finland Center for Integrative Genomics, Norwegian University of Life Sciences, Aas, Norway

Summary of Findings:

The joint Nordic infrastructure (a single-nucleotide polymorphism (SNP) genotyping platform) was successfully used to identify signals of natural selection in the genomes of Atlantic salmon populations that differ from aquaculture escaped fish (Mäkinen et al. 2015; Pritchard et al. 2016) and also to identify regions of the genome linked with phenotypic traits of ecological and evolutionary importance (e.g. Bourret et al. 2013; Barson et al. 2015)

Barson NJ, Aykanat T, Hindar K, Baranski M, Bolstad GH, Fiske P, Jacq C, Jensen AJ, Johnston SE, Karlsson S, Kent M, Moen T, Niemelä E, Nome T, Næsje TF, Orell P, Romakkaniemi A, Sægrov H, Urdal K, Erkinaro J, Lien SS, Primmer CRS (2015) Sex-dependent dominance at a single locus maintains variation in age at maturity in salmon. **Nature** 528: 405-408

Bourret V, Kent M, Primmer CR, Vasemägi A, Karlsson S, Hindar K, McGinnity P, Verspoor E, Bernatchez L, Lien S. (2013) SNP-array reveals genome wide patterns of geographical and potential adaptive divergence across the natural range of Atlantic salmon (*Salmo salar*). **Molecular Ecology** 22: 532-551

Mäkinen H, Vasemägi A, McGinnity P, Cross TF, Primmer CR (2015) Population genomic analyses of the early phases of domestication in the Atlantic salmon (*Salmo salar*) **Evolutionary Applications** 8: 93-107

Pritchard VL, Erkinaro J, Kent MP, Niemelä E, Orell P, Lien S, Primmer CR (2016) SNPs to discriminate different classes of hybrid between wild Atlantic salmon and aquaculture escapees **Evolutionary Applications** 9: 1017-10

Project No. Fi3 Status: Ongoing

Party or relevant jurisdiction	European Union - Finland
Title of project	**Integrative science for adaptive co-management in the Arctic: Teno Atlantic salmon as a model system (ISAMA)**
Objective of research project	The aims of the project are to: 1) characterise the ecological and genetic changes in the Teno salmon stock over the past 40 years; 2) identify the key human-mediated/climatic factors that have contributed to these changes; 3) determine the relationships between these changes and the co-occurring societal and political changes 4) better understand the genetic basis of life-history traits important for maintaining stock diversity and stability and thus salmon-related livelihoods 5) use local knowledge and management of Teno salmon as a case study to examine the links between scientific research, local resource users, and adaptive co-management and policy.
Brief description of research project	Atlantic salmon are a cornerstone of culture and livelihoods in many regions, especially the Arctic, but wild salmon numbers have declined considerably over the past 40 years. Key challenges in the sustainable management of salmon and other harvested species include determining the relative importance of different human-mediated and environmental effects, identifying the significance of interactions between them, and predicting the evolutionary response of populations. Further, governance of Arctic natural resources such as wild salmon stocks is a complex task that often involves cross-boundary interests between nations, regions, and communities. The Atlantic salmon stock of the River Teno (Tana in Norwegian, Deatnu in Northern Sami) in northernmost Finland/Norway is an ideal study system to show how an integrative scientific approach can promote the sustainable use of such Arctic natural resources. The ISAMA project brings together three research groups who have each been investigating different aspects of natural resource management: population dynamics, evolutionary genetics, fisheries science and environmental sociology, with a view to integrating these research approaches.
Dates during which research will take place	2015 -2018
Area in which research will take place	Finland and Norway
Estimated number and weight of salmon to be retained	-
Resources	
Estimated cost of the research project	£1.2 million over 3 years
Number of participating scientists	10

Name and e-mail address of coordinating scientist in charge of project	Craig Primmer craig.primmer@utu.fi Jaakko Erkinaro jaakko.erkinaro@luke.fi
Details of research vessels, e.g. name, registration, call sign and description of vessel	-
Type and amount of gear and other equipment to be used	-
Details of any collaborating countries	Department of Biology, University of Turku, Finland Center for Integrative Genomics, Norwegian University of Life Sciences, Aas, Norway

Summary of Progress:

The project is divided into three subprojects: evolutionary genetics, population dynamics and environmental sociology. During the first two years of the project, genetic background of salmon age at maturity (see e.g. Barson et al. 2015 Nature) and local adaptation of tributary poplations have been studied. The ecology sub-project has focused on life history variation, cohort-based population dynamics, and developing bayesian population models. Interviews of local fishermen in the River Teno valley have been carried out, and planning for workshops for building congnitive maps and improving the understanding between traditional and scientific knowledge is underway.

Project No. Fr1 Status: Completed

Party or relevant jurisdiction	European Union - France
Title of project	**Evolution of biological characteristics in Atlantic salmon from all the Armorican massif rivers (Brittany and Low-Normandy, France)**
Objective of research project	Relationships between the cumulative effects of climate warming and other anthropogenic stresses and changes in biological features in populations in the southern part of the European distribution range of the species.
Brief description of research project	This project focused on the analysis of biological data (biometric and demographic) from rod catches and other information (catches by trapping, dead fish, etc.) to identify the biological changes in salmon populations. A long-term data series (biological and catches statistics) since the beginning of the 1970's (more than 30 years) is available for all the Armorican massif rivers. Furthermore, the sampling effort has been improving in space and time since 1987 with the obligatory registration of salmon catches and an extension of the fishing season towards the summer and autumn periods. Moreover, we have a lot of additional information from smolt and adult trapping on two index rivers, the Oir River in Low-Normandy and the Scorff River in Brittany. At the same time, a climatological and freshwater quality time series (temperature and rainfall mainly) might be analysed. The joint analysis of the different data series might allow better understanding of the natural and anthropogenic factors responsible for the biological changes in Atlantic salmon stocks. The project was operated jointly by the National Institute for Agronomical Research (INRA) and the National Council on Water and Aquatic Environments (ONEMA).
Dates during which research took place	1972 - 2005
Area in which research took place	All salmon rivers in the Armorican Massif (about 25-30).
Estimated number and weight of salmon retained	No fish are retained; all fish come from the rod fishery and all individuals trapped are released.
Resources	
Estimated cost of the research project	N/A, part of a larger long-term monitoring programme
Number of participating scientists	2 scientists + 2 technicians
Name of coordinating scientist in charge of project	Dr Jean-Luc Baglinière
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	Adult and smolt counting fence, juveniles survey by electrofishing
Details of any collaborating countries	None

Summary of Findings:

Results confirmed at a multi-regional scale the decrease in the two-sea-winter component in stocks. Furthermore, they showed a decrease in the freshwater age, a strengthening of the semelpare character of the species (strong decrease in the multi-spawner population) and the near extinction of the large multi-sea-winter salmon (three years at sea). Other changes appear in the adult run during upstream migration resulting in a later annual return to freshwater and decreasing size in both components (spring salmon and grilse). Changes in freshwater age seems more related to the increase of river productivity (increase of $\delta C13$) and the variability of parr density (density dependent growth) than to the water temperature increase (low to very low in twenty/thirty years period). All the modifications seem to lead to a shorter turn-over in populations and so to their greater sensitivity to environmental factors.

This project is completed and a scientific paper published. Another publication is in progress and will be submitted shortly.

Project No.   Fr2   Status: Ongoing

Party or relevant jurisdiction	European Union - France
Title of project	**The sea survival of Atlantic salmon from the River Scorff, Brittany**
Objective of research project	Estimation and long-term monitoring of survival at sea in the southern part of the European distribution range of the species
Brief description of research project	This project centres on quantifying smolt production and adult returns, by means of trapping and mark-recapture techniques, to enable estimation of sea survival. The Scorff is an index river which provides management-oriented scientific information at the regional (Brittany) and international (ICES) levels. It is the only stock in the Southern European part of the species distribution range (France and Spain) for which both smolts and adults are enumerated at the mouth of the river. In addition, no coastal or estuarine commercial fishery targeting Atlantic salmon is currently operating. Thus, the Scorff provides a unique opportunity for assessing marine survival of salmon in an area for which such information is virtually lacking. The project is operated jointly by the National Institute for Agronomical Research (INRA), the National Office for Water and Aquatice Environment (Onema) and Angling Associations.
Dates during which research will take place	1994 onwards
Area in which research will take place	The River Scorff (Southern Brittany)
Estimated number and weight of salmon to be retained	No fish are retained, all animals trapped for tagging or mark control are released
Resources	
Estimated cost of the research project	£143,000 per annum
Number of participating scientists	2 scientists + 2 technicians
Name and e-mail address of coordinating scientist in charge of project	Etienne Prévost eprevost@st-pee.inra.fr
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Adult and smolt trapping facilities specially designed to minimize impacts on wild fish due to handling
Details of any collaborating countries	none

Summary of Progress:

First estimates of sea survival are indicative of higher marine mortality than for more northern stocks (UK, Scandinavia, Iceland). Sea survival is conditioned by smolt size (the bigger the smolts, the higher their survival at sea). Recent years have shown a decrease in marine mortality (reduction by half of the smolt to adult survival) and an increase in its variability. In addition there is a steady and ongoing decline in the size combined with a later date of freshwater entry of the adults returning in the Scorff.

Project No. Fr3 Status: Completed

Party or relevant jurisdiction	European Union - France
Title of project	**Atlantic salmon metapopulation investigation in Normandy rivers**
Objective of research project	Estimate exchanges between rivers flowing into the Mont-Saint-Michel-Bay and impact on the management of salmon populations
Brief description of research project	Straying salmon and river proximity lead to individual exchanges and genes flow between populations and can result in a metapopulation structure. Moreover, stocking of Atlantic salmon populations with non-native and hatchery-reared fish can have important consequences on metapopulations by increasing gene flow. Inversely, the river proximity could increase straying of released fish. A good example for such study is the salmon populations in four neighbouring rivers flowing into from the Mont-Saint-Michel Bay (Couesnon, Sélune, Sée, and Sienne) in Lower Normandy and were stocking has been settled since 1989 using non-native salmon coming from two French hatcheries. We propose to explore 1- the functioning of the metapopulation by investigating salmon and gene flows between the four rivers 2- the genetic impact of stocking 3- the consequences for management, including habitat, stocking, and exploitation. We are coupling three approaches: - Molecular genetics using microsatellite markers - Otoliths microchemistry - Modelling the two types of data with capture-recapture information
Dates during which research will take place	2007 to 2010
Area in which research will take place	5 rivers flowing into the Mont-Saint-Michel Bay, Normandy, France
Estimated number and weight of salmon to be retained	No adult fish are retained; all fish trapped are released. Genetic analyses are performed mainly from scales of adult salmon caught by angling. 100 juveniles have been caught and killed for removing otoliths and. for microchemistry analysis.
Resources	
Estimated cost of the research project	£150,000 (Euro150,000) i.e. £50,000 per annum
Number of participating scientists	1 PHD, 8 scientists, 2 technicians
Name and e-mail address of coordinating scientist in charge of project	Jean-Luc Baglinière Jean-Luc.Bagliniere@rennes.inra.fr
Details of research vessels, e.g. name, registration, call sign and description of vessel	None

Type and amount of gear and other equipment to be used	Standard sampling equipment Standard genetics laboratory equipment LAICPMS (Laser Ablation Inductively Coupled Plasma-Mass Spectrometer) for microchemistry analysis Trapping
Details of any collaborating countries	none

Summary of Findings:

Molecular analyses showed very low and not significant differentiation between populations from the Mont-Saint-Michel Bay. Furthermore, the comparison with others wild stocks (Brittany populations (west side) and Upper Normandy (north side)), and with hatchery-reared strains, showed large genetic differences. These results also show relatively high genetic introgression of Normandy populations following stocking. LAICPMS analysis discriminated juveniles from the four rivers with 85% accuracy and also allowed to discriminate juvenile from hatchery. Overall, coupling genetic and microchemistry analyses showed high straying rates of wild and released hatchery-reared adults salmon among the rivers of Normandy and successfull reproduction of stocked fish in the wild.

Further investigations have been carried out to quantify the natural exchange rate (admixture) between the four populations, and the impact of stocking (admixture in wild populations). A dual approach was used based on molecular analyses of samples collected before and after hatchery fish introduction in combination with a simulation study to obtain insight into the mechanisms of admixture in wild populations. Using 17 microsatellites, pre- and post-stocking samples were genotyped from four Atlantic salmon populations supplemented with non-native fish to estimate genetic admixture. Individual-based temporally explicit simulations were also used based on realistic demographic and stocking data to predict the extent of admixture. A low admixture by hatchery stocks was found within pre-stocking samples but moderate to high values in poststocking samples (from 12% to 60%). The simulation scenarios best fitting the real data suggested a 10–25 times lower survival of stocked fish relative to wild individuals. Simulations also suggested relatively high dispersal rates of stocked and wild fish, which may explain some high levels of admixture in weakly stocked populations and the persistence of indigenous genotypes in heavily stocked populations. This study overall demonstrates that combining genetic analyses with simulations can significantly improve the understanding of admixture mechanisms in wild populations.

This project is ended and resulted in three scientific papers (coupling genetic and microchemistry, genetic structure of French Atlantic salmon populations and Understanding admixture patterns in supplemented populations).

Project No. Ir1 Status: Completed

Party or relevant jurisdiction	European Union – Ireland
Title of project	**Assessment of the levels of the parasite *Lepeophtheirus salmonis* on Atlantic salmon post-smolts in salmon aquaculture bays along Ireland's western seaboard.**
Objective of research project	Determine whether sea lice from marine salmon farms are a contributory factor in increased marine mortality of salmon post-smolts migrating from bays with salmon aquaculture. A further objective was to gather information on salmon post-smolt migration patterns.
Brief description of research project	Trawling was undertaken using the Fishlift live aquarium to capture salmon post-smolts in selected bays along Ireland's Western seaboard. Salmon post-smolts were examined for sea lice and data was collected on post-smolt diet, growth and migration. Trawling further off-shore has provided information on post-smolt migration patterns.
Dates during which research took place	First week in May, 2002.
Area in which research took place	South-West Coast (Kenmare Bay), West Coast (Killary Harbour, Bertraghboy Bay, Clew Bay), North-West Coast (Inver Bay)
Estimated number and weight of salmon retained	Up to 250 post-smolts
Resources	
Estimated cost of the research project	£20,000
Number of participating scientists	Two
Name of coordinating scientist in charge of project	Dr. Patrick Gargan, Central Fisheries Board paddy.gargan@cfb.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	Naomh Jude, based in Rossaveel, Connemara, Co Galway. 85 ft pelagic trawler, 850 HP.
Type and amount of gear and other equipment used	Salmon smolt surface trawl with Spectra ropes. Fishlift live aquarium, separator frame and cod-end.
Details of any collaborating countries	

Summary of Findings:

This work has now been submitted for publication. Eight experimental releases of tagged, hatchery-reared salmon smolts were released in river systems draining into 3 salmon aquaculture bays over a 3-year period. For each experiment, groups of smolts were fed untreated pellets or were treated prophylactically with pellets including an in-feed sea louse treatment (Slice™; emamectin benzoate) prior to their release. Analysis of tag recaptures showed that Slice-treated smolts experienced increased survivorship over un-treated controls in six of the seven releases when farm net-pens were in production. The present experimental results suggest that sea lice larvae released from over-wintering farmed salmon may influence the survivorship and conservation status of wild salmon in these river systems.

Project No. Ir2 Status: Completed

Party or relevant jurisdiction	European Union – Ireland
Title of project	**Oceanic factors influencing marine survival of Irish salmon stocks**
Objective of research project	The programme was initiated in 1999 to: Provide information on marine survival at various stages of ocean migration.
Brief description of research project	Marine Institute have funded a fellowship for an entry level scientist to enter a PhD programme in the University of Massachusetts. The fellowship enabled the researcher to avail of the extensive information sets on oceanographic parameters relevant to survival of salmonids at sea. The long-term objective was to examine the relationships between marine survival indices available for Irish salmon stocks with corresponding marine environmental data sets.
Dates during which research took place	August 2001 – 2005
Area in which research took place	Oceanic data was examined for: Post-smolts Norwegian Sea, Wyville Thompson Ridge, North of Scotland, North of Faroes Grilse West Greenland, Irish coast MSW North of Faroes, Irish coast
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£25,000 per annum (Phase 1 – studentship)
Number of participating scientists	5
Name/e-mail of coordinating scientist in charge of project	Dr Niall Ó Maoileidigh (Ireland), niall.omaoileidigh@marine.ie Dr Kevin Friedland (US), friedlandk@forwild.umas.edu
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	USA

Summary of Findings:

Evidence was found that the level of marine recruitment of 1SW salmon is linked to growth during the marine residency, and that decreasing growth over the last 30 years explains the observed decrease in salmon recruitment. Furthermore, the work concludes that changes in climate in the northeast Atlantic have affected the salmon via bottom-up effect, by affecting the abundance, distribution and phenology of key zooplankton species in the northern North Sea and southern Norwegian Sea.

Project No. Ir3 Status: Completed

Party or relevant jurisdiction	European Union – Ireland
Title of project	**Sustainable management of interactions between aquaculture and wild salmonid fish** (EU SUMBAWS project – Irish component of project only)
Objectives of research project	To assess efficacy of prophylactic treatments for salmon smolts migrating through aquaculture bays
Brief description of research project	Two treated and control fish groups, differentially micro-tagged (5,000 fish in each group), released from two freshwater river systems' fisheries, in three years, 2002 to 2005. Survivors in experimental groups were recaptured in commercial fisheries and freshwater traps.
Dates during which research took place	3 year programme 2003-2006. Final release groups returned summer 2006.
Area in which research took place	Kilkerrin Bay, Bertraghbouy Bay, Connemara
Estimated number and weight of salmon retained	
Resources	
Estimated cost of the research project	£143,000
Number of participating scientists	2
Name of coordinating scientist in charge of project	Paddy Gargan, Central Fisheries Board. paddy.gargan@cfb.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	Traps, Microtagging, Commercial fishery
Details of any collaborating countries	UK (Neil Hazon, Scotland); Norway (Bengt Finstad)

Summary of Findings:

In Canadian Journal of Fisheries and Aquatic Sciences,
Published February 2012, 10.1139/f2011-155

Evidence for sea lice-induced marine mortality of Atlantic salmon (*Salmo salar* L.) in western Ireland from experimental releases of ranched smolts treated with emamectin benzoate
Gargan, P.G., Forde, G. Inland Fisheries Ireland. Neil Hazon, Deborah Russell, Christopher Todd, Scottish Oceans Institute, University of St Andrews, Scotland.

Abstract
Sea trout (*Salmo trutta* L.) stock collapses in coastal areas of western Ireland subject to salmon aquaculture were contemporaneous with high abundances of larval sea lice (*Lepeophtheirus salmonis* Krøyer) on juvenile sea trout. Whereas sea trout remain in near-shore waters throughout their marine migration, Atlantic salmon (*Salmo salar L.*) smolts typically move quickly offshore into oceanic

waters. It might therefore be predicted that salmon smolts would be less vulnerable to coastal stressors, and less likely to be negatively affected by infestations of sea lice early in their marine phase. Groups of micro-tagged, hatchery-reared Atlantic salmon smolts were fed either untreated pellets or pellets incorporating the in-feed sea louse treatment SLICE® (emamectin benzoate) prior to eight experimental releases in three marine locations over a 3-year period. In total 74,324 smolts were released and analysis of tag recaptures from returning adult salmon showed that emamectin-treated smolts experienced increased survivorship and were 1.8 times more likely to return compared to control fish. These results suggest that sea lice-induced mortality on adult Atlantic salmon returns in Ireland can be significant, and that sea lice larvae emanating from farmed salmon may influence individual survivorship and population conservation status of wild salmon in these river systems.

Project No.   Ir4   Status: Completed

Party or relevant jurisdiction	European Union - Ireland
Title of project	**Early distribution and migration of Atlantic salmon smolts off the west of Ireland.**
Objective of research project	– To test a new pelagic trawl in open waters off the Irish coast; – To train and familiarise technical and support staff on the operation and deployment of the trawl for further surveys in 2008 and 2009; – To obtain samples of post-smolts for biological and genetic analyses; – To relate run timing, timing of migration, swimming speed, growth etc to oceanographic parameters.
Brief description of research project	A single pelagic trawl was deployed from the Celtic Voyager off the west of Ireland to intercept out-migrating salmon smolts.
Dates during which research took place	7 May and 16 May 2007.
Area in which research took place	North-west coast of Ireland
Estimated number and weight of salmon retained	Depending on survey success but probably no more than 100 individual salmon smolts.
Resources	
Estimated cost of the research project	Trawl = approximately £11,700 (Atlantic Salmon Trust - AST) Vessel = £62,000 (Marine Institute – MI) Staff = £3,500 (MI), £1,400 (AST), £1,000 (University College Cork - UCC), £1,000 (Central Fisheries Board – CFB) Samples = £3,500 (UCC) Approximate overheads @ 50% = £42,000 Total = £126,100
Number of participating scientists	MI = 3 UCC = 1 AST = 1 or 2 CFB = 1
Name and e-mail address of coordinating scientist in charge of project	N Ó Maoiléidigh niall.omaoileidigh@marine.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	RV Celtic Voyager General Description 31.4m length, 8.5 beam Gross tonnage 340 - Fishery, acoustic, oceanography, buoy handling, environmental sampling, geological and hydrographic research vessel Lloyd's Classification: Δ100A1 Research Vessel, LMC
Type and amount of gear and other equipment used	Pelagic trawl with smolt cod-end, CTD and Water sampling rosette mounted with Fluorometer and transmissometer, thermosalinograph, Fluorometer, Weather Station, Data Acquisition System

Details of any collaborating countries	UK
Summary of Findings: A summary of the cruise and the catches of post-smolts was provided to NASCO in document CNL(07)35.	

Project No. Ir5 Status: Completed

Party or relevant jurisdiction	European Union – Ireland
Title of project	**Migration of salmon in estuarine and coastal waters**
Objective of research project	Investigate the timing, route of migration and aspects of the biology of migrating ranched salmon smolts in comparison to the native wild smolt migration.
Brief description of research project	There were three main elements to the project: *a) Timing of wild smolt migration* The downstream traps were monitored for the wild salmon smolt migration and this was related to environmental, lunar and tidal conditions. *b) Tracking of wild smolts by acoustic sounding and ranched smolts by acoustic pinger tags and remote receivers* Wild and ranched smolts were tracked using acoustic echo-sounders to ascertain migration patterns within fresh water and the upper estuary. Acoustic Vemco V8SC-6L-4K pingers were inserted into 40 ranched smolts. A series of 13 automatic listening stations installed throughout the estuary and Clew Bay monitored the seaward movements of these fish, recording timing, direction of movement, temperature and tide. *c) Biological Sampling* Samples of migrating smolts were collected in the coastal waters by gill net and surface otter trawling. Analysis included scales (growth), diet and parasite load (internal and external).
Dates during which research took place	2005-2008
Area in which research took place	The Burrishoole Catchment, Newport, and Clew Bay, Co. Mayo
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£24,000 per annum
Number of participating scientists	3 Marine Institute (Irl), 2 CEFAS (UK)
Name and e-mail address of coordinating scientist in charge of project	Russell Poole russell.poole@marine.ie Deirdre Cotter deirdre.cotter@marine.ie Niall O'Maoileidigh niall.omaoileidigh@marine.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	40 Acoustic Vemco V8SC-6L-4K pingers. A series of 13 automatic listening stations. Echo sounders.

<table>
<tr><td>Details of any collaborating countries</td><td>UK (Andrew Moore, CEFAS)</td></tr>
<tr><td colspan="2">Summary of Findings:

54 ranched salmon smolts were tagged using Vemco acoustic pingers. These were released in late April into L. Furnace. Detection was good and 70% of the fish were recorded in the middle of Clew Bay and 65% were recorded at Clare Island, some 25km out to sea. Some fish not detected in the middle bay were detected at Clare Island, making minimum survival through the estuary and inner bay of >80%. Fish moved through the main channels and tidal flows and movement was influenced by outgoing tidal flows. Analysis of the data is continuing. Equipment will be upgraded in 2006 for application in 2007.</td></tr>
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Project No. Ir6 Status: Completed

Party or relevant jurisdiction	European Union - Ireland
Title of project	**National Development Plan - National Genetic Stock Identification Project**
Objectives of research project	To identify and map discrete spawning areas within tributaries of the salmon-bearing rivers in Ireland (approximately 149) and to collect juvenile Atlantic salmon from these rivers at locations close to the principal spawning areas for establishment of genetic baseline for mixed sample analysis. To undertake the molecular genetic analysis (genotyping) of juvenile salmon tissue samples and adult salmon scales using a pre-determined panel of microsatellite markers. To use the genotype data obtained above, using appropriate statistical packages to identify and characterise river populations as a basis for determining the relative contributions of different baseline river populations within mixed samples.
Brief description of research project	Genetic Stock Identification (GSI), the use of genetic markers for identifying the proportions of different contributing populations in salmon fisheries and new developments in GSI such as individual assignment (IA) methodologies, have been demonstrated to be powerful and valuable tools for the management of fisheries. As part of ongoing efforts to improve the salmon stock assessment programme, the Marine Institute commenced, in addition to the microtag recovery programme, a genetic stock identification (GSI) project in 2005.
Dates during which research took place	2006-2008 Data analysis only in 2008
Area in which research took place	Comprehensive survey of all Irish salmon rivers
Estimated number and weight of salmon retained	None.
Resources	
Estimated cost of the research project	£270,000 per annum in 2006 and 2007 provided under Ireland's National Development Plan. Analysis of results in 2008.
Number of participating scientists	2 project scientists and 1 technical staff, 2 field staff
Name and e-mail address of coordinating scientist in charge of project	Tom Cross t.cross@ucc.ie Paddy Gargan paddy.gargan@cfb.ie Philip McGinnity, Chairman of Scientific Steering Committee) phil.mcginnity@marine.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A

Type and amount of gear and other equipment used	Instream electrofishing equipment
Details of any collaborating countries	Links to ASAP Interreg Programme UK and Spain

Summary of Findings:

The report of this project The National (Ireland) Atlantic Salmon Genetic Stock Identification Project (ST-05-002 Final report is now available. This report was produced by University College Cork, Central Fisheries Board and the Marine Institute.

Preliminary results for both “offshore” and “inshore” confirmed the results using other tagging methods over the years and showed the highly mixed stock nature of the marine fisheries whether some distance offshore or even within estuaries and bays. These fisheries, despite being restricted to specific geographic districts and fishing season (June and July), will comprise of salmon destined not just for that particular district but also comprise salmon from neighbouring and even distant districts, sometimes in high proportions relative to the proportion of “own district” salmon. Also, the fisheries are indiscriminate in that they will not exclusively target only those stocks which are above Conservation Limits.

In general, the original objectives of the programme were achieved and several important spin-offs in relation to the development of markers and other techniques (Single Nucleotide Polymorphisms SNPS) are now under investigation.

Project No. Ir7 Status: Completed

Party or relevant jurisdiction	European Union - Ireland
Title of project	**Interactions between aquaculture and wild salmonid fish**
Objectives of research project	To assess efficacy of prophylactic treatments for salmon smolts migrating through aquaculture bays
Brief description of research project	Two treated and control fish groups of salmon, differentially micro-tagged (5,000 fish in each group), were released from several freshwater river systems' fisheries, between 2002 to 2006 (Burrishoole, Shannon, Lee, Delphi, Screebe). Survivors in experimental groups were recaptured in commercial fisheries and freshwater traps.
Dates during which research took place	2003-2009: Final release groups due back summer 2007.
Area in which research took place	Burrishoole, Shannon River, Lee River, Screebe and associated interceptory drift net fisheries around the Irish coast
Estimated number and weight of salmon retained	N/A. Hatchery-reared only
Resources	
Estimated cost of the research project	£50,000 approx.
Number of participating scientists	3
Name and e-mail address of coordinating scientist in charge of project	D. Jackson dave.jackson@marine.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	Traps, Microtagging, Commercial fishery
Details of any collaborating countries	

Summary of Findings:

Publications

D. Jackson, D. Cotter, N. ÓMaoiléidigh, P. O'Donohoe, J. White, F. Kane, S. Kelly, T. McDermott, S. McEvoy, A. Drumm, A. Cullen – Aquaculture 319 (2011) 37–40.
Impact of early infestation with the salmon louse *Lepeophtheirus salmonis* on the subsequent survival of outwardly migrating Atlantic salmon smolts from a number of rivers on Ireland's south and west coasts

The potential impact of sea lice infestation on outwardly migrating Atlantic salmon smolts has been investigated by treating populations of ranched salmon, prior to release, with a prophylactic sea lice treatment conferring protection from sea lice infestation, for up to 9 weeks. Established populations of ranched Atlantic salmon with well described rates of return were chosen to investigate the potential contribution of early infestation with the salmon louse, *Lepeophtheirus salmonis* to mortality in Atlantic salmon. Results of five releases from four locations are presented and compared with a time series of releases from Lough Furnace in Newport, County Mayo. The results of this study would suggest that infestation of outwardly migrating salmon smolts with the salmon louse (*L. salmonis*) was a minor component of the overall marine mortality in the stocks studied.

D Jackson, D Cotter, N ÓMaoiléidigh, P O'Donohoe, J White, F Kane, S Kelly, T McDermott, S McEvoy, A Drumm, A Cullen, G Rogan –j.aquaculture.2011.03.029 An evaluation of the impact of early infestation with the salmon louse *Lepeophtheirus salmonis* on the subsequent survival of outwardly migrating Atlantic salmon, *Salmo salar L.*, smolts

The potential impact of sea lice infestation on outwardly migrating Atlantic salmon smolts has been 20 investigated by treating populations of ranched salmon, prior to release, with a prophylactic sea lice treatment conferring protection from sea lice infestation, for up to 9 weeks. Established populations of ranched Atlantic salmon with well described rates of return were chosen to investigate the potential contribution of early infestation with the salmon louse, *Lepeophtheirus salmonis* to mortality in Atlantic salmon. Against a backdrop of a declining trend in survival rates of Atlantic salmon many studies are attempting to elucidate potential causes for this decline. Results from this study over a period of 9 years point to infestation with the salmon louse (*L. salmonis*) as being a minor component of marine mortality in the stocks studied.

D Jackson, F Kane, P O'Donohoe, T Mc Dermott, S Kelly, A Drumm and J Newell Sea lice levels on wild Atlantic salmon, *Salmo salar L.*, returning to the coast of Ireland. Journal of Fish Diseases 2013. doi:10.1111/jfd.12059

The sea lice population structure, prevalence and intensity of *Lepeophtheirus salmonis* have been studied over a period extending from 2004 to 2011. Infestation data were collected from the interceptory drift net fishery from 2004 until it was closed in 2006. From 2010, data were collected from the inshore draft net fishery. In all, 34 samples from the drift and draft net fisheries have been analysed to date. Prevalence of infestation with *L. salmonis* regularly approached 100% in samples of hosts recovered from the offshore drift net fishery. Abundance was variable both within and between years with a maximum mean abundance of 25.8 lice per fish recorded in 2004. The population structure of *L. salmonis* on hosts recovered in the inshore and estuarine draft net fisheries was different from that observed in the more offshore drift net samples. There is clear evidence of recent infestation with *L. salmonis* in the draft net samples.

D Jackson, D Cotter, J Newell, S McEvoy, P O'Donohoe, F Kane, T McDermott, S Kelly and A Drumm. Impact of *Lepeophtheirus salmonis* infestations on migrating Atlantic salmon, *Salmo salar L.*, smolts at eight locations in Ireland with an analysis of lice-induced marine mortality. Journal of Fish Diseases 2013 doi:10.1111/jfd.12054.

Sea lice infestation as a source of marine mortality of outwardly migrating Atlantic salmon smolts has been investigated by treating groups of ranched salmon, prior to release, with a prophylactic sea lice treatment conferring protection from sea lice infestation. A number of studies have been carried out in Ireland using both established ranched populations and groups of hatchery reared fish imprinted for 5–8 weeks in the sites of experimental releases. In this study, data on 352 142 migrating salmon from twenty-eight releases, at eight locations along Ireland's South and West coasts covering a 9-year period (2001 to 2009) are reviewed. Both published and new data are presented including a previously unpublished time series. The results of a meta-analysis of the combined data suggest that while sea lice-induced mortality on outwardly migrating smolts can be significant, it is a minor and irregular component of marine mortality in the stocks studied and is unlikely to be a significant factor influencing conservation status of salmon stocks.

P G Gargan, G Forde, N Hazon, D J F Russell, & C D Todd, 2012. Evidence for sea lice-induced marine mortality of Atlantic salmon (*Salmo salar* L.) in western Ireland from experimental releases of ranched smolts treated with emamectin benzoate. Can. J. Fish. Aquat. Sci. 69: 343-353.

Sea trout (*Salmo trutta*) stock collapses in coastal areas of western Ireland subject to salmon aquaculture were contemporaneous with high abundances of larval sea lice (*Lepeophtheirus salmonis*) on juvenile sea trout. Whereas sea trout remain in near-shore waters throughout their marine migration, Atlantic salmon (*Salmo salar*) smolts typically move quickly offshore into oceanic waters. It might therefore be predicted that salmon smolts would be less vulnerable to coastal stressors and less likely to be negatively affected by infestations of sea lice early in their marine phase. Groups of microtagged, hatchery-reared Atlantic salmon smolts were fed either untreated pellets or pellets incorporating the in-feed sea louse treatment SLICE (emamectin benzoate) prior to eight experimental releases in three marine locations over a 3-year period. In total, 74 324 smolts were released and analysis of tag recaptures from returning adult salmon showed that emamectin-treated smolts experienced increased survivorship and were 1.8 times more likely to return compared with control fish. These results suggest that sea lice-induced mortality on adult Atlantic salmon returns in Ireland can be significant, and that sea lice larvae emanating from farmed salmon may influence individual survivorship and population conservation status of wild salmon in these river systems.

M Krkosek, C W Revie, P G Gargan, O T Skilbrei, B Finstad, C D Todd. 2012. Impact of parasites on salmon recruitment in the Northeast Atlantic Ocean. Proc. R. Soc. B. 20122359 .http://dx. doi.org/10.1098/rspb. 2012.2359

Parasites may have large effects on host population dynamics, marine fisheries and conservation, but a clear elucidation of their impact is limited by a lack of ecosystem-scale experimental data. We conducted a meta-analysis of replicated manipulative field experiments concerning the influence of parasitism by crustaceans on the marine survival of Atlantic salmon (*Salmo salar* L.). The data include 24 trials in which tagged smolts (totalling 283 347 fish; 1996–2008) were released as paired control and parasiticide-treated groups into 10 areas of Ireland and Norway. All experimental fish were infection-free when released into freshwater, and a proportion of each group was recovered as adult recruits returning to coastal waters 1 or more years later. Treatment had a significant positive effect on survival to recruitment, with an overall effect size (odds ratio) of 1.29 that corresponds to an estimated loss of 39 per cent (95% CI: 18–55%) of adult salmon recruitment. The parasitic crustaceans were probably acquired during early marine migration in areas that host large aquaculture populations of domesticated salmon, which elevate local abundances of ectoparasitic copepods—particularly *Lepeophtheirus salmonis*. These results provide experimental evidence from a large marine ecosystem that parasites can have large impacts on fish recruitment, fisheries and conservation.

Project No. Ir8 Status: Ongoing

Party or relevant jurisdiction	European Union – Ireland
Title of project	**Marine survival of wild and hatchery reared salmon** **National coded wire tagging and tag recovery programme and Burrishoole wild salmon census**
Objective of research project	The National Coded Wire Tagging and Tag Recovery Programme was initiated in 1980 to: Provide information on marine survival and exploitation rates by commercial fisheries; Estimate the contribution of individual river stocks to catches; Examine the performance of selected experimental groups; Evaluate the potential of a salmon ranching industry in Ireland. The Burrishoole salmon census began in the 1960's to investigate factors influencing the survival at sea of salmon smolts migrating from the Burrishoole river until their returns as adult salmon. Data also facilitates assessment of the spawning escapement and ova to smolt freshwater survival.
Brief description of research project	Up to 500,000 salmon smolts are tagged with coded wire tags and released from 9 Irish rivers annually. Tag recovery takes place in scanning programmes in Greenland and Faroes (during any experimental fishing) and in experimental trawling for post-smolts in the Norwegian Sea and north of Scotland. Subsequently, tags are recovered from homewater fisheries at over 40 locations in Ireland. Between 40 and 50% of the total declared catch of salmon is examined for tags. With the imposition of the carcass tagging scheme, and the district quotas tag recovery has dropped to about 35% of the total catch. With the closure of the Irish mixed stock salmon fishery, returns are now being generated principally from river catches (commercial and recreational) and broodstock returns. This Burrishoole wild salmon census long-term project centres on enumerating numbers of migrating wild smolts and returning adults to the Burrishoole river, by means of trapping facilities, in order to assess return rates and maturation schedules and freshwater survivals. Return rates to Irish homewaters, which provides an index of natural survival at sea.
Dates during which research will take place	Coded Wire tagging since 1980 Tagging November to April. Recovery Post-smolts - May to July (Norwegian Sea), September to November (Faroes) Grilse – May to November MSW – January to November Wild salmon census in the Burrishoole are monitored 24/7 both upstream and downstream migrating since the 1960's
Area in which research will take place	Tag recovery Grilse: West Greenland, Irish estuarine and river fisheries, Irish rivers.

	MSW: North of Faroes, Irish estuarine and river fisheries, Irish rivers Salmon Census Facility, Newport Co. Mayo Ireland
Estimated number and weight of salmon to be retained	Up to 200,000 adults may be examined and cored to retrieve tags. Approximately 40,000 in recent years with mixed stock fisheries and approximately 10,000 since 2007 in the absence of MSF. Up to 40 post-smolts have been recovered in high-seas experimental fisheries of Faroes and Norwegian Sea
Resources	
Estimated cost of the research project	£100,000 per annum in recent 5 years nationally funded (does not include sampling in experimental fisheries in high seas, etc.) Staff approx. £200,000 Equipment (including tags) £100,000 Burrishoole salmon census - £72,000 per annum mainly staff costs
Number of participating scientists	National Coded Wire tagging and Tag Recovery programme = 5 Burrishoole salmon census = 6
Name and e-mail address of coordinating scientist in charge of project	Niall Ó Maoileidigh niall.omaoileidigh@marine.ie Russell Poole russell.poole@marine.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	None
Details of any collaborating countries	Norway, UK, Faroes, France, Spain, Germany, Denmark

Summary of Progress:

National Coded Wire Tagging and Tag Recovery Programme – This tagging programme takes place in up to 8 locations nationally, with recovery centres in commercial fisheries, recreational fisheries and hatchery broodstock collections. Up to 500,000 smolts have been tagged and released since 1980 with approximately 250,000 being tagged presently. The data are reported to ICES annually and are incorporated in the Reports of the Working group on North Atlantic Salmon. Returns of tagged adult salmon and the distribution of Irish and international tagged salmon in the drift net fisheries from 1980 to 2006 clearly demonstrated the mixed stock nature of these fisheries and has been a key element in the Irish government's decision to close this fishery on the precautionary principle in 2007. Subsequent genetic stock identification confirmed the highly mixed stock nature of this fishery. In the absence of the landings of salmon at many major ports, the tag recovery programme will concentrate on key areas with remaining single stock fisheries in estuaries, bays and rivers and the information will continue to be used for the management of the individual and district river stocks.–Following the closure of the Irish Mixed Stock salmon fishery in 2006, tag returns from commercial fisheries were as anticipated extremely low relative to other years but there was a significant increase in the recovery of tags in riverine brood stock collections in both years as more fish escaped to enter freshwater. In 2017 approximately 2,000 individual tag recoveries were generated from a release of approximately 200,000 smolts in 2016. Survival was again low in 2017 for most groups returning to the coast and rivers confirming that conditions at sea for salmon survival are not yet improving.

Burrishoole wild salmon census - Long-term monitoring programme reflecting the decline in marine survival of European salmon stocks. This site is one of only three facilities in NEAC area with total census capabilities (i.e. upstream adult and downstream adult and juvenile trapping and monitoring). Marine survival of wild smolt returning in 2017 is still amongst the lowest rates in the time series. Survival rates from all of these releases are reported in annual ICES WGNAS reports.

Project No. Ir9 Status: Completed

Party or relevant jurisdiction	European Union – Ireland
Title of project	**Kelt survival**
Objective of research project	Tag salmon kelts from four rivers in southern Ireland and monitor marine migration, depth and temperature preferences
Brief description of research project	33 Atlantic salmon kelts were captured in four Irish rivers, (Blackwater, Nore, Suir and Barrow) and fitted with satellite pop-off tags and released in inshore waters in March 2010 & 2011. The tags were programmed to pop-off after three, four and six month periods. After pop-off the tags communicate with the Argos satellite and data on depth and temperature and pop-off position are generated.
Dates during which research will take place	2010 – 2012 (Data analysis and publication only in 2015)
Area in which research will take place	Southern Ireland
Estimated number and weight of salmon to be retained	Salmon kelts between 2.3 and 4.5kg
Resources	
Estimated cost of the research project	£23,000 annually in 2010 and 2011.
Number of participating scientists	Two, Audun H. Rikardsen, Paddy Gargan
Name and e-mail address of coordinating scientist in charge of project	Audun H. Rikardsen audun.rikardsen@uit.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	

Summary of Findings:

Information was received from 10 salmon in 2010 and 9 salmon in 2011. Salmon kelts were recorded west and north west of Ireland and south of Greenland, some fish having travelled 2,500 km. A scientific paper is being prepared on the project in collaboration with all partners.

Project No. Ir10 Status: Ongoing

Party or relevant jurisdiction	European Union – Ireland
Title of project	**The ecology of salmon (*Salmo salar* L.) at sea – environmental factors affecting marine growth, survival and migration of Atlantic salmon**
Objective of research project	The main objective of the project is to investigate the decline in North Atlantic salmon stocks in the past two decades in an ecosystem context and to provide new information for use in forecast models of abundance and size of current stocks
Brief description of research project	The oceanic migration of Atlantic salmon is being investigated in the context of an EU SALSEA (salmon at sea) Merge (EU 7th Framework) project in which the Marine Institute is a key player. The principal aim of the SALSEA Merge project is to map the distribution of salmon stocks from all European countries at sea and is nearing completion. Apart from samples collected for the SALSEA Merge project itself, by the Marine Institute, Institute of Marine Research in Bergen and the Faroes Fisheries Laboratory, a unique set of biological samples and oceanic data was collected for further studies and projects on a collaborative basis by the participating institutes with Universities. These samples were collected to provide critical value added information beyond the scope of the SALSEA Merge project and to shed some light on the specific factors underlying the current ocean migrations of salmon, recent and persistent poor marine survival and information on associated fish species (herring and mackerel). Specific material has been collected which is not available through any other source or held by any other institutes i.e. • **archive and contemporary scale samples** for post-smolt growth and condition analyses, • **stomach content analyses** of post-smolts (and accompanying herring and mackerel) for dietary comparisons and energetics, and • identification and incidence of **parasites** with special reference to *Anasakis* spp. in salmon mackerel and herring.
Dates during which research will take place	2012 – 2015
Area in which research will take place	Ireland, Norway
Estimated number and weight of salmon to be retained	Samples already obtained

Resources	
Estimated cost of the research project	£150,000 total over three years Participant breakdown £90,000 IMR Bergen £50,000 MI, Ireland £10,000 Loughs Agency Ireland/UK
Number of participating scientists	Dr. D. Brophy, Dr. N. Ó Maoiléidigh, Dr. J. C. Holst, Dr. P. Boylan
Name and e-mail address of coordinating scientist in charge of project	Dr. D. Brophy, Galway/Mayo Institute of Technology, Galway Ireland
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	High resolution digital image capture and analyses software and hardware
Details of any collaborating countries	Institute of Marine Research, Bergen Loughs Agency, Cross Boarder Ireland/UK agency

Summary of Progress:

Work is underway on historical scale analyses in Ireland. Experimental scale growth experiments were completed successfully in 2013. The work was registered as a PhD following a review of the academic panel in 2014. Work is ongoing in relation to analyses of archive scale samples. A manuscript describing a comparative analysis of scale measurements from different body locations has been revised for submission while three additional manuscripts relating to experimental simulations of environmental effects on scale growth in prep. The PhD is due for completion in early 2018

Project No. **Ir11** **Status:** **Ongoing**

Party or relevant jurisdiction	European Union - Ireland
Title of project	**Experiment to determine the potential impact of sea lice from marine salmon farms on out-migrating salmon smolts in western Ireland**
Objective of research project	To assess efficacy of prophylactic treatments for salmon smolts migrating through aquaculture bays
Brief description of research project	Treated and control fish groups, differentially micro-tagged (10,000 fish in each group), released from, the Erriff river annually. Adult salmon in experimental groups are recaptured in commercial fisheries and freshwater traps.
Dates during which research will take place	2014 - 2019 This project continues on from previous similar projects under IR3.
Area in which research will take place	River Erriff and Killary Harbour,
Estimated number and weight of salmon to be retained	Approx.16,000 salmon smolt tagged with CWTs and released annually.
Resources	
Estimated cost of the research project	£50,000 annually
Number of participating scientists	Two
Name and e-mail address of coordinating scientist in charge of project	Dr Patrick Gargan Inland Fisheries Ireland Paddy.gargan@fisheriesireland.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Micro-tags, traps, commercial fishery
Details of any collaborating countries	

Summary of Progress:

Results on survival of salmon from release groups are being compiled and data will be published at the end of the programme period.

Project No. Ir12 Status: Ongoing

Party or relevant jurisdiction	EU - Ireland
Title of project	**Salmonid West Programme 2014-2019**
Objective of research project	To investigate migration, distribution, habitat usage and survival of sea trout and salmon smolts in the marine environment on the west coast. To determine factors that may influence salmonid migration and survival and to identify key marine habitats. To investigate ecology of smolts/kelts in the freshwater/marine interface and marine zone. To improve understanding of salmonid ecology at sea and allow assessment of impacts of development (e.g. finfish aquaculture etc.) on wild salmonids. To enable quality environmental impact assessment and optimised spatial planning.
Brief description of research project	The project will determine the mortality of sea trout smolts and kelts, and salmon smolts, on their migration through the lower reaches of two case study rivers, their estuaries and near-shore coastal areas in the west of Ireland. Sea trout migration, distribution and habitat use in the estuary/fjord will be investigated and are the main focus of the current study which is scheduled to run for five years. Acoustic telemetry is being used to determine mortality and monitor habitat usage by tagged salmonids using two acoustic receiver arrays deployed at two sites (Killary Harbour & Galway Bay) off the west coast of Ireland by Inland Fisheries Ireland in recent years. Complementary PIT telemetry is/will be used in both catchments to independently measure sea trout and salmon smolt to adult (return to freshwater) mortality (see IR15).
Dates during which research will take place	2014-2019
Area in which research will take place	River Erriff/Killary Harbour (National Salmonid Index Catchment); and Corrib River/Galway Bay
Estimated number and weight of salmon to be retained	No salmon retained.
Resources	
Estimated cost of the research project	Circa £70,000 per annum (non-pay) £320,000 (non-pay) total
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Dr William Roche willie.roche@fisheriesireland.ie Dr Patrick Gargan paddy.gargan@fisheriesireland.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	Primarily Inland Fisheries Ireland inshore craft and chartered work vessels

Type and amount of gear and other equipment to be used	Two receiver arrays deployed (Killary Harbour & Galway Bay); combination of Vemco VR2W and VR2AR used for arrays. **Erriff equipment:** receivers in freshwater, fixed wolf trap for smolts/kelts, screw trap, full upstream trap. Vemco V7, V9 and V13 used for sea trout of different sizes in both Erriff and inner Galway Bay. Hatchery reared salmon have been tagged in the Erriff River (2014-2015); wild salmon smolts were tagged at this site in 2017. In Killary Harbour a bag net is in operation during the out-migration period to capture salmonids to monitor sea lice levels. Environmental monitoring data being captured in freshwater and in upper estuary. **Galway Bay equipment**: smolt trap in lower Corrib river. Wild salmon smolts were tagged with V7 tags in the Corrib River which discharges into Galway Bay and monitored using single line array across Galway Bay in 2016. Repeat planned for 2018.
Details of any collaborating countries	Galway Bay array - Queens University, Belfast, Northern Ireland + SmartBay; see NASCO SMOLTRACK project also

Summary of Progress:

Erriff River/Killary Harbour: Hatchery reared salmon smolts were tagged with acoustic tags and released in the lower pools of the Erriff River (n=10 per annum; 2014 & 2015).Wild salmon smolts (n=40) were tagged and released with acoustic tags in the River Erriff 12km upstream of Killary harbour. The 40 fish tagged in 2017 contributed data to the NASCO Smolt-track/Lice-track projects.

Year	Species (Origin)	No. Tagged	Length (cm) (Range)	Weight(g) (Range)
2014	Salmon (hatchery)	10	20.0 (18.6-22.0)	92.3 (75.0-114.0)
2015	Salmon (hatchery)	10	21.6 (19.2-24.0)	114 (80.0-164.0)
2017	Salmon (wild)	40	13.8 (12.9-15.2)	25.2 (20.5-34.0)

Survival rates through Killary Harbour were 90% in 2014 and 2015. Wild smolt survival (tagging site through Killary Harbour) in 2017 was substantially lower, although all salmon smolts that entered Killary Harbour successfully migrated out of it. Data analysis is ongoing.

River Corrib/Galway Bay: wild salmon smolts from the Corrib system in Galway city were tagged in 2016 (n=30). Mean length (cm) and mass (g) was 19.0cm (range 17.4-21.2cm) and 66.9g (range 52-89g) respectively. Overall survival (tagging site to the main array) was moderate. This represents a minimum survival rate as array coverage was partially compromised. Data analysis is ongoing and will include temporal comparisons.

Extensive sea trout tagging data (acoustic) from 2014-2017 are being collated for detailed analyses at both sites.

Project No. Ir13 Status: Ongoing

Party or relevant jurisdiction	EU - Ireland
Title of project	**Investigation of the early migration of salmon and brown trout from the Burrishoole National Index River using telemetry technology in freshwater, brackish and inshore marine areas**
Objective of research project	This is a collaborative project under the Marine Institute Cullen Fellowship scheme involving the Marine Institute and University College Cork. The Marine Institute research facility at the Burrishoole system in the West of Ireland offers unparalleled opportunities to study the migration ecology and life histories of Atlantic salmon and sea trout in close detail. The Salmon Leap and Mill Race sea-entry traps provide for 'total trapping', i.e. monitoring and potential capture of every fish passing through the system, both upstream and downstream, 365 days a year. Moreover, the geography of the catchment lends itself very nicely to designing a telemetry study, as one can install receivers at strategic points along the migration route from fresh water to the open ocean.
Brief description of research project	WP1: Application of PIT tag technology technology to track early migration of salmon and trout through the Burrishoole system WP2: Interactions between freshwater and marine performance of salmonid (utilising existing biological and environmental data sets). Linking long-term biological data on Atlantic salmon and sea trout with climate time series to assess the effect of potential thermal mismatch between freshwater and marine environments on post-smolt survival. WP3: Stock recruitment and juvenile stock dynamics- towards establishing biological reference points.
Dates during which research will take place	2016 to 2019
Area in which research will take place	Burrishoole and environs, Newport, Co. Mayo
Estimated number and weight of salmon to be retained	None
Resources	
Estimated cost of the research project	Stipend = £60,000 Fees = £4,500 Equipment = £55,000
Number of participating scientists	6
Name and e-mail address of coordinating scientist in charge of project	Dr. R. Poole russell.poole@marine.ie Dr. T. Reed Treed@UCC.IE
Details of research vessels, e.g. name,	None

registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	PIT tag telemetry equipment, fish traps, draft nets, electrofishing gear
Details of any collaborating countries	None

Summary of Progress:

As of January 2018 there are 10 PIT antennas operating continuously at 5 different sites throughout the catchment. There are also a number of other PIT installations planned for the coming months. Once these are completed, fish from the top of the catchment (Fiddaunaveela) will pass 5 PIT antenna arrays prior to reaching the sea, allowing migration timing, migratory speed, and migratory survival rates to be calculated for salmon and trout as they move through various components of the catchment.

Over 1000 juvenile salmon have been tagged since December 2016. Biological data and genetic samples have been taken for each fish. PIT tagging of salmon parr and trout takes place on a daily basis at the Rough river trap. All fish entering or leaving the catchment through the Salmon Leap and Mill Race traps are also scanned by hand for tags prior to release and biological data is recorded for all recaptures. Juvenile autumn and spring migrating brown trout are also tagged at these traps prior to sea entry in order to assess marine survival and the contribution of each group to annual anadromous returns.

Project No. Ir14 Status: Ongoing

Party or relevant jurisdiction	EU - Ireland
Title of project	**Investigation of the causes of early migration mortality in salmon and sea trout from the Burrishoole National Index River using acoustic telemetry in estuarine, marine and coastal areas**
Objective of research project	This is a collaborative project under the Marine Institute Cullen Fellowship scheme involving the Marine Institute and the Galway/Mayo Institute of Technology. By definition, anadromous species are widely dispersed geographically and across habitat types. This makes it difficult to identify and quantify the various pressures that are exerted during the life cycle and understand their relative contributions to population fluctuations. Crucial knowledge gaps exist, particularly for the marine phase and this is an area that has been prioritised for research internationally(ICES 2013; ICES. 2015; NASCO 2014). In particular, it is recommended that future research efforts focus on partitioning mortality of salmon among phases of the marine migration (NASCO 2014).
Brief description of research project	• To build national capacity in the use of telemetry to monitor movements of migratory fish species • To evaluate and optimise methods for the tagging of wild and reared post-smolts • To describe and map the migration routes taken by post-smolts of Atlantic salmon and sea trout during their seaward migration from the Burrishoole catchment • To estimate survival of tagged post-smolts during their seaward migration from the Burrishoole catchment • To evaluate the influence of various endogenous (e.g. body size) and exogenous (predation, obstacles, habitat features) factors on the survival of migrating post-smolts • To analyse annual and regional changes in salmon return rates since 1980 using the coded wire tagging database • To evaluate the influence of factors such as smolt release time, fishery closures and climatic conditions on temporal trends in growth and survival • Retrospective growth analysis using archived scale collections - linking previously described temporal trends in growth to trends in marine survival
Dates during which research will take place	2016 to 2019
Area in which research will take place	Burrishoole River, Clew Bay and Environs, Co. Mayo
Estimated number and weight of salmon to be retained	None
Resources	
Estimated cost of the research project	Stipend = £60,000 Fees = £4,500

	Equipment = £55,000 Total = £119,500 per annum
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	Dr. Niall Ó Maoiléidigh Niall.omaoileidigh@marine.ie Dr. Deirdre Brophy Deirdre.Brophy@GMIT.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	An Bradán. Inshore research vessel of the Marine Institute
Type and amount of gear and other equipment to be used	Various acoustic tags and receivers
Details of any collaborating countries	None

Summary of Progress:

- Investigations into the survival of se run adult salmon in relation to historical exploitation rates and climate using CWT records from the National Coded Wire Tagging and Tag Recovery Programme has begun. Acoustic tagging equipment has been critically range tested and selected equipment has been purchased. Site selection is ongoing and local arrangements are being made to facilitate deployment in areas of boating activity. Ranched salmon from the Smolt Unit at the Marine Institute, Furnace were tagged with acoustic tags
- 80 salmon migrating through fish traps on site were tagged
- 47 receivers (listening stations) were positioned in Lough Furnace through to the inner bay, between Clare Island & Achillbeg Island, between Clare Island and Roonagh Head – to ensure complete detection of tagged salmon smolts leaving Clew Bay
- Receivers were downloaded on a regular basis
- The highest number of losses occurred in the mid-Bay, this could be down to a number of factors including, competition and food availability or predation
- It generally took fish between 1 and 4 days to reach Rosmore and the majority of fish reached Clare Island between 2 and 5 days after release

Project No. Ir15 Status: Ongoing

Party or relevant jurisdiction	EU - Ireland
Title of project	Estimate marine survival of wild Atlantic salmon in the North-east Atlantic from the National Salmonid Index Catchment (River Erriff system) and the River Corrib system in the west of Ireland
Objective of research project	The objective of this project is to estimate Atlantic salmon smolt to adult marine survival rates from respective stocks in the National Salmonid Index Catchment and the Corrib system in the west of Ireland. Complementary tagging work is also being undertaken on sea trout smolts in the River Erriff during the project period. The output from this work will be used to better inform more accurate regional, national and international stock assessments and conservation management strategies. In addition, it is expected that valuable biological information will be generated to better understand the life history of salmon in the marine environment (e.g. residence time and marine growth) to further address knowledge gaps in this area.
Brief description of research project	Out-migrating salmon smolts from each system are tagged with Passive Integrated Transponder (PIT) tags and returning adults are subsequently monitored for the presence of the tags to in order to determine marine survival rates. Trapping facilities to capture and tag migrating smolts are situated at a number of locations on the River Erriff catchment and at the Galway weir on the River Corrib system. Length measurements and scale samples are collected from tagged fish to allow the growth rates and age structure of each stock to be elucidated. In the Erriff catchment, a swim through PIT tag reader has been installed in the fish pass at the upstream trap in the lower stretch of the river to detect tagged salmon returning from sea. In the River Corrib system, a swim through PIT tag reader has been installed in 2017 in the fish pass to detect returning adult fish and those caught by anglers will also be scanned for the presence of PIT tags.
Dates during which research will take place	PIT tagging carried out from spring 2015 to spring 2020. Returning adults are expected up to 2021/ 2022.
Area in which research will take place	The National Salmonid Index Catchment (River Erriff) and the River Corrib system in the west of Ireland.
Estimated number and weight of salmon to be retained	0
Resources	
Estimated cost of the research project	PIT tags = £18,000 PIT tag readers =£18,000 Total =£36,000 per annum
Number of participating scientists	4

Name and e-mail address of coordinating scientist in charge of project	Dr Patrick Gargan paddy.gargan@fisheriesireland.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Telemetry Full duplex type resistivity tags Pass through pit tag reader x 2 IS1001 reader software Rotary screw trap
Details of any collaborating countries	N/A

Summary of Progress:

In the River Erriff, 1,020 salmon smolts were PIT tagged in 2016 and *c*. 1,000 salmon smolts were PIT tagged in 2017. The vast majority of adult returns from the 2016 cohort were expected to return in 2017 as this river is predominantly comprised of one-sea-winter grilse. Return rates (i.e. marine survival) in 2017 were *c*. 3.1%. It is envisaged that *c*. 1,000 salmon salmon smolts will be PIT tagged per year in the period 2018 – 2020 in the Erriff.

In the River Corrib system, PIT tagging of salmon smolts commenced in spring 2017 when *c*. 2,000 fish were tagged. A swim through PIT tag reader was installed the fish pass in 2017 to facilitate detection of adult returns from this cohort, which are expected in 2018 and 2019. It is envisaged that a maximum of 2,000 smolts will be PIT tagged on this river per year in the period 2018 - 2020.

Project No. Ir16 Status: Ongoing

Party or relevant jurisdiction	EU - Ireland
Title of project	**Sea lice model for the sustainable development of Atlantic salmon fisheries and aquaculture. (LICETRACK)**
Objective of research project	The project will support the development of a sea lice integrative model that will take into account relevant parameters, including biological, environmental, oceanographic, anthropogenic etc, with the aim of predicting the potential for the sea lice to occur at different locations at different times of the year and under different environmental conditions. The project will contribute to developing best management practice for sea lice control.
Brief description of research project	This project proposes to develop a sea lice integrative model developing and refining hydrodynamic modelling, environmental variables, sea lice production on salmon farms and other data requirements to support sustainable development of aquaculture and wild salmon stocks. Existing modelling tools have been developed in Norway and Scotland. These models simulate dispersal of larval sea lice based on farm production, hydrodynamics, water temperature and salinity, and have been used to identify the role of specific salmon farming sites as recipients or sources of sea lice. In order to make directly comparable estimations of lice dispersal, and hence larval concentrations and infection pressure, the models need to be standardised. The project work which will be carried out in the National Salmonid Index Catchment in Ireland (Killary Harbour), will benefit from the exchange of ideas to ensure optimal solutions are arrived at. For this reason we will seek to form a network that will meet with the objective of developing a standard model that can be plugged into any hydrodynamic model of local currents to generate sea lice dispersal patterns. This project will contribute to developing best management practice for sea lice control and define a range of production strategies aimed at reducing the presence of sea lice and their negative impacts, both on farmed and wild Atlantic salmon.
Dates during which research will take place	January 2017 to December 2018
Area in which research will take place	Ireland (National Salmonid Index Catchment), Norway and Scotland.
Estimated number and weight of salmon to be retained	N/A

Resources	
Estimated cost of the research project	Inland Fisheries Ireland: £160,500 (staff £99,500; Equipment /Consumables £21,000, Travel/Subsistence £5,000; Secretariat £3,500; Workshops £31,500). National University of Ireland, Galway: £143,000 (Staff £135,000, Equipment £3,000; Travel/ Subsistence £5,000). Institute of Marine Research Norway: Staff £103,500. Norwegian Institute for Nature Research: Staff £85,500. Marine Science Scotland: Staff £67,500. Total cost: £560,000. Contribution from EU: £216,000. Note: the EU contribution is coming through the IASRB.
Number of participating scientists	9
Name and e-mail address of coordinating scientist in charge of project	Dr Patrick Gargan paddy.gargan@fisheriesireland.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	6 x Sentinel cages 25 X Acoustic tags 1 X Bag net
Details of any collaborating countries	Norway (Norwegian Institute for Nature Research and Institute of Marine Research); Scotland (Marine Science Scotland)

Summary of Progress:

Following on from the first LiceTrack Workshop in March 20017, considerable progress was made including the deployment of sentinel cages containing salmon and use of a bag net during the May/June period to measure lice levels on fish. Data was recorded on salinity, temperature and water velocity at sites throughout Killary Harbour as parameter inputs to inform the development of the hydrodynamice and particle tracking model. The Aasleagh upstream trap was monitored between May and October 2017 and 179 sea trout were examined for sea lice, length, weight, condition and marine growth.

Bathymetric data for the Killary Harbour model was collated and a digital terrain model of Killary Harbour has been developed. Boundary condition data (open sea; river data and surface wind stresses) have been collated for the Killary Harbour model. A preliminary hydrodynamic model of Killary Harbour has been developed and some preliminary model runs have been simulated for flow fields in the fjord.

The parameters required for a sea lice integrative model developing and refining hydrodynamic modelling, environmental variables, sea lice production on salmon farms and other data requirements are being developed with the objective of developing a standard sea lice model.

Project No. Ir17 Status: Ongoing

Party or relevant jurisdiction	EU - Ireland
Title of project	**Unlocking the archive: using scale and otolith chronologies to resolve climate impacts**
Objective of research project	Investigations of climate change impacts on fish populations requires sustained and detailed long-term datasets capturing individual-level variation in the traits that are under environmental influence. Improvements in the availability and accessibility of environmental monitoring data allows researchers to more accurately describe the external conditions that contribute to changes in growth, phenology, migration and survival. Exceptionally detailed records of individual responses to these conditions can be gleaned from hard tissues (scales and otoliths) of teleost fish. Visible periodic increments provide an internal chronological record of life history traits such as age, growth and migration timing. Recent analytical advances also allow the reconstruction of temperature and feeding histories and migration pathways. Archived collections of scales and otoliths can generate incredibly detailed longterm biological time-series. Coupling this information with measurements of external conditions can yield powerful insight into how populations respond to environmental change and can inform predictions of likely future responses.
Brief description of research project	This project proposes to consolidate Marine Institute Newport Research Facility collections of scales and otoliths and associated images and data into a single biochronology repository linked to other biological time series and to relevant high resolution habitat and environment data, thus maximising the use of the archive by researchers. Existing growth time-series will be updated and an interface created to ease future access and updating. A comprehensive analysis of growth and environmental time series will be conducted to investigate responses of migratory fish to environmental change at both oceanic and catchment level scales. Stable isotope signatures in archived salmon scales will be used to identify temporal changes in feeding history that may coincide with changes in growth and marine survival. The feasibility of using scales to detect biochemical stress responses will be investigated. The research infrastructure and capacity developed by the project will complement and support ongoing NRF research programmes and will enable future Irish involvement in international biochronology networks. Such collaboration is likely to leverage additional international funding for an integrative analysis of ecosystem responses to climate change which is the ultimate goal of this research programme.
Dates during which research will take place	2017 to 2021
Area in which research will take place	Marine Institute, Newport Research Facility, Co Mayo and Galway/Mayo Institute of Technology

Estimated number and weight of salmon to be retained	0
Resources	
Estimated cost of the research project	Total award £270,000 over 4 years. £67,500 per annum. Breakdown not available as yet
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Dr. Deirdre Brophy Deirdre.Brophy@GMIT.ie Dr. Deirdre Cotter Deirdre.cotter@marine.ie Dr. N. Ó Maoiléidigh Niall.omaoileidigh@marine.ie Dr. R. Poole Russell.poole@marine.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	Study involves use of archival tag, otolith and scale material
Details of any collaborating countries	None

Summary of Progress:

Examination of database archival systems used for archiving biological specimens or samples has been advanced with identification of suitable application for use with scales and otoliths. Marine Institute scale archive has been re-examined and plans have been made to improve storage and access to samples. Historic samples have been provided in a collaborative genetic project on the River Erne to assess the status of the salmon population currently used for restocking and enhancement compared to the original Erne stocks.

Time series of scale growth (circuli number, intercirculi distances for freshwater and post smolt growth are being developed with new samples being digitised and data entered in a growth database.

Project No. Sw1 Status: Ongoing

Party or relevant jurisdiction	European Union – Sweden
Title of project	**Long-term variation in population dynamics, life history and exploitation of salmon stock in the index river Ätran**
Objective of research project	The objective is to estimate long-term variation of survival in different life stages, life history characteristics, stock/recruitment and growth of wild salmon in the Index River Ätran with its major tributary Högvadsån. Estimates of sea survival and exploitation are provided from annual Carlin tagging of wild smolt, but pit tags will be used as of 2018.
Brief description of research project	The wild salmon stock in River Ätran has been subject to monitoring since the 1950s with annual recording of the number of ascending fish in the tributary Högvadsån since 1954 and partial smolt trapping since 1959. Present monitoring programmes include electrofishing surveys, smolt trapping, adult counters in the main stem of River Ätran and in Högvadsån, catch sampling and scale reading, and collection of catch statistics. As the river Ätran is infected by *Gyrodactylus salaris*, there is also an annual monitoring of the parasite infection. Marine survival and growth are evaluated through: • Pit tag tagging of wild salmon smolt (ca. 500 annually). • Count of smolts and ascending spawners. • Age structure and growth of ascending spawners. • Fitness (Fulton condition factor) of ascending spawners. The habitat suitable for salmon has been mapped in 2013-2014. During 2015 the efficiency of the spawner trap has been evaluated. In 2016 the smolt trap efficiency was evaluated. In 2017 BRP's was established.
Dates during which research will take place	Long-term ongoing project (subject to annual review).
Area in which research will take place	Sweden (west coast; Kattegatt). N57.067885° E12.658044°
Estimated number and weight of salmon to be retained	No adult fish are retained. Circa 20 fry and 20 parr are sampled for Gyrodactylus salaris. Scales from circa 50 spawners are sampled annually.
Resources	
Estimated cost of the research project	£40,000 in 2018 dedicated to the project. Extra funding (ca £3,000) is also provided from the ongoing liming programme in the river. All funding is from public funds.
Number of participating scientists	2 (also participating in other projects). Erik Degerman & Ida Ahlbeck Bergendahl
Name and e-mail address of coordinating scientist in charge of project	Erik Degerman erik.degerman@slu.se
Details of research vessels, e.g. name,	N/A

registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Adult fish trap and smolt trap (Wolf trap, former eel fishing gear). Electrofishing gear.
Details of any collaborating countries	N/A

Summary of Progress:

Although River Ätran was infected by Gyrodactylus salaris in 1990, this river still supports the largest numbers of returning spawners of any of the 23 wild salmon rivers on the Swedish west coast.

In 2013 the lowermost hydropower plant was eliminated in River Ätran. Elimination of the plant will further enhance the spawning run and the smolt migration.

The establishment of conservation limits for the Swedish salmon stocks was set using data from Ätran in 2017. Stock/recruitment curve has been stablished with MSY and spawning target (9.3 eggs per m^2 of salmon habitat).

An index of habitat suitability for salmon parr has been developed from detailed field surveys combined with electrofishing in different habitats. The potential maximum parr density in different habitats will be established and the present densities of salmon parr will be compared to the expected maximum giving a simple index of recruitment status.

Project No. Ew1 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Salmonid migration and climate change**
Objective of research project	The main objective of the research is to describe and model the environmental factors affecting the migration of salmonids and to predict the effects of climate change on salmonid migration and survival in the sea.
Brief description of research project	Telemetry studies at CEFAS on the movements of post-smolts in coastal waters have provided information on the importance of water currents and tidal streams to the speed and direction of migration. The research project further developed the migration studies to examine the movements and distribution of salmon and sea trout smolts in the marine environment. Models were developed to describe the migration routes of post-smolts in relation to marine currents and sea surface temperature and the results used to predict the impact of oceanographic and climatic conditions on distribution and migration of salmonids in the marine environment.
Dates during which research took place	1 April 1999 - 31 March 2004
Area in which research took place	Coastal waters around the UK and extending to salmon feeding grounds in Faroes and Greenland seas
Estimated number and weight of salmon retained	250 salmon smolts
Resources	
Estimated cost of the research project	£140,000 per annum
Number of participating scientists	5 CEFAS scientists
Name of coordinating scientist in charge of project	Dr Andrew Moore
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	Acoustic transmitters and automated acoustic receiver systems
Details of any collaborating countries	N/A

Summary of Findings:

The key objectives of the research were to describe and model the environmental factors affecting the migration of salmonids and to investigate the effects of climate change on salmonid migration and survival both in fresh water and the sea.

The main findings of the research are as follows:

Migratory behaviour of salmonid smolts and post-smolts

- The migratory behaviour of the sea trout smolts in the River Fowey was similar to populations of both salmon and sea trout in other river systems in England and Wales.
- Smolt emigration in the freshwater section of the river was correlated with increasing water temperature and increasing river flows although no particular threshold was evident for either environmental parameter.
- There was a seasonal difference in the time that tagged smolts spent in the freshwater section of the river before entering the estuary. Fish released later in the season spent less time in the river before emigrating into coastal waters. As a result a significant proportion of the sea trout smolts migrated out of the estuary and into coastal waters during a 10-day period that coincided with a spring tide.
- Migration through the estuary was principally on a spring ebb tide and in the region of the water column with the highest flows. This is energetically the most advantageous strategy for migration and resulted in the fish being moved rapidly out into coastal waters.
- The smolts were pre-adapted in fresh water to the marine environment and as a result there was no requirement to spend long periods acclimating within the estuary during one of the most critical periods in the life-cycle of the sea trout.
- A physiological requirement for smolts to leave fresh water and to enter the marine environment is likely to be the major stimulus initiating the emigration of sea trout smolts in spring.
- In coastal waters salmon and sea trout post-smolts demonstrated active, directed swimming. Migratory behaviour was initiated when the direction of the prevailing tidal currents was suitable to assist the fish in rapid movement away from the estuary mouth and in the case of the salmon in the general direction of the principal feeding grounds in the Norwegian Sea.
- The speed of migrating salmon over the ground was within the range 18-23 cm sec^{-1}, which is similar to the migratory speeds recorded in studies on other salmon populations in UK river systems.
- The physiological transformation of the emigrating fish to full smolt status was necessary for successful migration within the marine environment. Therefore any factors that operate within the freshwater environment to inhibit smoltification (e.g. contaminants or high water temperatures) or delay migration (e.g. estuarine barrages, amenity constructions) will reduce the survival of the post-smolts in the marine environment.

Migratory behaviour of sea trout kelts

- The post-spawning survival of the sea trout was relatively high and over 60% of the tagged kelts emigrated from fresh water and into the coastal zone.
- Seaward migration within fresh water was predominantly nocturnal and generally occurred in conjunction with increasing river discharge and rising water temperature. Post-spawning residency within the freshwater zone was highly variable between individuals, ranging from 4 days to over 2 months.
- Measurements of gill ATPase activity in fish sampled soon after spawning indicated that the fish were not yet physiologically adapted to migrate into saline conditions. However, the subsequent movement through the estuary and into coastal waters was rapid and the fish showed no evidence of a requirement to adapt to the increasing salinities. Physiological adaptation after spawning would therefore appear to be rapid prior to the onset of emigration.
- Migration through the estuary was predominantly nocturnal and occurred during an ebbing tide. This ebb tide form of transport is energetically the most favourable method of movement and migration at night would reduce the level of mortality from visual predators.
- Tagged trout were recorded returning to the river after a period at sea and, in the case of one individual, successfully spawned whilst still retaining the tag in the body cavity.
- The high return rates of tagged sea trout suggests that similar techniques using electronic data storage tags would permit longer-term studies such as the thermal habitat requirements of the sea trout in the marine environment.

Distribution of salmon in the sea

- Attachment methods have been developed to allow data storage tags (DSTs) to be used as part of large-scale studies to determine the distribution of salmon in relation to marine environmental conditions. Existing DSTs can be placed within the body cavities of adult salmon for long-term monitoring of marine environmental conditions although the exteriorisation of the light sensor to permit the geographical position of the fish to be calculated would be necessary.
- A non-invasive technique for monitoring cortisol levels in tagged fish was developed in order to quantify the effect of electronic tag attachment to fish and their subsequent recovery. The technique measures the level of cortisol excreted into the water by individual tagged fish and allows the recovery rate of the fish to be assessed. The technique will be used to quantify the effects of tags on salmon prior to the long-term studies on the distribution and behaviour of salmon in the sea.
- Collaborative links have been developed with international organisations through the NASCO Working Group on International Cooperative Research held in Norway to study the factors regulating populations of salmon in the sea.
- CEFAS contributed to ***SALSEA – A marine research strategy to determine key factors affecting salmon survival at sea*** presented to the EU in 2004 for funding.

- Other opportunities have continued to be investigated for applying DSTs to salmon in the sea and a variety of approaches have been pursued through this project and related work programmes. These have included membership of the Lotek Wireless - Ocean Technology Fund Committee (funded by Lotek Wireless) and participation in the Census of Marine Life - Pacific Ocean Salmon Tracking Program.
- However, the cost of research programmes has been the main factor in preventing large-scale studies on salmon in the sea.

The impact of climate change on salmonids

- A literature review was completed using the available models and scenarios of climate change and organised into a framework with which to predict the impact on the freshwater and marine environments and subsequent effects on populations of salmon and sea trout over the next 20 and 50 years.
- The climatic information on which the study was based was taken principally from the UK Climatic Impacts Programme (UKCIP) Technical Report 1 and from the NOAA-CIRES Climatic Diagnostics Center and the work on the North Atlantic Oscillation (NAO) by CEFAS, Lowestoft.
- In fresh water, the expected increases in winter temperature and precipitation will be greatest in NW England and in Wales; the highest increase in summer temperatures will occur in SE England where there will be a corresponding reduction in summer and annual rainfall. Warming of rivers should be less than the 1-2°C anticipated for annual mean air temperatures. However, the warming of rivers in winter will probably be more significant for salmonids than increases at other seasons. The frequency of extreme events such as droughts and floods will increase. Increasing abstraction and reduced precipitation will increase the contaminant loading in many rivers and exacerbate their impact on salmonid populations.
- The warming of rivers by 1-2°C will accelerate embryonic and alevin development during the winter, and lead to earlier emergence of fry from the gravels.
- The consequential effects on survival and growth of later stages will depend on a synchronous phenological advancement of food organisms, plant growth and other requirements.
- Survival of eggs and alevins in upland rivers could be reduced should expected higher winter rainfall generate more frequent river spates resulting in wash-out of the embryos.
- Growth rates of salmonid parr will increase significantly as the result of a temperature rise of 1-2°C providing that there is a commensurate increase in their food resources.
- Faster growth could lower the mean age at which parr reach the smolt stage by about 1 year, increasing smolt production for a particular year-class. However, density-dependent regulation would regulate overall smolt production.
- Reduced river flows and lower water temperatures would inhibit or delay the emigration of smolts and their entry into coastal waters. Modification to the timing of the entry of smolts into the marine environment has been shown to affect survival and the return of spawning adults.
- Reduced flows will inhibit and delay the movement of adult spawning salmon into the freshwater environment. Increased temperatures will reduce the amount of suitable thermal habitat for returning salmon. Reproductive success and fecundity may be reduced at higher water temperatures.
- Increases in river flow will facilitate upstream spawning migration and assist the movement around obstacles such as weirs and barrages.
- There are major uncertainties regarding the impact of changes in climate within the marine environment. The various models and predictions indicate either small gradual rises in sea

surface temperature, no significant changes, or even slight cooling in those regions occupied by salmon.

- Changes to sea surface temperature and oceanographic features such as currents may modify the distribution and abundance of key prey items of the post-smolts and adult salmon. A mis-match in prey availability during entry into the marine environment may reduce post-smolt survival and growth.
- Changes in sea surface temperatures (SST) will reduce the amount of suitable thermal habitat required for the suitable growth and development of salmon in the sea.
- Changes in oceanographic features such as shelf edge currents may compromise the bio-energetic requirements of the migrating fish and lower survival.

Project No. Ew2 **Status:** **Completed**

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Impacts of agricultural contaminants on wild salmonids**
Objective of research project	The main objective of the research was to describe the nature and extent of the impact of aquatic contaminants derived from agriculture (e.g. pesticides) on migration and marine survival of salmonid smolts and post-smolts.
Brief description of research project	Recent research has demonstrated that the freshwater and the marine environments cannot be considered in isolation and that the conditions within the freshwater zone experienced by Atlantic salmon may be critical to their subsequent survival within the sea. In particular, exposure of juvenile salmon to a range of sub-lethal concentrations of freshwater contaminants such as pesticides and endocrine-disrupting chemicals (EDCs) may operate to reduce survival in fish once they have emigrated to sea. The research project described how freshwater contaminants such as the pesticide atrazine can interfere with the parr-smolt transformation and reduce the ability of the fish to physiologically adapt to saline conditions. Laboratory studies have indicated that smolts exposed in freshwater to environmental levels of the pesticide atrazine have reduced levels of gill Na+K+ATPase activity and plasma ion concentrations. Subsequent exposure to seawater resulted in poor hypo-osmoregulatory performance and mortality. In addition, modification of the physiological processes involved during smoltification by pesticides may also delay or inhibit smolt migration. The results of the studies have been incorporated into existing life-cycle models to determine the impact of freshwater contaminants on salmon at the stock and population level.
Dates during which research took place	April 1999 - April 2004
Area in which research took place	England and Wales
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£425,000 (over 5 years)
Number of participating scientists	6
Name of coordinating scientist in charge of project	Dr Andy Moore
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A

Details of any collaborating countries	Sweden and Canada

Summary of Findings:

The key objectives of the research were to identify and describe the effects of environmental levels of agricultural pesticides on salmonid embryo survival, smolt emigration and marine survival and to model their potential impacts at the population level. In addition, the role of pheromones in sea trout biology was investigated in order to predict the effects of water quality on sea trout reproduction.

The main findings of the research are as follows:

- Exposure of juvenile salmon during the parr-smolt transformation to environmentally relevant levels of the herbicide atrazine inhibited smoltification and reduced the ability of the fish to adapt to salt water conditions. Smolts exposed in fresh water to atrazine demonstrated low survival when transferred to seawater.

- Exposure of juvenile salmon during the parr-smolt transformation to environmentally relevant levels of the herbicide atrazine inhibited or delayed downstream migratory behaviour during the spring.

- Exposure of juvenile salmon during the parr-smolt transformation to mixtures of environmentally relevant levels of the herbicide atrazine and the endocrine-disrupting chemical 4-nonylphenol inhibited smoltification and reduced the ability of the fish to adapt to salt water conditions. Mixtures of the two contaminants operated synergistically to reduce survival when the fish were transferred to seawater.

- Exposure of juvenile salmon during the parr-smolt transformation to mixtures of environmentally relevant levels of the sheep dip insecticides diazinon and cypermethrin had no significant effect on smoltification or reduced the ability of the fish to adapt to salt water conditions.

- Exposure of juvenile salmon during the parr-smolt transformation to environmentally relevant levels of the brominated flame retardant PBDE inhibited smoltification and reduced the ability of the fish to adapt to salt water conditions. Smolts exposed in fresh water to PBDE demonstrated low survival when transferred to seawater.

- The freshwater environment cannot be considered in isolation from the marine environment. The contaminants that juvenile salmon are exposed to within the freshwater environment can have a direct impact on their subsequent survival within the sea.

- Exposure to environmentally relevant levels of the sheep dip insecticides diazinon and cypermethrin for a brief period during fertilisation inhibits or delays the timing of emergence of fry from the spawning gravel. Exposure to the insecticides also reduces the subsequent survival and development of salmonid fry.

• Exposure of fertilised salmon and sea trout embryos to sediments containing environmentally relevant levels of the sheep dip insecticides diazinon and cypermethrin reduces survival and inhibits or delays the timing of emergence of fry from the spawning gravel.
• The sea trout has a similar reproductive pheromone system to the Atlantic salmon and is likely to be affected by environmental contaminants in the same way and that has been previously shown for Atlantic salmon. The shared reproductive pheromone system may further explain the occurrence of hybridisation in certain sympatric populations. • Exposure of mature male trout to mixtures of the pesticides diazinon and cypermethrin inhibited the ability of the fish to detect and respond to the reproductive priming pheromone Prostaglandin $F_{2\alpha}$. As a result there was no significant increase in the levels of milt that are required for successful reproduction. • The life-cycle model developed in order to predict the potential effects of environmental contaminants on Atlantic salmon at the population level predicted that exposure to contaminants during fertilisation, smoltification and reproduction result in a significant decline in the number of returning adult fish, particularly in exploited stocks.

Project No. Ew3 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Impact of intensive in-river aquaculture on wild salmonids**
Objective of research project	The main objective of the research was to describe the nature and extent of the impact of aquatic contaminants derived from intensive freshwater aquaculture (effluents, pesticides, antibiotics and hormones) on reproduction and migration of wild salmonids.
Brief description of research project	Previous studies have demonstrated that sublethal concentrations of agricultural pesticides and contaminants may significantly affect salmon reproduction, embryo survival and the ability of smolts to adapt to the marine environment. A similar variety of compounds are also known to be released within the effluents from freshwater aquaculture facilities and these include pesticides and antibiotics for the control of parasitic and bacterial diseases, and hormones and hormone metabolites from the farmed fish. Recent studies have also indicated that these hormones/pheromones have an important role in increasing the reproductive status of wild salmon prior to spawning. However, it is not clear to what extent the contaminants within fish farm effluents may affect reproduction, migration and survival of wild salmonids and whether they could result in serious declines in salmonid stocks. The aim of the present research programme was to describe the impact of environmentally relevant concentrations of fish farm contaminants on salmonid reproduction and migration. Firstly, the concentrations of relevant contaminants (pesticides and hormone/pheromones) entering the freshwater environment were determined and described. Secondly, the effects of these contaminants on reproduction/spawning and survival of post-smolts in the marine environment was assessed and described. The results were incorporated into salmonid life-cycle models, in order to increase our understanding of the impacts of aquaculture contaminants on stocks of salmonids.
Dates during which research took place	November 2001 – April 2005
Area in which research took place	England and Wales
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£325,000 (over 4.5 years) £72,000 per annum
Number of participating scientists	4
Name of coordinating scientist in charge of project	Dr Andy Moore andy.moore@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A

<table>
<tr><td>Details of any collaborating countries</td><td>N/A</td></tr>
<tr><td colspan="2">Summary of Findings:

The study investigated the effects of trout farms (both rainbow trout farms and brown trout) on both reproduction and smoltification in Atlantic salmon. The research involved laboratory-based studies on the impacts of identified contaminants within the fish farm effluents on salmon reproduction, smoltification and the ability of smolts to adapt to sea water. In addition, field-based studies were carried out where both male salmon and salmon smolts were caged upstream and downstream of rainbow and brown trout fish farms to investigate the impact of the effluents on physiology and survival. The majority of the research was undertaken at an intensive rainbow trout farm on the River Test at Romsey and a brown trout farm at Netheravon on the River Avon. Additional studies were undertaken at a mixed rainbow/brown trout farm at Stockbridge on the River Test. The research has indicated that the effluents from fish farms can have significant impacts on Atlantic salmon particularly during sensitive life-history stages such as reproduction and smoltification. In addition, effluents from rainbow trout farms may also have a deleterious effect on the macro-invertebrate populations, which include many of the prey items of juvenile salmonids.</td></tr>
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Project No. Ew4 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Modelling the bioenergetics of salmon migration**
Objective of research project	The principal objectives of the research was to model the energetic requirements of salmon during their marine migrations and predict the effects of environmental and oceanographic changes on smolt growth and survival.
Brief description of research project	Successful migration of salmon within the marine environment requires that sufficient energy stores are either available prior to, or replenished throughout, migration. Therefore, the overall energy budget of a smolt may be an extremely important factor contributing to the migratory success, growth and survival in the sea. The project developed a model to describe the basic energy requirements of salmon and how it is utilised for movement, maintenance and growth in the marine environment. The model was used to predict the effects of environmental and oceanographic changes (e.g. sea surface temperature, ocean currents, food availability) on smolt growth and survival in the sea.
Dates during which research took place	April 2002 – April 2005
Area in which research took place	The research will model the migrations of selected stocks of salmon from English and Welsh rivers.
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£40,000 per annum
Number of participating scientists	2 CEFAS scientists
Name/e-mail of coordinating scientist in charge of project	Dr Andrew Moore a.moore@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

The aim of the research was to develop a numerical model for investigating potential changes in the growth and survival of Atlantic salmon during the marine phase arising from changes in smolt condition or oceanic conditions. A numerical model was designed to calculate growth and survival resulting from spatial and temporal patterns of physical oceanographic conditions, specifically ocean currents, sea surface temperature and prey availability. The results of the different modelling scenarios suggest that, during their oceanic phase, salmon may be capable of adapting to future climate change provided that their migration routes are not inherited and guided by cues other than temperature (e.g. celestial or wave patterns). However, the ability to predict the effects of climate change on salmon populations is limited by a lack of knowledge about migration behaviour, which in turn is due to the paucity of observations of salmon movements and growth in the open sea.

Project No. Ew5 **Status:** **Completed**

Party or relevant jurisdiction	European Union – UK (England and Wales)
Title of project	**Cardiff Bay Fisheries Monitoring Programme**
Objective of research project	Assess the impact of Cardiff Bay Barrage on salmon and sea trout stocks in rivers Taff and Ely
Brief description of research project	1. Tracking movements of adult salmon up to and past barrage and through impoundment using contained acoustic and radio tags. 2. Tracking movements of smolts through impoundment and past barrage. 3. Monitoring changes in the return rates of microtagged smolts (hatchery origin) before, during and after construction.
Dates during which research took place	Through years 1990-2006
Area in which research took place	Cardiff Bay at mouth of rivers Taff, Ely, South Wales, UK
Estimated number and weight of salmon retained	Up to 20 per year
Resources	
Estimated cost of the research project	c. £250,000 per annum
Number of participating scientists	5/6 per annum
Name of coordinating scientist in charge of project	Peter Gough peter.gough@environment-agency.wales.gov.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	‘Challanger’ M00WB70085 7-4 Metres long
Type and amount of gear and other equipment used	<60 C.A.R.T tags pa. 40-50 smolt tags pa. 10,000 - 70,000 micro-tagged and/or fin-clipped smolts stocked each year.
Details of any collaborating countries	None
Summary of Findings: No summary provided.	

Project No. Ew6 **Status:** **Completed**

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Atlantic Salmon Arc Project, ASAP**
Objective of research project	Define exploitation at sea on a regional basis using genetic tools. Create a long-term database for these studies and create an international management tool to inform decision-making.
Brief description of research project	A Europe wide collaboration to define tools for genetic metapopulation studies culminating in a Europe wide effort that collected samples from all the regions and genotyped using defined methods and took first steps to assess proportional stock exploitation at sea. Microsatellite analysis was the method used. The genetic laboratories directly involved were Exeter University and Oviedo University. There were many associated partners in the study helping to collect salmon samples from the rives of the North Atlantic; however, the funded partners in the study are: Central Fisheries Board of Ireland Westcountry Rivers Trust (Lead partner) Association of West Coast Fisheries Trusts Oviedo University Asturias government Galician Government Exeter University.
Dates during which research took place	May 2004 – July 2008
Area in which research took place	Europe, North Atlantic
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£2.2 million Approximately £550,000 per annum
Number of participating scientists	12
Name/e-mail address of coordinating scientist in charge of project	Dr Dylan Bright dylan@wrt.org.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	Spain, France, Ireland, Scotland, USA, Iceland
Summary of Findings: The ASAP project has successfully completed its first phase. A database of salmon population genotypes has been defined for Spain, France the UK and Ireland. The database has been blind tested	

and shows a very good level of discrimination in assigning salmon from different regions to their correct population of origin and destination. The database has been tested with samples from small inshore net fisheries in the UK and it has been demonstrated that in most cases these fisheries are exploiting multiple populations. The database has been used in collaboration with the Marine Institute to examine the destination and origin salmon represented by an extensive suite samples from Irish Inshore and Offshore fisheries. The findings from this study are in press. Details of each population used in the database and the details of each of the rivers of origin are available online in an interactive, multilingual web based GIS. Data is only partially uploaded to the data base at present.

Project No. Ew7 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Diffuse pollution and freshwater fish populations**
Objective of research project	The main objective of the research was to investigate the role of diffuse aquatic contaminants in regulating populations of freshwater fish with particular reference to salmonid stocks and fisheries.
Brief description of research project	There is increasing evidence from studies carried out in Europe and North America that contaminants derived principally from intensive agriculture and in-river aquaculture may have significant effects on salmonids at specific periods during the life cycle (e.g. spawning and reproduction, embryo development, migration, parr-smolt transformation and/or entry into saltwater) at concentrations frequently found in the environment. Initial modelling from these laboratory-based studies has indicated that exposure at these critical stages may affect productivity at the population level. The present research programme had two principal aims. Firstly, to validate the results from the laboratory based studies carried out under SF0228 – *Impacts of agricultural contaminants on wild salmonids*, and determine whether exposure to these contaminants within river systems in England and Wales are affecting populations in the wild. The research tested the conclusions made about the effects on populations of wild salmon by the retrospective analyses of the relationship between specific declining stocks and land management changes resulting in the occurrence of target contaminants in the aquatic environment. Secondly, recent monitoring of the aquatic environment has highlighted the presence of novel contaminants whose chemical structure and toxic mechanisms are known to target important biological processes in fish and which may significantly compromise and regulate populations. These contaminants include specific pharmaceuticals, antibiotics from intensive agriculture and aquaculture and brominated flame retardants from industry. The research therefore determined the potential impacts of these contaminants on fish at both the individual and population level in order to support both the advice on the regulation of contaminants within aquatic ecosystems and the conservation and management of fish populations.
Dates during which research took place	April 2005 – March 2010
Area in which research took place	England and Wales
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£694,680 (over 5 years) of which £68,500 was added to research on salmon at sea.
Number of participating scientists	3

Name/e-mail address of coordinating scientist in charge of project	Dr Andrew Moore a.moore@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

There is now evidence from studies carried out in Europe and North America that contaminants derived principally from intensive agriculture may have significant effects on salmonids at specific periods during the life cycle, often at concentrations frequently found in the environment. In particular, research carried out at the Cefas, Lowestoft Laboratory has indicated that a range of pesticides may compromise Atlantic salmon (*Salmo salar* L.) sense of smell, reproduction, embryo development and the parr-smolt transformation and/or entry into saltwater. This research has highlighted that in terms of the life cycle of the Atlantic salmon, the freshwater and marine environments cannot be considered in isolation and that exposure to poor water quality in freshwater may be a key factor influencing survival of the fish once they migrate into the sea. However, the majority of this research was based on laboratory experiments and there is a requirement to determine whether exposure to environmentally relevant contaminants within river systems in England and Wales are indeed affecting populations in the wild.

Therefore, the present research programme had two principal aims. Firstly, to validate the results from the laboratory based studies carried out under a previous Defra funded research programme SF0228 – *Impacts of agricultural contaminants on wild salmonids*, and determine whether exposure to these contaminants within river systems in England and Wales are affecting populations in the wild. Secondly, recent monitoring of the aquatic environment has highlighted the presence of novel contaminants whose chemical structure and toxic mechanisms are known to target important biological processes in fish and which may significantly compromise and regulate populations. These contaminants include specific pharmaceuticals, antibiotics from intensive agriculture and aquaculture and brominated flame retardants from industry. The present research examined the potential impacts of these contaminants on fish at both the individual and population level in order to support the advice to the Policy Customer on the regulation of contaminants within aquatic ecosystems and the conservation and management of fish populations.

The specific objectives of the research programme were:

1. To determine the impact of novel diffuse contaminants on juvenile salmon with specific reference to development, olfactory imprinting, run-timing and behaviour within the marine environment.

2. To determine the impact of novel diffuse contaminants on adult salmon with specific reference to freshwater entry, homing, and fecundity in female salmonids.
3. Determine the relationship between specific declining salmon stocks, land management changes and occurrence of target contaminants in the aquatic environment.
4. To assess the effects of diffuse contaminants on the biology of salmon within wild populations.
5. To provide recommendations to Policy Division for any required remedial action to reduce the impacts on diffuse contaminants on fish populations.
Laboratory and field based experiments have formed the basis of the research to determine the impact of contaminants on juvenile and adult salmon. The contaminants that were selected for study are known to routinely occur in rivers during the period of the parr-smolt transformation and seaward migration of the smolts and during the spawning season. The concentrations of the contaminants studied also reflect the levels that may occur routinely in the rivers and tributaries and so are therefore relevant to many salmonid populations. Extensive literature and data based investigations formed the basis for the studies examining the relationship between the decline in salmonid stocks and the occurrence of specific agriculture derived contaminants within river catchments.

The major findings of the research were that contaminants such as the brominated flame retardants, which are known to mimic thyroid hormones, significantly disrupt the parr-smolt transformation process whereby the juvenile salmon undergo a number of physiological and behavioural changes that adapt them to a life in the ocean. Specifically, hexabromocyclododecane reduces the olfactory abilty of the fish to detect odours that are considered important during the imprinting process during which the emigrating fish remember the "smell" of their home river and subsequently use this to home to their natal tributaries as spawning adults. Exposure of salmon smolts to hexabromocyclododecane was also shown to reduce the survival of the fish during the transition from freshwater and into the sea. Exposure of salmon smolts in freshwater to environmental levels of the pesticide atrazine (0.5, 1.0, 2.0 and 5.0 $\mu g\ l^{-1}$) also reduced their ability to detect specific odours during the imprinting period. The results clearly demonstrate that exposure of salmon smolts to environmental levels of a range of diffuse contaminants inhibits olfactory function, which is known to play a pivotal role in the imprinting process and the subsequent homing of adult salmon to their natal river.

Diffuse contaminants were also demonstrated to interfere with female salmonid reproduction and the subsequent survival of the eggs and embryos. Eggs exposed to atrazine during fertilisation had a 66% higher risk of mortality compared to control eggs for every microgram per litre of atrazine in the water. Comet assays also indicated that in those surviving eyed eggs, 30 days after fertilisation, DNA damage was higher in the eggs that had been fertilised in the water containing both 0.5μg/l or 2.0μg/l atrazine. Exposure to polycyclic aromatic hydrocarbons (PAH) produced modifications to the kidney structure of the female fish, as well as lower levels of intestine Na^+K^+ ATPase activity. This may indicate that the female fish are under physiological stress as a result of PAH exposure. There was also a significant difference in the subsequent survival of the eggs after 50 days, which had been fertilised in PAH water compared to the controls. Once again exposure of eggs to contaminants during fertilisation have a poorer survival rate than those fertilised in "clean" water.

It proved difficult to obtain suitable data with which to investigate relationships between pesticide concentrations in the catchments and variations in salmon stocks. However, in the River Avon rod catches of salmon were lower in years when the atrazine levels were high, and similar correlations were shown between the level of another triazine herbicide (simazine) rod catch in this river. Such results may be informative, but must be interpreted with great care.

The incorporation of the laboratory and field-based experimental data into the life cycle model of the salmon demonstrated that low levels of environmental contaminants can have a serious impact on both individuals and populations of salmonids. As more data is gathered, both from laboratory and field-based research programmes the models and the predictions will become more robust.

Project No. Ew8 **Status:** **Completed**

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**The influence of the freshwater environment on salmonid populations**
Objective of research project	This is a large research project examining the impact of environmental change on juvenile salmon production and ecology
Brief description of research project	One aspect of the research that is directly related to marine survival examines the potential role of assessment techniques in influencing marine survival of salmonid smolts. Assessment methodologies such as trapping, anaesthetisation and tagging of wild/hatchery fish could affect the ability of smolts to adapt and survive in fresh or saline water and there is a need to identify any such effects in order to ensure best possible practice in assessment programmes. The proposed research will critically assess the techniques routinely used as the tools for population assessments and that provide the basis for the provision of advice to managers on biological reference points, the status of stocks and management measures for specific fisheries.
Dates during which research took place	April 2005 – March 2010
Area in which research took place	England and Wales
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£615,350 (over 5 years) of which £72,700 was added to research on salmon at sea
Number of participating scientists	3
Name/e-mail address of coordinating scientist in charge of project	Dr Andrew Moore a.moore@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

In recent years declines in salmon catches and shifts in population structure involving a diminishing of the multi-seawinter fish component have given concern for many salmon populations throughout the NE Atlantic. Although there has been much recent concern regarding the factors influencing and regulating populations of salmon in the sea, it is now accepted that conditions within freshwater also play a pivotal role to a juveniles salmons subsequent survival within the marine environment. However, human pressures on freshwater environments continue to mount and the effects of these are likely to be exacerbated by climate change. There is, therefore, a requirement to understand how the predicted changes in river flow may modify wild populations of juvenile salmonids.

There is increasing evidence that juvenile salmon migrate downstream in the autumn in a wide range of river systems throughout the NE Atlantic. However, the extent and range of movement of these fish and their distribution and habitat requirements during the winter and prior to the spring smolt migration are not known. If such movements are widespread in UK rivers, it could have significant effects on our approaches to stock monitoring and assessment, the evaluation of factors affecting stocks, particularly during the critical transition between freshwater and marine environments and the development of management strategies.

Assessment methodologies such as trapping, anaesthetisation and tagging of wild/ hatchery juvenile salmon could subsequently affect the ability of the fish to adapt and survive in fresh or saline water and there is a need to identify any such effects in order to ensure best possible practice in assessment programmes.

There is also increasing concern regarding the potential impact on ecosystems of increasing levels of artificial light throughout the northern hemisphere. Much of our inland waters are now affected by light pollution, which has the potential to affect salmon at a number of stages throughout their life cycle.

Therefore, the main objectives of the research were to:

Investigate the impact of changes in freshwater river flows expected to result from the predicted climate change scenarios on juvenile salmon production in rivers in England and Wales and determine how these should be managed.

Determine the abundance and distribution of the autumn migrant component of salmonid populations in rivers and estuaries in order to assess their relative contribution to smolt production and determine the effects on current stock assessment and management practices;

Critically assess the techniques routinely used for population assessments in the development of advice to managers on stock assessments, biological reference points and management measures for specific fisheries and propose appropriate improvements.

Review the known information on the impact of diffuse artificial light pollution on freshwater fish populations in order to assess the potential problem and provide recommendations on appropriate research.

Objective 1. Investigate the impact of changes in river flows expected to result from the predicted climate change scenarios on juvenile salmon production in rivers and determine how these should be managed.

The effects of managed severe low summer flow events on habitat use, displacement and survival of wild populations of juvenile salmon, trout and grayling were investigated in a small chalk stream. Significant changes in habitat use and range of movement were identified, many associated with the loss of the stream margins under low flow. However, with no net downstream movement of any species under low flow, displacement was spatially limited. There was an increase in the mortality rate in first year salmon, trout and grayling. This may be related to their small size and increased vulnerability to predation under low flow conditions due to the reduction in depth and loss of the stream margins that are their preferred habitat under normal flow. The findings have implications for the management of chalk streams. In particular, they underline the importance of the stream margins as juvenile salmonid habitat, and suggest that a flow management strategy is required to combat drought conditions.

Conversely, subsequent investigations suggested that low spring flow at the same study site in 2007 had little, or no, impact on the migratory behaviour of wild salmon smolts.

Objective 2. Determine the abundance and distribution of the autumn migrant component of salmon populations in rivers and estuaries in order to assess their relative contribution to smolt production and determine the effects on current stock assessment and management practices.

The autumn juvenile salmon migration on the R. Frome was monitored between 2005-2007, in collaboration with Centre for Ecology and Hydrology (CEH). The results found the size of the autumn migration to be significant. Subsequent investigations have confirmed a contribution by autumn migrating parr to the returning adult stock.

Integrated laboratory and field investigations were carried out to determine whether autumn migrants are physiologically adapted for migration into saline water. The results showed that the juvenile salmon migrating downstream on the R. Frome in autumn, and those fish that were subsequently found in the tidal reaches during the winter, were not sufficiently physiologically adapted to survive entry to seawater. Therefore, this autumn migration of parr represents a habitat shift to the lower freshwater reaches of the river.

If such findings are generic to salmon populations, it would have important implications for fisheries managers, and catchment scale management plans, which should now take account of the tidal reaches as important juvenile salmon habitat. Further, stock-monitoring programmes that do not account for autumn migrations to the lower river, or any inter-annual variation in their abundance, will under-estimate total smolt output, with a consequential under-estimation of marine mortality, and confound the interpretation and comparison of marine mortality and adult return rates.

Objective 3. Critically assess the techniques routinely used for population assessments in the development of advice to managers on stock assessments, biological reference points and management measures for specific fisheries and propose appropriate improvements.

Integrated field and laboratory investigations found that both the migratory behaviour and ability survive in saline water of some salmon smolts is affected following tagging. Previous studies have suggested that natural smolt migration patterns are a predator avoidance tactic and also ensure that the fish enter the marine environment at the optimum time. Therefore, any such disruption may increase the rate of predation on these fish or impact on their fitness to survive at sea.

Differences in adult return rates between wild salmon tagged as smolts and a control population are currently being determined on the River Frome, in collaboration with CEH. At present the number of returns is too small for useful statistical comparison, however this study is ongoing, with more returns expected from the 2007, 2008 and 2009 smolt migrations. Applying the precautionary approach until the results of this large-scale field based investigation are known, we provisionally recommend that fisheries scientists carefully consider the costs/ benefits of the capture, handling and tagging of salmon smolts and ensure that they can account for any potential bias these commonly used marking methodologies may have on their experimental results before commissioning programmes which involve handling smolts.**Objective 4. Review the known information on the impact of diffuse artificial light pollution on freshwater fish populations in order to assess the potential problem and provide recommendations on appropriate research.**

Our extensive literature review revealed large gaps in our knowledge on this subject. Indeed, detailed case studies on the impact to wild freshwater fish were noticeable only by their absence. As a consequence, we strongly recommend that research programmes on this subject be commissioned.

Project No. Ew9 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Factors affecting the distribution and behaviour of salmonid populations**
Objective of research project	The main objective of the research is to investigate the habitat requirements of adult salmonids within the estuarine and freshwater environments. However, one key element of the study is to investigate how changes in prey availability within the marine environment may influence recruitment of stocks between years.
Brief description of research project	Potential changes in the marine environment such as suitable water temperature and changes in oceanographic circulation patterns may influence the migration routes, growth, run-timing and survival of salmon in the sea and these changes will be influenced further by modifications to the climate. It has also been hypothesised that these changes in marine conditions may regulate salmon populations through modifying the distribution and abundance of key prey items. Therefore, variations in the numbers of returning adults may be directly correlated to previous feeding conditions in the open sea. One potential method to test this hypothesis is to retrospectively measure the stable isotopic composition of salmon scales, which reflect the isotopic composition of the prey items. Changes in the abundance or availability of specific food items may show up as changes in the stable isotopes within salmon scales. The purpose of the research is to investigate using this method whether “poor” years in terms of adult recruitment can be related to changes in productivity and the availability and quality of key prey species within the marine environment. This study will also form part of the programme of research on salmon in the sea being co-ordinated by NASCO.
Dates during which research took place	April 2005 – March 2010
Area in which research took place	England and Wales
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£721,830 (over 5 years) of which £67,000 is related to research on salmon at sea.
Number of participating scientists	4
Name/e-mail address of coordinating scientist in charge of project	Dr Andrew Moore a.moore@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A

Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

This programme had three parallel themes addressing the factors that might affect the distribution and behaviour of adult salmon in the sea, estuaries and freshwater.

Although there has been a substantial amount of research on the habitat requirements of juvenile salmonids and the factors controlling the emigration and behaviour of smolts, there has been very little work describing the migration of adult fish within estuaries. In addition, we have very little understanding of the environmental mechanisms controlling the entry, migration and the habitat requirements of adults within estuaries. In many river estuaries returning salmon congregate in holding areas for variable periods waiting for suitable freshwater conditions before continuing their spawning migration. This may make salmon stocks very susceptible to adverse conditions but losses may often go unnoticed. However, there is little information on the physical and water quality characteristics of these areas, their temporal and spatial distribution or the environmental and anthropogenic factors that may affect them. The purpose of the research is to describe the behaviour of adult salmon in estuary systems prior to freshwater entry and of salmon kelts as they return to sea.

One of the potential causes of the decline in salmon stocks may be modification to the freshwater environment that result in changes to the thermal regime, thereby reducing the habitat available to salmon and affecting their survival and reproductive success. Such changes could be due to general climate warming and/or changes in flow regimes due to agricultural and other land-management practices, such as groundwater abstraction. The purpose of the research is to establish whether or not the freshwater thermal environment in rivers in England and Wales impacts on the migratory behaviour, and reproductive success of adult salmonids.

Potential changes in the marine environment such as suitable water temperature and changes in oceanographic circulation patterns may influence the migration routes, growth, run-timing and survival of salmon in the sea and these changes will be influenced further by modifications to the climate. It has also been hypothesised that these changes in marine conditions may regulate salmon populations through modifying the distribution and abundance of key prey items. Therefore, variations in the numbers of returning adults may be directly correlated to previous feeding conditions in the open sea. The purpose of the research is to investigate using this method whether “poor” years in terms of adult recruitment can be related to changes in productivity and the availability and quality of key prey species within the marine environment.

The research was conducted using an integrated approach of field-based telemetry studies and laboratory investigations. Much of the telemetry work was conducted on the River Tyne, north east England. Returning salmon and sea trout were caught in the lower estuary and their subsequent movements monitored using an acoustic telemetry system consisting of individually coded transmitters and an array of submersed receivers. Data was obtained of the patterns of behaviour through the estuary, into freshwater and, for those fish that survived the ordeal of the spawning migration, their emigration back out to sea. Smaller studies were also conducted on other river systems. Data from this aspect of the programme revealed detailed and novel information on many aspects of migratory behaviour, including; swimming depth behaviour of returning salmon and emigrating kelts, impacts of seal predation and previously unreported data on the behaviour of salmon in freshwater holding pools. The findings of this work provide practically useful information that will aid the protection of adult salmon in estuaries and rivers and open up new areas of research into thermal refuging, predation, energy dynamics, olfactory response and the impacts of estuarine engineering projects (e.g. pile driving and tidal barrages).

The laboratory studies had two objectives. The first, focused on investigating the effect of temperatures within the range experienced by wild salmonids, on gonad investment, egg production and reproductive success in hatchery reared fish. This was achieved by holding adult and juvenile salmonids in climate controlled tank facilities under various thermal conditions at specific stages in their life cycle. The results suggest that water temperatures can influence the level of gonad investment, timing of ovulation and the trade-off between the number and size of eggs produced by migratory salmonids. These findings have implications for population models that do not take account of the variation in egg numbers, reproductive success and subsequent offspring fitness of spawning anadromous salmonids. The second objective was to investigate the relationship between marine prey consumption and recruitment of adult salmon. This was achieved by retrospective measurement of the stable isotopic composition of salmon scales. Scales reflect the isotopic composition of the prey items and therefore changes in the abundance or availability of specific food items may show up as changes in the composition of salmon scales. The results revealed cyclical patterns in the level of carbon isotope that are likely to reflect cyclical variations in the North Atlantic Oscillation (NAO). These patterns explained a large proportion of variation in the numbers of adult salmon returning to regional waters. This implies that there will be greater returns of adult salmon (relative to the number of juveniles entering the ocean) following higher levels of primary production. It also suggests that high winter temperatures leading to smaller phytoplankton blooms, less enriched $\delta^{13}C$ values and therefore less favourable trophic conditions for salmon at sea, may increase mortality perhaps by nutritional stress. Techniques developed within this programme provide a wide range of future research opportunities, including further investigations on the influence of ocean productivity on regulating fish populations

The research has continued to examine salmon scale microchemistry in order to determine the potential role of climate/environmental change in regulating populations within the marine environment.

Project No. Ew10 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales) (Northern Ireland) and (Scotland)
Title of project	**Genetic sampling to type British salmon stocks**
Objective of research project	Coordinate and support the establishment of baseline information on the genetic character of breeding populations within and among rivers in Britain.
Brief description of research project	The initial aim will be to provide the basis for identifying salmon to specific rivers or regions to assist in a range of stock assessment and management scenarios (e.g. management of mixed stock fisheries). Subsequently it may be possible to answer a range of additional questions relating to the size and structure of breeding populations, levels of exploitation, and the contribution of stocked fish. The study will also provide a tool that may be used in a variety of other scientific investigations. The project will complement the work already undertaken to characterise genetically salmon river stocks in Ireland, and for optimum benefit will build on the sample collection and analysis currently budgeted for under the SALSEA MERGE programme. Sampling of fry and parr will be conducted in the main spawning areas of a range of rivers in Scotland, England and Wales as required to supplement sampling that has already been undertaken or is planned under other contracts (e.g. ASAP and SALSEA MERGE). Genetic analyses will be undertaken using the same techniques and markers (micro-satellites) as in those other studies. The project will be overseen by a Steering Group which will coordinate and support the establishment of the baseline genetic information. In additional, a Technical Working Group will: • Determine how best to achieve the overall objective • Provide technical advice • Coordinate methodologies Participants in the programme will include Environment Agency, AFBNI, Defra/Cefas, Marine Institute, Scottish Government, Association of River Trusts, FRS, AFTS / DSFBS
Dates during which research will take place	1 April 2008 - 31 March 2010. Data analysis from April 2010.
Area in which research will take place	England, Wales, Northern Ireland and Scotland.

Estimated number and weight of salmon to be retained	50 fry and 50 parr per population sampled. No adults will be killed specifically for this project but samples will be taken from fish caught in the rod and net fisheries.
Resources	
Estimated cost of the research project	£120 k (total) £20 k (staff costs includes overheads)
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Miran Aprahamian Miran.aprahamian@environment-agency.gov.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	No RVs involved
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	Northern Ireland, Scotland
Summary Findings: The full report of this study can be found at: http://www.nasco.int/sas/salseamerge_documents.htm	

Project No. **Ew11** **Status** **Ongoing**

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Deriving estimates of marine survival for monitored river stocks in England and Wales**
Objective of research project	The objective of this programme is to establish 'monitored' rivers in England and Wales where estimates of marine survival can be derived for comparison with other North Atlantic stocks.
Brief description of research project	For a number of indicator stocks around the North Atlantic there is evidence that the marine survival of salmon is highly variable and is currently well below previous levels. However, until relatively recently, there were no long-term data sets for stocks in England and Wales. The project seeks to collect data in a consistent manner from year to year in order to provide a reliable time series and to allow trends to be identified. In order to provide data for different regions and thus allow for possible spatial differences, three monitored stocks have been established: the River Dee (North Wales), the River Tamar (SW England) and the River Frome (S England). All these stocks have a reasonable proportion of MSW salmon. Smolt tagging programmes have been carried out at sites on the Dee and Tamar for a number of years using rotary screw traps. This has enabled the trapping and tagging of wild fish on the main stems of these two rivers. The Tamar tagging programme did not operate in 2014 due to resource issues, but resumed in 2015. Both rivers also have facilities (counters/traps) close to the tidal limit for monitoring returning adult fish and for estimating the return rate of the tagged fish. Models have been developed which provide confidence limits around the return rate estimates. These investigations are run on a collaborative basis by Natural Resources Wales (NRW), the Environment Agency and the Centre for Environment, Fisheries and Aquaculture Science (Cefas). On the River Frome, the Game & Wildlife Conservation Trust (GWCT) are able to estimate smolt output. This is achieved through automated counting facilities, but is augmented by an extensive PIT tagging programme and a range of PIT tag detection systems that monitor fish at various locations. GWCT also operate an adult counting facility on the lower river, which enables return rate estimates to be generated. The results of all these studies are included in the annual Cefas/Environment Agency/NRW salmon stock status report and are also reported annually to the ICES North Atlantic Salmon Working Group.
Dates during which research will take place	Smolt tagging / counting takes place in spring (April-May); monitoring of adult returns takes place throughout the year. These annual monitoring programme are currently ongoing, but are subject to regular review.
Area in which research will take place	River Dee (North Wales) River Tamar (SW England) River Frome (S England)
Estimated number and weight of salmon to be retained	N/A

Resources	
Estimated cost of the research project	Approximately £150,000 per annum
Number of participating scientists	~15 – involves fishery science staff from both Natural Resources Wales and the Environment Agency; personnel from the Cefas Salmon & Freshwater Fisheries Team and researchers from GWCT.
Name and e-mail address of coordinating scientist in charge of project	Ian Davidson (Natural Resources Wales – Dee) Ian.Davidson@cyfoethnaturiolcymru.gov.uk Rob Hillman (Environment Agency – Tamar) rob.hillman@environment-agency.gov.uk Ian Russell (Cefas) ian.russell@cefas.co.uk Rasmus Lauridsen (GWCT) rlauridsen@gwct.org.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Rotary screw fish traps, coded wire microtagging equipment, in-river PIT tag detectors and smolt counting facilities, adult fish traps and fish counters.
Details of any collaborating countries	N/A

Summary of Progress:

Natural Resources Wales (NRW) have continued the programme on the Rivers Dee (North Wales) to monitor marine survival. Smolt trapping with rotary screw traps continued (at two sites), with about 300 salmon smolts tagged in 2017 (trapping was constrained by unusually low spring flows); additional sea trout smolts were also marked or tagged. NRW have also continued to operate an upstream trap on the Dee throughout the year to monitor the run of adult fish and allow return rates of tagged fish to be estimated. The trap is also used to collect additional biological information, such as the size, age and condition of the returning fish. The collaborative Environment Agency (EA) / Cefas smolt tagging programme on the River Tamar (SW England) resumed in 2015 after a one-year break (the programme is now almost exclusively run by EA). Just over 2,000 wild salmon smolts were captured and tagged in 2017, and the operation of the counting/trapping facility at the head-of-tide also continued enabling adult returns to be monitored and tagged fish identified. Plans are now being introduced on both rivers to derive estimates of the sex composition of both the smolts and returning adults; this will involve collaboration with scientists at Exeter University.

On the River Frome, GWCT continued to operate a variety of PIT tag detector systems on the river. In collaboration with Cefas, GWCT also tagged large numbers of juvenile salmon with PIT tags and operated a rotary screw trap to sample migrating smolts. The proportion of PIT tagged fish among the migrating smolts is used, together with counts of out-migrating PIT-tagged fish, to estimate the size of the smolt run. GWCT also operate counting facilities for returning adults and estimate the age split of returning adults. This combination of facilities enables annual estimates of return rates (marine survival) to be derived.

Project No. Ew12 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**The marine life of Atlantic salmon: evidence from the microchemistry of scales**
Objective of research project	1. To identify existing Atlantic salmon scale libraries in England and Wales. 2. Refine and improve existing methods to stable isotope ratios and trace elements in salmon scales. 3. Measure the stable isotope composition (C and N) from salmon scales in relation to variations in the marine environment. 4. Measure trace element compositions from salmon scales in relation to variations in the marine environment. 5. Develop a model to predict the impact of changes in the marine environment (e.g. productivity) on return rates of salmon from specific populations. 6. Assess the suitability of stable isotope and trace element analysis to understand the distribution of other keystone fish species (e.g. European eel).
Brief description of research project	The research will focus on scale microchemistry using scales from existing libraries together with scales taken from grilse and MSW salmon sampled in the ocean to develop a model to predict the impact of changes in the marine environment (e.g. productivity) on return rates of salmon from specific populations using scale microchemistry.
Dates during which research will take place	1 April 2007 – 31 March 2010
Area in which research will take place	England and Wales
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£66,709 over 3 years
Number of participating scientists	3
Name and e-mail address of coordinating scientist in charge of project	Dr Clive Trueman trueman@noc.soton.ac.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

The wild Atlantic salmon has been in heavy decline throughout its native range over the past four decades, largely due to increases in marine mortality. This research aimed to investigate potential causes of this decline using stable isotope analysis of archived scale samples, taken from returning adult salmon over the past few decades. Stable isotopes of carbon and nitrogen in marine animals, which are naturally incorporated into the tissue from diet, give information on oceanic conditions of climate and productivity experienced by the animal, along with data on the trophic level of that animal.

Initially, the aim was to identify, and catalogue if possible, salmon scale archives in England and Wales. To date 35 scale holding authorities from England, Wales and Northern Ireland were contacted with responses received from 27. Details of existing archive collections have been compiled into a database. Relatively few authorities maintain curated archives extending for more than 10 years, and we have identified the North Sea drift net (Cefas) and River Frome (EA/CEH) as the best candidate archives, giving good spatial contrast and temporal coverage. Samples from the North Sea and Frome archive are in house and analyses of these archives is complete.

Secondly, the aim was to develop sampling and analytical protocols for the scales and the mass spectrometry analysis. We optimised mass spectrometer parameters to utilise a scale mass of between 0.5mg and 0.6mg. This mass is significantly lower than sample masses used in most other stable isotope laboratories, allowing us to recover a reliable and precise isotope value from collagen laid down during the last season at sea cut from a single scale. Following optimisation of laboratory protocols, we measured the variation in isotopic composition between scales within single fish. This allowed us to determine how many scales were needed to reliably reflect the isotopic composition of a fish. We analysed multiple scales from 7 fish reared in a common tank and showed that variation between fish is significantly larger than variation within fish for both carbon and nitrogen isotopes. We are confident that a single scale provides a valid estimate of the isotopic composition of a fish within analytical error. Once this was completed, carbon and nitrogen isotopic composition was measured in the marine portion of grilse (one-sea winter) and multi-sea winter (MSW) salmon scale samples taken from the River Frome over 23 years (247 salmon analysed) and the Northeast Coast over 14 years (244 salmon analysed) to complete the third project aim. Analyses were performed on the last marine growth season, giving a retrospective record of marine conditions experienced by each fish.

A record of the changes in isotopic composition of salmon returning to the River Frome and from fish sampled in the North East Coast fishery was produced, with a separate record for fish returning after 1 and 2 winters at sea. We found that both region of origin and sea age influence the carbon isotope signal. This means that fish returning to the two regions of the UK must feed in different locations. Furthermore, fish of different sea age also feed in different areas. This contrasts with one model of salmon migration that suggests all fish of southern European origin (<60°N) share a common migration and feeding ground.

We developed a new method to predict feeding location from isotope records. Because plankton carbon isotopes are influenced by sea surface temperature, we compared the temporal record of isotopes measured in salmon scales with temporal records of sea surface temperature measured by satellite across the North Atlantic. Fish are likely to have fed in areas where these records coincide. We mapped the strength of the correlation between the two records to suggest likely feeding grounds for each cohort within the two groups of fish, with the River Frome grilse and MSW salmon respectively feeding near the shelf breaks of the Porcupine Bank and south Iceland. The Northeast Coast grilse and MSW salmon were, in contrast, feeding near the shelf breaks of the southern Norwegian Sea and the Bear Island Trench in the northern Norwegian Sea, respectively. These areas experience very different environmental and climatic conditions, which are likely to influence marine mortality. This is reflected

in the relationship between return rates and carbon isotopes, where carbon isotopes correlate with return numbers for the North East Coast fishery, but not the Frome stock.

The identification of putative feeding grounds for the River Frome and fish sampled from the Northeast Coast fishery means that these areas may be monitored remotely to determine oceanic conditions during periods of summer growth, and thereby predict, based on the mechanisms controlling individual populations, the likely strength of the returning stock on an annual basis. These maps, together with correlations between isotope data and returning numbers of fish, provide a model for predicting the impact of changes in the marine environment on return rates of salmon at a scale relevant at the population level.

The use of the isotopes as indicators of marine conditions, and the mapping approach used to identify feeding grounds within this project are both applicable to many other marine species for which tissue archives may exist. These techniques thus complete objective 6 (after removal of the trace elements part of the objective for the reason discussed above), which was to assess the suitability of stable isotope analysis to understand the distribution of other keystone fish species. Future work is likely to concentrate on mapping the distributions of other fish species than salmon, including herring, and on using the isotope signatures of marine plankton caught under known conditions to create predictive area maps for different combinations of carbon and nitrogen isotope values found in North Atlantic fish species.

Project No. Ew13 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Development and application of salmonid life cycle models**
Objective of research project	1. Undertake a review of available salmonid life cycle models to assess their suitability to apply to migratory salmonid populations in England and Wales; 2. Build on existing models and/or develop new models of salmon and sea trout life-histories to permit: – Prioritisation of factors affecting stocks in freshwater – Scaling of impacts on individuals to populations – Comparison of marine and freshwater factors affecting stocks – Comparison of the impacts of factors on stocks with different life-cycle characteristics (e.g. grilse v MSW stocks) – Comparison of anthropogenic and environmental impacts on stocks; Comparison of management regimes for salmon and sea trout.
Brief description of research project	The general objectives of the project are to develop tools to assist with the interpretation of results from a range of experimental studies on salmonids and advise policy on the prioritisation of management decisions relating to the protection, conservation, restoration and enhancement of salmonid populations and related research activities.
Dates during which research will take place	April 2009 – March 2013
Area in which research will take place	England and Wales
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£210,000 over 4 years ie £52,500 per annum
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Ted Potter: ted.potter @cefas.co.uk

Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

A review has been undertaken of life-cycle models that have been developed for migratory salmonids, with particular reference to models of UK salmonid populations and the data available to parameterise them. Various approaches have been examined, including life-history models, Leslie Matrices, individual based models (IBMs) and Bayesian models.

The Population Viability Analysis model developed by Legault (2005) to investigate the status of salmon stocks in Maine, USA has been used as a basis for developing a model that divides a salmon river stock into separate ‘populations’ within different reaches of the river. The extent of mixing between these ‘populations’ can be altered, along with mortality rates at different life stages. This therefore allows simulation of hypothetical impacts on a stock that affect mortality on limited temporal and/or spatial scales, and the model will be used to simulate the impact of various factors on salmon populations and to identify key gaps in our knowledge.

The Exposure Assessment Modelling System (EXAMS model) has been to explore the distribution of freshwater contaminants from point sources and investigate the effects that their chemical properties have on the risks that they pose to fish. These results have been utilised to parameterise the life-cycle model and investigate potential impacts of certain contaminants at a population level.

The development of sea trout life-cycle models has been investigated in conjunction with the Celtic Sea Trout Programme (CSTP) which began in 2010. Problems with obtaining consistent and reliable aging from scale reading has favoured the use of stage-based models (using weight categories) rather than age based models; weight categories may also be more meaningful in management terms. The CSTP will be completed in May 2014.

Legault, C. M. (2005). Population Viability Analysis of Atlantic Salmon in Maine, USA. Transactions of the American Fisheries Society 134:549–562, 2005

Project No. Ew14 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**The impacts of contaminants and temperature on freshwater fish populations**
Objective of research project	The main objectives of the research are to undertake further studies of the impacts of contaminants derived from intensive agriculture and aquaculture facilities on wild salmonids and investigate the implications of predicted climate change scenarios on the impacts of different sources of diffuse and point source pollution on wild fish populations.
Brief description of research project	The research will further investigate contaminants derived from or associated with freshwater aquaculture facilities and determine their effects on critical salmonid life stages particularly the transition of smolts from the freshwater to marine environments. In addition, the work will investigate the impact of the changes in flows and temperatures that may be expected under different climate change scenarios on the impacts of environmental levels of specific contaminants on biological processes regulating fish populations (e.g. reproduction and survival of diadromous fish between fresh and marine environments). Finally, the results of the work will be used to model the impact of different climate change scenarios on the impacts of specific contaminants on wild salmonid populations.
Dates during which research will take place	April 2009 - September 2014
Area in which research will take place	England and Wales
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£795,000 over 5 years i.e. £159,000 per annum
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	Dr Marta Assunção marta.assuncao@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

According to the most recent UK Climate Projections (UKCP09), water temperature in salmonid rivers in the southeast and west of England will be the most affected by the predicted increases in inland and marine air temperature by the 2050s and 2080s. These effects are expected to be associated with significantly decreased rainfall in these regions, particularly in the summer months, probably making these rivers less favourable habitats for salmonids. Changes to the river temperature and flow will be further exacerbated by the increased abstraction of water for domestic, industrial, aquaculture and agricultural uses, there will be pressure on local government and the Environment Agency to issue more abstraction licences.

Previous laboratory based ecotoxicological investigations funded by Defra have indicated that a range of agricultural and industrial contaminants found in UK rivers and coastal areas (e.g. triazine herbicides, organophosphate and pyrethroid insecticides, brominated flame retardants) can affect specific life history stages of Atlantic salmon and sea trout (e.g. reproduction, intragravel development, and pre-adaptation to sea life-smoltification). Considering the predicted changes to the freshwater environment, there is a need to assess whether, and if so how, diffuse pollution will have a more significant impact on fish physiology under these conditions. Higher water temperature could modify the toxicological effects of contaminants on fish, and if combined with reduced flows, could further concentrate the levels of contaminants and increase the residency and exposure of fish to reduced water quality. In addition, several of these river catchments, including chalk streams in southern England, receive point-source effluents from in-river fish farms and there is concern regarding the actual impact of the effluents on migratory salmonids downstream of the facilities (Cefas position paper, 2013).

The main objectives of this research were to undertake further studies on the impacts of contaminants derived from aquaculture facilities on wild salmonids and investigate the implications of predicted climate change scenarios on the impacts of different sources of diffuse and point source pollution on wild salmonid populations.

The specific aims were to:

1. Conduct further investigations to identify contaminants derived from or associated with freshwater aquaculture facilities and determine their effects on critical salmonid life stages;
1.1 Investigate and identity contaminants derived from aquaculture
1.2 Determine the impact of aquaculture contaminants on embryo and intragravel survival
1.3 Determine the impact of aquaculture contaminants on smoltification
1.4 Determine the impact of aquaculture contaminants on salmonid reproduction

2. Model the effects of diffuse and point source contaminants derived from agriculture and aquaculture on wild salmonids populations;

2.1 Model the effects of diffuse contaminants on wild salmonid populations

3. Provide an updated literature review on the predicted effects of climate change on flows and temperatures in salmonids rivers in the light of the new climate predictions detailed in UK Climate Projections (UKCP09)

3.1 Update the literature review on impacts of climate change on salmonids

4. Investigate the impact of the changes in flows and temperatures that may be expected under different climate change scenarios on the impacts of environmental levels of specific contaminants on biological processes regulating fish populations (e.g. reproduction and survival of diadromous fish between fresh and marine environments);
4.1 Laboratory studies on the impact of relevant contaminants on smoltification at elevated temperatures

4.2 Laboratory studies on the impact of relevant contaminants on olfactory sensitivity at elevated temperatures
4.3 Field studies on the impact of relevant contaminants on smolt behaviour and survival at the sea at elevated temperatures
4.4 Laboratory studies on the impact of relevant contaminants on female fecundity at elevated temperatures

5. Investigate the impact of obstructions on the biology of migratory fish in the context of increased residency within zones of high temperatures and contaminant loading

5.1 Field studies on the residency, thermal history and contaminant loading of salmonids at barriers to migration

6. Model the impact of different climate change scenarios on the effects of specific contaminants on wild salmonid populations

6.1 Model the impact of contaminants at elevated temperatures on fish populations

7. Develop water quality monitoring programmes that will address the temporal and spatial distribution of salmonid populations

8. Provide recommendations to Policy Divisions on the management of the freshwater environment within the context of the effects of the predicted increased water temperatures and reduced river flows in England and Wales.

The main findings were as follows:

Under objective 1, a field work study was carried out at an operating fish farm (Britford) in the river Avon (Hampshire), following site selection discussions with the British Trout Association. Analysis of the effluent water in the settlement ponds revealed compounds related to fish farm activities (e.g. disinfectants and pharmaceuticals) and compounds with known toxicological effects to fish (e.g. phthalates and phenols) that were not present in the water abstracted from the river. The screening of the abstracted water also indicated a large variety of other pollutants present in the lower Avon (from pesticides to flame retardants) which are also known to affect fish physiology and behaviour, including in salmonids. These results indicate the need for longer term assessments of the effluents from operating fish farms in order to establish seasonality in compound presence and concentration ranges. A controlled study was carried out by exposing salmonids in experimental tanks to water abstracted to the farm or to the effluent from the settlement ponds. Our results showed a degree of osmotic imbalance in Atlantic salmon smolts after transfer to saltwater, but with no associated mortalities and no significant effects of effluent on maturing female brown trout or subsequent egg survival and development. Therefore the impacts of the effluents on wild salmonids below the outlets of the Britford farm, under normal river conditions, are likely to be low. Britford however, is one of three operating fish farms abstracting and discharging into the Lower Avon. However, our results indicate that there is a need to analyse the effluent from all the main operating fish farms along the upper and Lower Avon in order to obtain a complete picture of the water quality of the river and tributaries, on a seasonal basis.

Using the UKCP09 climate projections tool, future climate scenarios were generated for UK river catchments and the potential effects of temperature and flow changes on sensitive life stages of salmonids was assessed (Objective 3). This was used to inform the laboratory studies carried out to assess how the toxicity of some of the pollutants found in UK rivers and coastal waters will affect different sensitive life stages of salmonids under increased water temperature conditions (Objective 4). Overall, our results show that the effects of a particular contaminant at environmentally relevant concentrations, and increases in water temperatures up to 4-5ºC above ambient, can vary depending on the life cycle stage. As an example, a similar exposure time and concentration to a flame retardant found in UK rivers, tributyl phosphate, had significant sub-lethal effects on the osmoregulatory ability of Atlantic salmon smolts, but not on maturing adult brown trout or subsequent egg survival and development. A 4-5ºC increase in water temperature however, resulted in transitory osmoregulatory imbalance in salmon smolts but impaired oocyte development in maturing female brown trout, resulting in significant mortality during egg fertilization and development. By applying a salmonid life cycle model (Objective 6), we established that the egg mortality resulting from the exposure of maturing females to a 4ºC increase above ambient water temperature would significantly reduce the stock size of the salmonid population, in particular if returning adult losses were operating (e.g. fisheries). This modelling exercise provides valuable information, however it may underestimate the total impact to the stock. The sub-lethal effects observed in Atlantic salmon smolts (Objectives 4.1 and 4.3) and mature parr (Objective 4.2) are likely to play a part in the fish fitness and quality, with potential consequences to the overall population.

By applying a non-lethal technique, we have also established that adult salmonids returning to the river Tees have measurable levels of persistent organic contaminants in their bodies, potentially resulting from accumulation via the food chain (Objective 5). Whether increased estuarine residence, due to the presence of the barrage, contributed to the contaminant uptake and decreased the fish fitness needs to be further investigated. Developing the use of adipose fins to assess body contaminant load of returning adults (with known origin and sea feeding grounds) could provide a means to discriminate between coastal and open sea sources of contamination, and also to infer the fitness of returning adult fish and possible impacts on reproductive ability.

The results from the experimental work carried out in this project highlight the complexity of assessing contaminant exposure in migrating salmonids under changing environmental conditions. The modelling exercise under objective 2 showed how river flow, water temperature and suspended sediments during spring and winter can affect the dispersion and persistency of different types of contaminants in a river system. As shown in objective 1.1, several types of contaminants were found in the river Avon (Hampshire), probably originating from known sources (sewage treatment plants, water cress and fish farms and animal rearing). Whereas individual contaminant analysis is impractical from a catchment management perspective, tools like EXAMS can be applied to assess the distribution of compounds with contrasting water solubility in the water column and sediments. This could form a basis to advise managers on seasonal mitigation measures in order to minimise impact for salmoinds during sensitive life stages

More comprehensive and targeted monitoring programmes are required in salmonid catchments. These should incorporate the seasonality of environmental stressors and parameters (e.g. water temperature and flow changes together with land use, e.g. effluent discharge of multiple fish farms and seasonality of pesticide use) and be assessed in relation to salmonids presence in the catchment (Objectives 7 and 8). Modelling approaches (river water quality and hydrology) are currently being applied to salmonid catchments, and the scenarios generated being related to salmon abundance indexes, with the view of identifying the seasonality of key parameters potentially contributing to regulate populations (water quality parameters, flow and temperature). Furthermore, this approach will assess how predicted changes in land use and climate will influence these key parameters (Defra SF0268-A modelling toolkit to assess present and future multiple stressors in salmonid rivers: the Tamar case study). This integrated catchment approach is necessary to inform regional River Basin Management Plans and contribute to the Defra Catchment Based Approach policy framework in relation to salmonid-bearing catchments.

Project No. Ew15 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Impacts on juvenile salmonid populations from a changing freshwater environment**
Objective of research project	The overall aim of the research programme is to investigate how predicted changes within the freshwater environment might impact upon juvenile salmonid populations and how changing conditions during the early life history stages of the fish may influence their behaviour and subsequent survival within the marine environment. The aim will be to better understand the potential changes to the characteristics of salmonid populations in order to better manage and conserve stocks within a dynamic environment. The research will principally focus on specific factors within the freshwater environment that are considered to directly impact upon specific life-history strategies of juvenile salmonids, regulate production, and modify the fitness of emigrating smolts.
Brief description of research project	The research project will examine the following areas of concern to salmonid populations: 1. Determine the ecological drivers within freshwater that affect the propensity for wild juvenile salmon to migrate downstream in the autumn. 2. Determine whether there are changes in the relative number of adult returns derived from autumn and spring migrating juveniles over time, and the geographic significance of the autumn migration. 3. Determine the impact of assessment techniques on wild salmon smolt physiology and subsequent adult return rates. 4. Assess the impact of changes within the freshwater environment on smolt “quality”, biological characteristics and survival in the marine environment. 5. Determine the impact of diffuse artificial light pollution on salmonid fry emergence and smolt migratory behaviour. 6. In 2013, Defra requested that Cefas also convene an Expert Workshop on Small Streams.
Dates during which research will take place	April 2009 - February 2015.
Area in which research will take place	England and Wales
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£903,000 over 5 years ie £180,600 per annum
Number of participating scientists	12
Name and e-mail address of coordinating scientist in charge of project	Bill Riley: bill.riley@cefas.co.uk

Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A

Summary of Findings:

1. Determine the ecological drivers within freshwater that affect the propensity for wild juvenile salmon to migrate downstream in the autumn.

Whilst most juvenile Atlantic salmon (*Salmo salar* L.) parr are thought to remain in their natal streams until the spring, when they become smolts and migrate to the sea, an early downstream movement of parr has been recorded during the autumn by Passive Integrated Transponder (PIT) tag detection systems in England and Wales on the R. Frome, R. Itchen & R. Ceiriog. Recent results on the R. Frome have demonstrated that the autumn migration of parr can be as large as the number of smolts in the spring. Physiological parameters known to be important in the salmonid parr-smolt transformation suggest that autumn parr migrants, and those fish which subsequently reside in the estuary during the winter months, are not sufficiently physiologically adapted to permit permanent, or an early, entry into saltwater. Subsequent monitoring of PIT tagged adult returns has confirmed that a proportion of autumn migrating parr survive and contribute to the adult stock. However, the ecological driver(s) for this autumn migration and the reasons for the marked variability between years are unknown.

To investigate this, over three years 32444 PIT tagged Atlantic salmon parr on R. Frome were assigned to one of three groups: non-migrants, autumn migrants and spring smolts depending on detection and the timing of detection at downstream PIT tag detection systems. We examined the effect of parr density at the time of tagging, distance upstream from the tidal limit, fish length, Fulton condition index, habitat type, days after 1 September that each fish was tagged and year on the proportions of fish in each of the migration groups.

Distance upstream from tidal limit was: strongly negatively related to the proportion of autumn migrants, consistent with a general downstream shift in the population, or a re-distribution of parr rather than a targeted migration to the tidal reaches of the river; and positively related to the proportion of spring smolts, in spite of a likely greater mortality rate experienced by migrating greater distances. We therefore conclude that over-wintering survival of Atlantic salmon parr is greater in the upper reaches of the river than in the middle or lower freshwater reaches, adding weight to the need to ensure that adult salmonids can reach the uppermost reaches of spawning tributaries. The management implications of this are that both partial and complete barriers to migration should be removed and that where possible in regulated rivers, flows are appropriate at the right times of year to facilitate passage upstream by adults. Confining adults to the lower reaches of a river with weirs, hatches, dams and an inappropriate flow regime, may result in lower survival of parr over their first winter and consequently lower freshwater production. Both autumn migrating parr and spring smolts were larger than those fish that did not migrate, and the size of parr had no effect in determining whether any individual was detected as an autumn migrant or a spring smolt. Neither was there any impact of parr density on the proportion of fish that became autumn migrants. Therefore, the results of this study do not support the hypothesis that the movement is initiated by dominance/ subordination, or by crowding or resource competition for space or cover. However, we did observe that a higher proportion of parr, tagged in the main river channel became autumn migrants than parr from the smaller flood relief channels. There were no such differences for those fish observed as spring smolts. This suggests that there are attributes of local habitat that do have an effect on the movement of parr in the autumn. These observations could either occur because a lower proportion of parr undertake downstream migration, perhaps in response to a greater availability of over-wintering habitat in the smaller flood relief channels or that they migrate a shorter average distance. Interestingly, there was also some evidence that parr destined to become autumn migrants underwent a lower mortality rate during the month of PIT tagging than those destined to become spring migrants indicating possible physiological or behavioural differences between these two groups of fish at that time. Despite being unable to distinguish between the two groups on the basis of size or condition this raises the possibility of the existence of some other physiological or behavioural attribute, of subsequent autumn migrants, that is not shared with the spring smolts. Clearly the factors that drive individuals to undergo this autumn migration needs more study at the individual level if we are to gain a better understanding of its manifestation.

2. Determine whether there are changes in the relative number of adult returns derived from autumn and spring migrating juveniles over time, and the geographic significance of the autumn migration.

To achieve this we had hoped to use evidence from the microchemistry of scales (analysed using laser ablation–inductively coupled plasma–mass spectrometry) held in our archives. However, without a clear pattern emerging using this technique for scales sampled from parr residing throughout the R. Frome catchment (upper freshwater reaches to tidal reaches with fluctuating salinity) it appears unlikely that this technique will be effective.

However, we were able to obtain gill samples from autumn migrating salmon parr caught at Pont Scorff (at the tidal limit of the R. Scorff) a spate river in Brittany, France during October & November 2013. These samples were analysed and compared to samples taken from river resident parr caught in the upper freshwater reaches of R. Scorff in late November 2013. Physiological parameters (gill Na+K+ ATPase activity) known to be important in the salmonid parr-smolt transformation suggest that these autumn parr migrants were not sufficiently physiologically adapted to permit entry into saltwater, thus confirming previous findings for autumn migrants on R. Frome.

With an early downstream movement of Atlantic salmon (and other salmonid species) parr during the autumn recorded in many populations in both North America and Europe, and more recently in the Baltic, it now seems likely that this is a common life history strategy manifest in many, if not most, Atlantic salmon populations. This has important implications for fisheries managers, and catchment scale management plans, which should recognise the tidal reaches as important juvenile salmon habitat, and managed and protected them accordingly. Furthermore, stock-monitoring programmes that do not account for autumn migrations to the lower river/ tidal reaches, or any inter-annual variation in their abundance, will under-estimate total smolt output, with a consequential under-estimation of marine mortality, and confound the interpretation/comparison of marine mortality and return rates.

3. Determine the impact of assessment techniques on wild salmon smolt physiology and subsequent adult return rates.

The decline in Atlantic salmon stocks in the North East Atlantic has been partly attributed to poor survival in the marine environment. As a result, the marine survival of Atlantic salmon is being monitored in a number of rivers, and estimates of return rates are reported annually to the International Council for the Exploration of the Seas (ICES). One technique that is widely used to study marine survival of salmon is the capture and tagging of migrating smolts, thus allowing the subsequent assessment of this tagged cohort on return to freshwater. However, it has been reported that assessment methodologies that utilise such techniques may have a negative effect on fish behaviour and survival. Improving our understanding of the potential impact of capture and tagging techniques on the subsequent survival of smolts is important in the context of utilising marine survival estimates in management. Therefore, this investigation assessed the impact of trapping, handling, anaesthesia and tagging (using Coded Wire Tags; CWT) on Atlantic salmon smolt physiology, migratory behaviour/ timing, and subsequent adult return rates.

Migrating wild smolts trapped and held for 1 h post-capture exhibited a highly significant stress response compared to a control group. Similarly, hatchery-reared smolts subjected to a handling/ tagging procedures exhibited an acute stress response, but not a chronic stress response. However, there were some mortalities in the fish that had undergone a handling or tagging procedure after transfer to saltwater, and those which died had all exhibited a higher stress response throughout the experimental period than those fish that survived. Variation in the response to stress is an individual trait that has been shown to be stable over time with a degree of heritability. It may be that the fish that died after transfer to saltwater exhibited a natural 'high-response' to stress and that this meant they were less able to cope with the additional stressors of handling/tagging as well as the subsequent saltwater transfer. In a separate investigation, variation in the response of individual smolts was also apparent on post-tagging migratory behaviour, where the process of interception, anaesthetisation, handling and tagging (CWT) of wild salmon smolts significantly altered the migratory behaviour of some individuals compared to that of a control group. The functional significance of this difference between individuals is currently unknown. Previous studies have suggested that smolt downstream migratory behaviour is a predator avoidance tactic. Therefore, any disruption to this pattern of movement may increase the rate of predation in this proportion of the population. Further studies are recommended which examine individual variability in stress responses.

To evaluate the impact of assessment techniques on subsequent adult return rates, approximately 10,000 wild Atlantic salmon parr were captured each September throughout the R. Frome catchment (2005 to 2011, inclusive), PIT tagged and released back to their site of capture. During the following springs (2006-2012), PIT tagged smolts were intercepted, anaesthetised, adipose fin-clipped, tagged (CWT), and returned to the river. PIT-tagged smolts that successfully migrated downstream without being re-captured, but that were detected using PIT antenna arrays, were used as the control group. Differences in the survival between the experimental CWT fish and the control population were determined based on the detected adult return rate (using PIT antenna arrays) of the two groups.

Compared to control smolts, capture and CWT tagging of experimental smolts affected detected return rates only under certain conditions, with a decreased return probability for smolts caught and tagged following mild winter river temperature anomalies and during the night. Similarly, analysis of the experimental smolts revealed that capture and CWT tagging following mild winters decreased their probability of return as adults. There were also marginal positive effects of length at PIT tagging as parr, and length at CWT tagging as smolts, on individual probability of return as adult. The results support the hypothesis that the impact of procedures involving the capture and tagging of migrating wild *S. salar* smolts will vary with the circumstances under which they are performed. The implications of the findings were considered in the context of ongoing investigations to derive and report marine return rates for *S. salar* in support of national and international stock assessments, and in developing best practice.

4. Assess the impact of changes within the freshwater environment on smolt "quality", biological characteristics and survival in the marine environment.

During the parr-smolt transformation juvenile salmonids undergo significant changes in their morphology, physiology and behaviour that enable them to move out of freshwater and survive in the sea. However, in order to successfully complete the initial marine migration the smolts need to have not only physiologically adapted to the sea but also need to have laid down sufficient energy reserves within the freshwater environment. Growth and condition of the smolt prior to the marine migration is therefore likely to affect survival in the early months in the sea, and conditions during freshwater life history might be expected to be critical in regulating early marine stages. However, very little is understood regarding how conditions within the freshwater environment affects the "quality" of the smolt and what the minimum requirements in terms of growth and lipid reserves are for successful migration. Therefore, this objective focused on the relationship between conditions in freshwater, growth & size, run timing, smolt physiology & 'quality' and subsequent survival of fish within the marine environment. We used: stable isotope analysis of archived scales samples from emigrating smolts to determine whether there are any signals which may be used to relate historic productivity within the freshwater environment to the subsequent successful return of adult salmon; physiological sampling to determine whether certain variables vary with run timing, and to explore the possibility of developing an indicator of salmon smolt "quality''; and the size, origin, and migratory history of individually PIT tagged wild salmon parr/ smolts subsequently detected returning as adults to determine whether morphological characteristics or behaviour patterns displayed in the juvenile stage appear to influence survival to adult.

Preliminary work suggests potential for the analysis of the stable isotopic composition of smolt scales as a predictor for successful recruitment of grilse to the spawning population. It is recommended that additional scale samples are collected and anaysed to increase the number of years in the datasets, to strengthen the statisical analysis.

Standard statistical methods and Bayesian networks were used to investigate relationships between physiological variables. Standard methods showed some unexpected correlations in actively migrating smolts, such as significant positive correlations between: smolt size and gill ATPase activity which could suggest a physiological advantage for larger smolts entering saltwater; and plasma protein concentration and time of day. The Bayesian networks suggest a lower condition factor, higher fat/ oil content, higher plasma protein concentration and gill ATPase activity as the smolt run proceeded. All indicative of later run smolts being further advanced in the physiological and morphological smoltification process. Decreasing carbon and nitrogen stable isotope values suggest a varying source (river stretch or habitat) for the smolts as the run developed.

On the R. Frome, returning Atlantic salmon adults were longer ($p=0.003$) and heavier ($p=0.20$) at tagging as parr than those fish that did not become adults. Fish measured as spring smolts that returned as adults were also longer and heavier at than those that did not return, although neither was a significant factor ($p>0.05$). No river stretches produced more adult salmon than other sites. However, more adults returned from parr that were tagged higher up the catchment ($p=0.005$), which concurs with the higher survival of fish higher up the catchment to the spring smolt stage (see Objective 1). Return to adult stage was not affected by time of day smolts migrated ($p=0.52$). However, spring smolts were much more likely to return as adults than autumn migrants ($p<0.001$). This is probably due to the earlier detection of autumn migrants and therefore the additional time over which mortality can take place. More work needed here to determine whether mortality in estuary is more or less than in the river (see Objectives1 & 2).

5. Determine the impact of diffuse artificial light pollution on salmonid fry emergence and smolt migratory behaviour.

There is growing concern regarding the impact on ecosystems of increasing levels of artificial night light. By far the largest part of artificial external lighting outside city centres is public road lighting. The most numerous current type of street light in the UK emit light that is narrowly concentrated in the longer wavelengths of the visible spectrum, appearing yellow or orange to the eye. However, nearly one third of the UK's stock of 7.4 million street lights is currently scheduled for replacement. Replacement lights emit considerably more light across the visible spectrum especially at shorter wavelengths, providing superior colour rendering for human vision. However, these more naturalistic whiter lights could lead to significant changes in the impact of artificial light on natural systems, particularly aquatic ecosystems where penetration through water will be increased. Moreover, there is growing concern regarding how anthropogenic freshwater stressors might interact with each other and that the effects of artificial night light may be confounded with other urban stressors making it difficult to determine the role it has played in declines in freshwater biodiversity and ecosystem functioning. In this investigation, we compared the timing of Atlantic salmon fry dispersal from incubators in an aquarium, and the migratory timing and behaviour of wild Atlantic salmon smolts leaving their natal stream, under control and ecologically relevant street-lit conditions.

Fry dispersal occurred days later ($p < 0.001$) and on average fry were significantly ($p < 0.001$) smaller at dispersal in the incubators exposed to the modern street lighting. There were also notable disruptions to the diurnal pattern of fry dispersal with the mean time of fry dispersal occurring significantly ($p < 0.001$) later in the night and with many more fry dispersing during the hours of daylight in the incubators exposed to modern street lighting.

The migratory timing and behaviour of wild Atlantic salmon smolts leaving their natal stream was determined using PIT antenna systems at a study site on R. Itchen. Experiments compare the downstream migration of smolts under natural control conditions with two years when the exit to the study site was subject street-lit conditions every alternate night. Migration of smolts under control conditions was significantly ($p < 0.01$) correlated with sunset. By contrast, street lighting resulted in the timing of migration being random with respect to time of day. Furthermore, migration of smolts was significantly ($p = 0.01$) correlated with the time of sunset for fish migrating on nights when the lamp was off, but random ($p = 0.36$) when the lamp was on.

Clearly, the presence of modern street lighting had a significant impact on the timing and behaviour of Atlantic salmon fry dispersal in an aquarium and wild smolts migrating from their natal stream. As both are suggested to be predator avoidance tactics, any alteration or disruption by street lights may have significant impacts on recruitment in the population, the strength of a cohort, and ultimately the size fluctuations of entire populations. Recent studies have reviewed management options and developments for reducing the ecological consequences of artificial night light. Given the relatively low artificial night light intensities shown to disrupt the dispersal of Atlantic salmon fry and smolt migratory behaviour in this investigation preventing areas from being artificially lit may turn out to be the only effective option. However, more systematic investigation is needed to determine the light intensities at which broader spectrum street lamps do not affect animal behaviour. The spatial area over which these levels of artificial night light might pose a problem should then be modelled, and carefully designed investigations conducted to determine the interaction between artificial night light and other anthropogenic threats to freshwater ecosystems. Such information could then be used as a management tool to identify sites where potential problems may exist to provide evidence-based information to guide the replacement of street lamps to lessen impacts on natural systems.

6. Convene an Expert Workshop on Small Streams.

An Expert Workshop on Small Streams: to highlight the contribution that small streams make to river basin ecosystems, identify current/ emerging policy priorities, summarise key evidence gaps to inform future programmes of research, and brief Defra Policy Leads, was held over 2 days at Defra on 10th & 11th September 2014.

Since then an Expert Group on Small Water Bodies (SWBs) has been established which holds bi-annual meetings. The Group are in the process of finalising a multi-disciplinary review paper on SWBs with a focus on improved management and options for restorative action (key stressors/ wins) from the perspectives of the experts on the Group. This is a scientific review, structured to be accessible to managers, policy makers & stakeholders, but also intended to inform the uncertain policy landscape as a result of BREXIT and/ or the WFD review process. Cefas are leading on the development of this manuscript which we hope to submit to the journal 'Science of the Total Environment' by mid- 2018.

Project No. Ew16 Status: Ongoing

Party or relevant jurisdiction	European Union - UK (England and Wales) (Northern Ireland) and (Scotland)
Title of project	**Impacts of in-river hydropower production on migratory fish**
Objective of research project	The research project will examine the cumulative effects of freshwater hydropower schemes on habitat connectivity within river basins and on the migratory behavior and survival of Atlantic salmon and European eels, and assess potential effects at the fish population level.
Brief description of research project	The research will use both laboratory and field based techniques to examine how possible delays to the seaward migration of salmonid smolts as the result of in-river renewable energy schemes may compromise the fish once they enter the sea. Further work will examine whether any mechanical damage caused to emigrating smolts as the result of passage through the turbines also results in physiological changes that compromise survival during entry into the marine environment. The results of the work will be incorporated into life cycle models (Project N. EW13) to assess the potential impact of renewable energy schemes at the population level.
Dates during which research will take place	1 June 2012 – 31 March 2018.
Area in which research will take place	Rivers in England (e.g. Frome and Ribble)
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£504,000 i.e. £168,000 per annum
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Dr Andy Moore: andy.moore@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A

Summary of Progress:

The field and laboratory based research has now been completed and the analyses of the results are on-going.

Project No. Ew17 Status: Ongoing

Party or relevant jurisdiction	European Union - UK (England and Wales) (Northern Ireland) and (Scotland)
Title of project	**Estuarine habitat requirements and distribution of diadromous fish**
Objective of research project	The research project will examine the residency and habitat preferences of migratory fish within estuaries and assess the impact of construction and operation of man-made structures on the migratory behaviour and survival of key diadromous fish species as they move between the marine and freshwater environments.
Brief description of research project	Estuaries are considered to be the most impacted and at risk ecosystems in the UK. They are the transition zones through which many economically important or endangered migratory fish (e.g. salmonids, eels, shad, lamprey) must pass to reach suitable feeding or spawning areas. However, the behaviour, distribution and habitat utilization of many key diadromous species as they migrate between freshwater and the sea is poorly understood as is the potential impact of modification to the environment as part of infrastructure developments (e.g. port facilities, renewable energy schemes). The proposed research will examine the distribution, residency and behaviour of key migratory fish during their transition between freshwater and the marine environment and quantify the potential impact of noise and light from estuarine constructions and structures. Experimental work will involve the application of advanced fish capture, marking and telemetry techniques to map the migratory pathways and residency of migrating salmon, shad and eels during their migration between freshwater and the marine environments. Field based research will determine the impacts on the physiology and behaviour of fish in relation to man-made light produced by structures, and piling activity and additional noise generated by construction within the transition zone.
Dates during which research will take place	1 October 2012 – 31 March 2017
Area in which research will take place	Estuaries and coastal waters in England and Wales
Estimated number and weight of salmon to be retained	N/A

Resources	
Estimated cost of the research project	£299,988 i.e. £100,000 per annum
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Dr Andy Moore: andy.moore@cefas.co.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	N/A
Summary of Progress: The research has been completed and the Report has been submitted for external review.	

Project No. Ew18 Status: Completed

Party or relevant jurisdiction	European Union - UK (England and Wales)
Title of project	**Genetic stock identification of salmon caught in the Faroes fishery**
Objective of research project	The overall aim of the project was to provide the basis for assigning potential catches in a fishery at Faroes to their regions of origin in the NEAC area. The specific objectives are: • To catalogue the scale samples collected from salmon caught in the Faroes fishery between 1984 to 2000; • To identify a selection of scales that will best represent the likely stock composition during a baseline period or periods; • To use the Genetically-based Regional Assignment of Atlantic Salmon Protocol (GRAASP) to provide country/region of origin assignments for the selected scales; To report to NASCO and ICES on the results of the study, the estimated changes in stock composition in the Faroes area within the fishing season and over time and how the finding can be used in the provision of catch advice for the NEAC area.
Brief description of research project	Scales taken from salmon caught in the Faroes fishery between 1983 and 1993 will be genetically typed by the Institute of Marine Research, Bergen, Norway, led by Vidar Wennevik, using an ABI3730XL 48 capillary system. The GRAASP genotypes will be used by the Marine Scotland Genetics Unit at the Freshwater Fisheries Laboratory, led by John Gilbey, to provide regional assignments to SALSEA Level 1- Level 4 groupings. The results of the assignment will be used in further developing the risk based framework for the provision of catch advice for the NEAC, led by Ted Potter, Cefas.
Dates during which research will take place	September 2012 - April 2015 (project extended due to genotyping problems)
Area in which research will take place	Laboratory/desk based studies in Norway and UK, based on samples collected in Faroes salmon fishery
Estimated number and weight of salmon to be retained	Nil
Resources	
Estimated cost of the research project	£37,500
Number of participating scientists	6
Name and e-mail address of coordinating scientist in charge of project	Ted Potter ted.potter@cefas.co.uk

Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	See project description above.
Details of any collaborating countries	UK(England and Wales) UK(Scotland) Norway Faroe Islands

Summary of Findings:

Approximately 750 samples were selected from each of two periods comprising the 1983/84 and 1984/85 fishing seasons and the 1993/94 and 1994/95 seasons, with scales being selected from all months in which samples were collected. DNA from the samples collected in the 1980s was found to be severely degraded, with most of the longer microsatellite alleles failing to amplify. These samples could not therefore be used to determine the origin of the fish, and the analysis had to be based upon the later period. Adequate DNA was extracted from 656 scale samples collected during the two fishing seasons, 1993/94 and 1994/95. The samples were assigned to their region of origin by comparing at least 11 (and up to 14) microsatellites markers to a baseline established from 467 site locations, in 284 rivers responsible for ~ 85% of the non-Baltic European salmon production.

Genetic exclusion analytical techniques and conformation analysis identified 5.7% of the 1SW fish and 20.5% of the MSW fish as being of North American continental origin. The remaining, European fish were assigned to northern Europe, southern Europe and Iceland and these proportions were scaled to the distribution of commercial catches in the Faroes fishery in an average season between 1983/84 and 1990/91. This analysis indicated that about 84.2% of the 1SW fish and 20.9% of the MSW fish were identified as coming from southern European (UK and Ireland, France and Spain), 9.0% of the 1SW fish and 58.0% of the MSW fish from northern Europe (Russia, Finland, Norway and Sweden) and 1.2%of the 1SW fish and 0.6% of the MSW fish from Iceland. Despite the relatively small sample sizes, the results were consistent between months/seasons (Nov to April in 1993/4 and 1994/5). Sample sizes were too small to split the northern and southern European components by country/region, although the more detailed genetic assignments suggested that these compositions were broadly consistent with the relative pre-fishery abundance (PFA) of stocks in these areas.

Results of the study have been presented to the ICES Working Group on North Atlantic Salmon and to NASCO's International Atlantic Salmon Research Board and were incorporated into the assessment of salmon stocks in the North East Atlantic and the catch advice for the Faroes fishery in 2015 (ICES(2015).

Project No. Ew19 Status: New Project

Party or relevant jurisdiction	England (European Union) and France (European Union)
Title of project	**SAlmonid MAnagement Round the CHannel project (SAMARCH)**
Objective of research project	SAMARCH 2017 –2022 will provide new transferable scientific evidence to inform the management of salmon and sea trout (salmonids) in the estuaries and coastal waters of both the French and English sides of the Channel. It will provide new information to further improve the models used in England and France to manage their salmonid stocks.
Brief description of research project	There are four technical work-packages (WP T), a summary of their aims are:- • Technical WP T 1, uses acoustic tracking technology to follow sea trout and salmon smolts through the estuaries of the rivers Frome, Tamar, Scorff and Bresle in the spring of 2018 and 2019 to apportion the mortality rate of smolts between the estuary and the sea. Using both acoustic and data storage tags in sea trout kelts in the Frome, Tamar and Bresle in the winters of 2017 and 2018, to track their movements through the estuary and around the coast. • Technical WP T 2, collects samples of juvenile brown trout from rivers in northern France and the south of England and adult sea trout across the Channel to build a common genetic data base of trout and sea trout to facilitate the identity of the river of origin of sea trout caught at sea. Genetic analysis to identify the sex of large numbers of juvenile and adult salmon and sea trout will feed into models used in the UK and France to manage salmonid stocks. To develop a transferable map based on sea scape in the Channel area to predict which coastal areas are important for sea trout. • Technical WP T 3, involves collecting data on the marine survival of salmonids and modelling this and historic data from the five Index rivers to develop a predictive model for the abundance of returning salmonids. Analysing large numbers of historical adult salmonid scales for changes in growth rates and sex ratio over time and assessing the fecundity of salmonids; these will all feed into the models used to manage salmonid stocks in England and France. • Technical WP T 4, will be used to ensure the results produced by the project inform, improve and develop new policies for the management of salmonids in estuaries and coastal waters. It will engage with stakeholders in both England and France and further afield to maximise the impact of the results generated by the project
Dates during which research will take place	2017-2022
Area in which research will take place	Although the project involves working on a number of rivers in the Channel area, the majority of the data collection and research will

	focus on the five salmon and sea trout “Index” rivers in the Channel area. These are the rivers Frome and Tamar in the south of England and the Scorff, Oir and Bresle in northern France.
Estimated number and weight of salmon to be retained	-
Resources	
Estimated cost of the research project *Details of the full economic costs of each study are requested, including staff costs, equipment and overheads. For collaborative projects, a breakdown of costs between public and private partners is requested.*	SAMARCH is a five-year project with a budget of **7.8 M€** which is part funded (**69%**) by the EU’s France Channel England Interreg Channel programme
Number of participating scientists	**Lead Partner: Game & Wildlife Conservation Trust (UK)** • Institut National de Recherche Agronomique (France) • Agrocampus Ouest (France) • Agence Française pour la Biodiversité (France) • Normandie Grands Migrateurs (France) • Bretagne Grands Migrateurs (France) • University of Exeter (UK) • Bournemouth University (UK) • Environment Agency (UK) • Salmon and Trout Conservation (UK)
Name and e-mail address of coordinating scientist in charge of project	The project manager is Dylan Roberts droberts@gwct.org.uk office 01550 777 910 mobile 07968 586 538
Details of research vessels, e.g. name, registration, call sign and description of vessel	-
Type and amount of gear and other equipment to be used	acoustic tracking technology historical adult salmonid scales
Details of any collaborating countries	-

Project No. Ni1 Status: Completed

Party or relevant jurisdiction	European Union – UK (Northern Ireland) and Republic of Ireland (Loughs Agency is a statutory cross-border body).
Title of project	**Development of conservation limits, pre-fishery abundance and management of the Foyle salmon fishery**
Objective of research project	To build upon the existing Foyle salmon management system, to develop it into a precautionary catch advice framework that fully takes account of biological data on stock abundance and which fulfils all the main requirements of the Precautionary Approach.
Brief description of research project	To strengthen the basis of the existing in-season management system, by revising the conservation requirements, estimating abundance of cohorts before any fishing takes place and by providing explicit assessment of the uncertainties and risks involved in management decisions on safe levels of catches.
Dates during which research took place	October 2005-October 2008
Area in which research took place	Foyle area, Ireland
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	£125,000 over three years (£41,700 per annum) Staff £110,000 Equipment £15,000 (funded by Loughs Agency)
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Dr. Patrick Boylan p.boylan@loughs-agency.org
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	N/A
Details of any collaborating countries	This is a collaborative project between Loughs Agency (ROI and N Ireland – cross-border Agency), AFBNI (N Ireland), Marine Institute (ROI), Institute National de la Recherche Agronomique (INRA) (France) and the University of Glasgow (Scotland)
Summary of Findings: Preliminary models have been developed. Conclusions not yet available. This work is being further developed under the auspices of the IBIS Project (www.loughs-agency.org/ibis)	

Project No. Ni2 Status: Ongoing

Party or relevant jurisdiction	European Union – UK (Northern Ireland)
Title of project	**The marine survival of Atlantic salmon from the River Bush, Northern Ireland**
Objective of research project	Investigate factors influencing the survival at sea of salmon smolts migrating from the River Bush until their return as adult salmon
Brief description of research project	This long-term project centres on enumerating numbers of migrating wild smolts and returning adults to the River Bush, by means of trapping facilities, in order to assess return rates and maturation schedules. A programme of microtagging hatchery-origin smolts provides detailed information on exploitation levels and patterns in coastal and distant-water fisheries. Run-reconstruction modelling provides information on return rates to Irish homewaters, which provides an index of natural survival at sea.
Dates during which research will take place	Started in 1973. Project ongoing 2017.
Area in which research will take place	River Bush, N. Irish/Irish coastal waters and distant-water fisheries.
Estimated number and weight of salmon to be retained	None retained, as tag recovery based on already-captured fish. Tagged adults at River Bush retained alive as broodstock for hatchery programme.
Resources	
Estimated cost of the research project	Total annual cost: £260,000 Breakdown: Staff £233,500 Consumables £6,500 Travel and Subsistence £10,000
Number of participating scientists	2 project scientists and 3 technical staff
Name and e-mail address of coordinating scientist in charge of project	Dr. Dennis Ensing dennis.ensing@afbini.gov.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	EU Republic of Ireland (tag recovery programme)

Summary of Progress:

The marine survival project continues to provide annual metrics on marine survival of River Bush wild and hatchery-origin salmon. These data are made available to ICES. The River Bush programme involves the Coded-Wire-Tagging (CWT) of wild and hatchery-origin smolts and provides detailed annual information on exploitation levels and patterns in coastal and distant-water fisheries.

Project No. Ni3 Status: Completed

Party or relevant jurisdiction	European Union – UK (Northern Ireland) and Republic of Ireland (Loughs Agency is a statutory cross-border body)
Title of project	**Investigating the movement and mortality of Atlantic salmon in the Foyle from river to sea**
Objective of research project	To establish movement and potential for loss of smolts in their riverine migration and early marine phase
Brief description of research project	Thirty nine salmon smolts acoustically tagged in 2013 and 20 acoustically tagged in 2014. These were monitored downstream using VR2 receivers out to where they exited the sea lough and entered the North Atlantic
Dates during which research will take place	April/May/June 2013 and 2014. Project will conclude when Ph.D thesis submitted in 2016.
Area in which research will take place	Foyle catchment and L Foyle to where it entered the North Atlantic
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	The IBIS Grant is approx. £6mstg, it is not possible to fully apportion the costs to this particular study at this stage.
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Dr Patrick Boylan patrick.boylan@loughs–agency.org
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	20 Vemco VR2 receivers
Details of any collaborating countries	University of Glasgow Scotland

Summary of Findings:

Project Ni3 Investigating the movement and mortality of Atlantic salmon in the Foyle from river to sea was part of a PhD study under an EU INTERREG IV programme and is complete. This study acoustically tagged 59 salmon smolts over two years in the upper reaches of the Foyle and monitored their movement downstream. Findings would suggest that there was good survivorship in the river and tidal reaches but between entering the lower tidal / sea lough and when they left the sea lough there was a significant loss. Further work is needed to investigate this in more detail. A more in-depth summary of this work can be given once the PhD has been awarded.

Project No. Ni4 Status: Ongoing

Party or relevant jurisdiction	European Union – UK (Northern Ireland)
Title of project	**COMPASS** (Collaborative Oceanography and Monitoring for Protected Areas and Species)
Objective of research project	Tracking sea-trout and salmon movement in the near shore marine environment
Brief description of research project	Sea trout (Smolt, finnock and adults) and Atlantic salmon smolts (possibly kelts too) will be acoustically tagged on rivers and estuarine areas in the Irish sea coastal area (Northern Ireland and Republic of Ireland) and followed on their migrations in the near shore marine environment using detection equipment. The ultimate aim is to quantify habitat range and assess life-stage based mortality in the near-shore marine area. Sea trout (three life stages) and Atlantic salmon (smolts, with kelts if feasible) (500 total all species) will be fitted with acoustic tags and released from selected Irish sea coastal rivers from Co. Louth north to Co. Antrim. Their migration will be followed by placing telemetric detection stations at various points between Belfast Lough and the mouth of the River Boyne, focussing on river mouths and coastal embayments.
Dates during which research will take place	01/04/2017-31/03/2022
Area in which research will take place	Island of Ireland; coast Belfast to Dublin
Estimated number and weight of salmon to be retained	Not applicable
Type and amount of gear and other equipment to be used	Acoustic tags: ~500 Acoustic receivers: ~60
Details of any collaborating countries	UK, (Northern Ireland, Scotland), Republic of Ireland,
Resources	
Estimated cost of the research project	Total costs estimate: £810,000 Apportioning of budget under discussion with EU funders
Number of participating scientists	10
Name and e-mail address of coordinating scientist in charge of project	Dr. Robert Rosell: Robert.Rosell@afbini.gov.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	Does not apply

Type and amount of gear and other equipment to be used	Acoustic tags: ~500 Acoustic receivers: ~60
Details of any collaborating countries	EU UK, (Northern Ireland, Scotland), EU Republic of Ireland.

Summary of Progress:

COMPASS (submitted to Inventory in 2017) has not generated any data/results yet.

Project No. Ni5 Status: New Entry

Party or relevant jurisdiction	European Union – United Kingdom (Northern Ireland)
Title of project	**The marine survival of Atlantic salmon from the River Bush, Northern Ireland**
Objective of research project	Investigate factors influencing the survival at sea of salmon smolts migrating from the River Bush until their return as adult salmon
Brief description of research project	This long-term project centres on enumerating numbers of migrating wild smolts and returning adults to the River Bush, by means of trapping facilities, in order to assess return rates and maturation schedules. A programme of microtagging hatchery-origin smolts provides detailed information on exploitation levels and patterns in coastal and distant-water fisheries. Run-reconstruction modelling provides information on return rates to Irish homewaters, which provides an index of natural survival at sea.
Dates during which research will take place	Started in 1973. Project ongoing 2018.
Area in which research will take place	River Bush, N. Irish/Irish coastal waters and distant-water fisheries.
Estimated number and weight of salmon to be retained	None retained, as tag recovery based on already-captured fish. Tagged adults at River Bush retained alive as broodstock for hatchery programme.
Resources	
Estimated cost of the research project *Details of the full economic costs of each study are requested, including staff costs, equipment and overheads. For collaborative projects, a breakdown of costs between public and private partners is requested.*	Total annual cost: £270,000 Breakdown: Staff £243,500 Consumables £6,500 Travel and Subsistence £10,000
Number of participating scientists	2 project scientists and 3 technical staff
Name and e-mail address of coordinating scientist in charge of project	Dr. Dennis Ensing dennis.ensing@afbini.gov.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	EU Republic of Ireland (tag recovery programme)

Project No. Sc1 Status: Completed

Party or relevant jurisdiction	European Union – UK (Scotland) in collaboration with Norway and the Atlantic Salmon Trust
Title of project	**Testing and development of Institute of Marine Research (IMR) Bergen, Norway, salmon trawl gear**
Objective of research project	Test a prototype trawl developed by IMR, Bergen, Norway, which, rather than capturing post-smolts, records, by use of CCTV, their passage as they pass through an open-ended trawl net. A supplementary objective, dependent on the success of the gear trials, was to conduct a post-smolt survey at the shelf edge.
Brief description of research project	
Dates during which research took place	
Area in which research took place	
Estimated number and weight of salmon retained	
Resources	
Estimated cost of the research project	
Number of participating scientists	
Name and e-mail address of coordinating scientist in charge of project	Julian MacLean (Marine Scotland Science) j.c.maclean@scotland.gsi.gov.uk Jens Christian Holst (IMR) jens.christian.holst@imr.no Dick Shelton (Atlantic Salmon Trust) freda.shelton@btopenworld.com
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	
Details of any collaborating countries	
Summary of Findings: The trial of the modified pelagic trawl gear was a success with real-time footage of fish passing through the net being obtained and recorded. In total 178 post-smolts, one wild adult and one farmed adult salmon were observed. In addition, the supplementary aim of	

undertaking survey trawls on the shelf edge and collecting ancillary hydrographical information was also achieved.

The successful survey along the shelf edge has shown that the trawl gear is a practical tool for investigating post-smolt distribution at sea. This is extremely relevant with respect to the SALSEA proposal. In summary there are three major advantages of the new gear. First, it is much more cost-effective than using normal pelagic trawls with cod ends. The new trawl can be towed for almost unlimited periods and the fish passing through the net can be observed via the camera link, negating the need to shoot and haul the net every hour or so. Thus, a much greater area of sea can be covered, greatly increasing the efficiency of collecting distribution information. Second, the new trawl provides a non-destructive way in which to observe the distribution of post-smolts. This is a major breakthrough given the high sea mortality rates currently impacting upon salmon in the sea. Third, it is now possible to link the distribution of individual, or shoals of, post-smolts, much more closely to the prevailing hydrographical conditions as the precise location of each observation can be recorded. This was not the case previously when normal pelagic trawls were used and the location of capture could only be recorded relative to the entire area of the particular trawl.

While the trial was an undoubted success, there are some areas of development that need to be considered further in order to obtain the maximum benefits from the new trawl system. In particular, the conditions under which the gear was deployed were relatively calm (gale force 3 – 4) and thus the stability of the trawl requires testing under more testing conditions. In addition to a short FRS Internal Report by Julian MacLean, outlining the findings, an article written by Dr Richard Shelton has also been published in the Atlantic Salmon Trust Journal, Winter 2005-06.

Project No. **Sc2** **Status:** **Completed**

Party or relevant jurisdiction	European Union – UK (Scotland)
Title of project	**Protecting salmonid fisheries from seal damage**
Objective of research project	1.Develop and apply new molecular tools for discriminating among species of fish in the diets of seals from their remains in scats. Test the possibility of using molecular tools to quantify the occurrence of diet components. 2.Develop and deploy cetacean-friendly seal-scarer. 3.Identify factors influencing the in-shore migration routes of salmon. 4.Characterise behavioural interactions between salmon and their predators and seals and their prey. 5.Investigate the digestion of salmonid otoliths during passage through a seal's gut.
Brief description of research project	1.A project funded by the Atlantic Salmon Trust (undertaken by Dr Kim Parsons) has developed a molecular tool for detecting the presence of salmon DNA. The tool will be further developed and tested. 2.There is concern that seal-scarers may adversely affect cetaceans. Recent work by Dr Vincent Janik of St Andrews University suggests potential for natural calls of marine mammals to modify behaviour of sound recipients. This will be tested at the Shieldaig research facility in north-west Scotland with the aim of developing a cetacean-friendly seal-scarer for fixed deployment in rivers/estuaries, and/or for use as a hand-held deterrent. The final scope of the project is to some extent dependent upon final level of funding. 3.Salmon were fitted with acoustic transmitters and followed using active (manned boats) and passive (acoustic receiver buoys) tracking systems. Migration routes were mapped in relation to topographical features and distributions of predators. Salmon and sea trout smolts will also be examined. Work will be concentrated in the Cromarty Firth in north-east Scotland, and at Shieldaig. 4.Detailed examination of behavioural interactions between predators and prey were made using acoustic observations, visual observations and side-scan sonar.

	5.Captive feeding trials were used to determine the proportion of otoliths that pass through a seal, and the degree to which these otoliths are eroded.
Dates during which research took place	April 2003-March 2008
Area in which research took place	Principally north-west Scotland (Shieldaig) and north-east Scotland (Cromarty Firth). Possible work in other estuaries as required. Captive work to be undertaken at Sea Mammal Research Unit, St Andrews.
Estimated number and weight of salmon retained	-
Resources	
Estimated cost of the research project	2003/04 - £166,000 2004/05 - £142,000 2005/06 - £100,000
Number of participating scientists	Multi-disciplinary work will involve scientists from a number of teams within Fisheries Research Services. Feeding experiments undertaken in conjunction with staff at the Sea Mammal Research Unit, University of St Andrews.
Name of coordinating scientist in charge of project	Dr John Armstrong
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	Laboratory –DNA analysis Field work - Acoustic tags and receivers, inflatable craft, seal-scarers, side-scan sonar Feeding experiment - Home Office licensed captive facility
Details of any collaborating countries	

Summary of Findings:

1. Seal diet.

Occurrence of salmon and sea trout in the diets of seals has usually been estimated by quantifying hard part remains of the fish in seal scats. However, there is concern that this method underestimates consumption due to either seals discarding heads of the fish, which contain the principle diagnostic hard parts, called otoliths, or the otoliths nor surviving digestion. Furthermore, it is not possible to differentiate between salmon and sea trout from the morphologies of their otoliths. The use of DNA remains in scats potentially has some advantages over the conventional techniques because it does not depend on the consumption of and recovery of hard parts. A quantitative PCR (qPCR) assay was therefore developed for detecting and providing a semi-quantitative measure of the occurrence of salmon and sea trout DNA in seal scats. The qPCR assay was shown to be consistent in detecting salmonids in scats, and was found to be more sensitive than conventional analysis of hard-parts. Nevertheless, the results confirmed findings from previous studies indicating that salmon and sea trout are not common prey for seals in Scottish estuaries.

In addition to the molecular work was undertaken in developing a seal- mounted detector that can record each time a seal consumes a sea trout post smolt fitted with as passive integrated transponder (PIT tag). The aim was to try and quantify the consumption of smolts by seals, which has not proved to be possible using other means. Major advances have been made through collaboration with WyreMicro and SMRU to miniaturise the device and test it on captive seals. The Mk III version currently in final stages of testing uses a SMRU mobile phone transmitter to relay information to shore. The expected outcome is the development of a state-of-the-art electronic device that will provide an insight into consumption of sea trout post-smolts by seals that could not be achieved by any other means.

2. Identify factors influencing the in-shore migration routes of salmon.

If the benefits of non-lethal scaring techniques are to be maximised, then they need to be targeted at areas where salmon and sea trout congregate. Acoustic tracking was used to examine the habitat use of salmon and sea trout in coastal areas. Adult salmon tagged in the Cromarty Firth did not follow common migration routes through the firth nor were there areas in which they were shown to congregate. This finding led to the outcome that protection should best be concentrated at river mouths. Similarly, tracking of sea trout in Loch Torridon suggested that best value would be to offer protection to the fish around the river mouths during the period of smolt migration. Sea trout largely remained near their natal river over the first 20-day period after sea entry, during which the population experienced a loss rate of c. 50%. This combination of high loss and localised distribution provides a clear management target time and area.

The tracking programmes also allowed losses of salmon and sea trout to be quantified. Losses of salmon in the Upper Cromarty Firth were roughly ten percent, with half being possibly attributable to seals and half to net and coble fisheries. No difference in mortality of sea trout was detected between two areas contrasting seal abundance. Neither study provided evidence that seals were the main cause of fish mortality.

3. Recommend strategies for the most effective deployment of methods for protecting salmonid stocks in inshore waters.

The rationale behind this aim was to translate the findings of this project into management advice. Balancing SG's obligations to conserve salmon and seals while maintaining economically sustainable fisheries is a considerable challenge, particularly when both spring-running salmon and common seals on the East Coast are declining.

In the past, seal management has focussed on populations of seals around the coastline, particularly in the estuaries of salmon rivers. However, in view of the decline in numbers of common seals and the need to conserve their stocks, it is becoming increasingly important to control only those seals that are actually causing damage to salmonid stocks. The work undertaken during this project supports a policy of concentrating management efforts at river mouths for the following reasons. First, there is no evidence that all seals present in estuaries consume salmon and sea trout and therefore shooting in estuaries is unlikely to be effective at targeting those seals that are consuming salmonids. Second, there is no evidence of high losses of salmon in estuaries. Third, there is no evidence that there are specific areas in which salmon congregate within estuaries or on the high sea and where they can be protected by localised scaring of seals.

A modelling exercise was undertaken to examine the benefits to the salmon populations of removing seals. This work emphasised that targeting management on small rivers, and on larger rivers during key periods (eg during spring), is likely to have most value. The outcome of such action is a capacity for increasing the efficiency of protection of fish stocks. The aim was further supported through diversion of resources into directly supporting the Moray Firth Management Project and undertaking counts of seals in 2006 and 2008.

Project No. Sc3 Status: Ongoing

Party or relevant jurisdiction	European Union – UK (Scotland)
Title of project	**Post-smolt mortality of Atlantic salmon**
Objective of research project	Assess post-smolt mortality rates of Atlantic salmon from the rivers North Esk, Aberdeenshire Dee (two tributaries) and Conon (a river harnessed for hydro-electricity generation) and their contribution to fisheries that exploit them.
Brief description of research project	North Esk: Project started in 1964. Annual smolt production estimates are made using stratified mark-recapture models. Over the time series the smolts have been tagged with a number of tag types including coded-wire microtags, modified Carlin tags and PIT tags. Age distribution and sex ratio data are collected by sampling trap catches of smolts. Analysis of recapture data yields information on post-smolt mortality levels and contribution of North Esk salmon to fisheries. River Dee: Adult and juvenile traps have been operated in the Girnock Burn since 1966, and in the Baddoch Burn since 1989. This data is supplemented by in-river electrofishing at selected reference sites Fish at the Girnock are tagged using coded-wire microtags. Salmon and grilse entering the tributaries to spawn are trapped, with age and length data recorded. Stock-recruitment relationships and salmon population dynamics are investigated. Analysis of data on emigrant and returner numbers, combined with information on fish ages provides information on return rates, indicative of marine mortality (assuming in-river mortality rates remain constant). Both tributary populations are driven by early-running salmon (2SW plus a minor proportion of early-running grilse and older fish). The datasets are currently undergoing review following the inclusion of raw data in a corporate fish observation database. Revised analyses and conclusions will follow. River Conon: Collaborative project with Conon District Salmon Fishery Board and Scottish and Southern Energy started in 1996. Juvenile salmon are captured by electro-fishing and trapping exercises in selected parts of the River Conon catchment. The fish are tagged using a variety of tags including coded-wire microtags (occasionally) and PIT tags (annually). Returning adults are registered automatically as they pass through a Borland lift in Torr Achilty Dam. Occasional surveys and trapping exercises have recorded the proportion of tagged fish in the net-and-coble and rod-and-line fisheries. Work has been undertaken to provide information on the contribution of seals to the marine mortality of Conon salmon.

Dates during which research will take place	Ongoing
Area in which research will take place	North Esk, Western catchment of River Dee, River Conon salmon fishery district
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	Approximately £50,000 per annum
Number of participating scientists	North Esk - 7 (also employed on other projects) River Dee - 5 (also employed on other projects) River Conon - 6 (includes non-MSS staff, and all are also employed on other projects)
Name and e-mail address of coordinating scientist in charge of project	North Esk - Gordon Smith Gordon.Smith@gov.scot River Dee – Iain Malcolm Iain.Malcolm@gov.scot River Conon - John Armstrong John.Armstrong@gov.scot
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	North Esk - Purpose-built smolt trap and resistivity counter on the lower reaches of the North Esk. One additional resistivity counter and two rotary screw traps deployed to assess trends in sub-catchment populations. Electrofishing gear used for juvenile surveys. River Dee - Purpose-built traps, electro-fishing. River Conon - Electro-fishing gear, traps, PIT tagging equipment and detectors.
Details of any collaborating countries	N/A

Summary of Progress:

This long term monitoring programme continues to provide detailed site specific information. However, with respect to the North Esk, the smolt trapping method became ineffective in 2014 and the collection of smolt data has ceased. Results from the surveillance monitoring continue to be provided to the Working Group for consideration in their on-going modelling work for the assessment of distant water fisheries.

Project No. Sc4 Status: Ongoing

Party or relevant jurisdiction	European Union – UK (Scotland)
Title of project	**Analysis of post-smolt life history by scale reading**
Objective of research project	Investigate the relationship between growth and mortality in Atlantic salmon, particularly during the marine phase, by analysis of scale growth patterns
Brief description of research project	Scale samples of fish of known age (recaptures from smolt tagging operations) and from salmon catches generally are examined to assess growth characteristics. Associations between growth performance and independent measures of mortality are examined with the aim of identifying the periods crucial to survival.
Dates during which research will take place	Continuing project under longer-term remit.
Area in which research will take place	Samples from around Scotland and from the North Esk and Girnock Burn (Aberdeenshire Dee) in particular
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	Approximately £10,000 per annum
Number of participating scientists	3 (also employed on other projects)
Name and e-mail address of coordinating scientist in charge of project	Gordon Smith Gordon.Smith@gov.scot
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	USA and Canada

Summary of Progress:

Factors affecting early marine mortality and its possible causes continue to be investigated. Growth patterns across Europe are being examined in collaboration with colleagues from other organisations. Fine scale data relating to growth checks have been collected for further analysis.

Publications:

Friedland, K. D., MacLean, J. C., Hansen, L. P., Peyronnet, A. J., Karlsson, L., Reddin, D. G., Ó Maoiléidigh, N., and McCarthy, J. L. 2009 The recruitment of Atlantic salmon in Europe. ICES Journal of Marine Science, 66: 289-304.

Friedland, K. D., Chaput, G., and MacLean, J. C. 2005. The emerging role of climate in post-smolt growth of Atlantic salmon. - ICES Journal of Marine Science, 62: 1338-1349.

Todd, CD, Hughes, SL, Marshall, CT, MacLean, JC, Lonergan, M & Biuw, M 2008, 'Detrimental effects of recent ocean surface warming on growth condition of Atlantic Salmon' Global Change Biology, vol 14, no. 5, pp. 958-970.,

Bacon, P. J., Palmer, S. C. F., MacLean, J. C., Smith, G. W., Whyte, B. D. M., Gurney, W. S. C., and Youngson, A. F. 2009. Empirical analyses of thelength, weight, and condition of adult Atlantic salmon on return to the Scottish coast between 1963 and 2006. – ICES Journal of Marine Science, 66: 844–859.

Bacon, P.J., Gurney, W.S.C., McKenzie, E., Whyte, B., Campbell, R. Laughton, R., Smith, G. W., and MacLean, J.C. 2010. Objective determination of the sea age of Atlantic salmon from the sizes and dates of capture of individual fish. ICES Journal of Marine Science; doi:10.1093/icesjms/fsq142

Todd, CD, Whyte, B, MacLean, J, Revie, C, Lonergan, M & Hanson, NN 2014, 'A simple method of dating marine growth circuli on scales of wild one sea-winter and two sea-winter Atlantic salmon (Salmo salar)' Canadian Journal of Fisheries and Aquatic Sciences, vol 71, no. 5, pp. 645-655.

Gurney, W. S. C., Bacon, P. J., Malcolm, I.A., MacLean, J. C. Youngson, A. 2015. The demography of a phenotypically mixed Atlantic salmon (Salmo salar) population as discerned for an eastern Scottish river. Scottish Marine and Freshwater Science Vol 6 No 12.

Project No. Sc5 Status: Completed

Party or relevant jurisdiction	European Union – UK (Scotland) and Ireland
Title of project	**Fisheries-induced evolution**
Objective of research project	The Specific Targeted Research Project on Fisheries-induced Evolution will analyze the prevalence and consequence of fisheries-induced adaptive changes in exploited salmon (and other fish) stocks. This objective will be realized through a carefully selected set of empirical phenotypic case studies, the investigation of salient adaptive genetic variation, and through the development of new quantitative models for understanding trends and evaluating management options. The FinE project will deliver insights and recommendations for addressing the overlooked evolutionary dimension of modern fisheries. The FinE project aims at combining fields of expertise as diverse as population genetics and quantitative genetics, life-history theory, population dynamics, evolutionary theory, and fisheries science. The project will ensure a close integration of both empirical and theoretical lines of development in our understanding of evolutionary processes in exploited populations. The FinE project will thereby provide the scientific basis required for designing policies and implementing management measures that can cope with fisheries-induced adaptive changes.
Brief description of research project	The project's overall objective can be broken down into three main lines of research: 1) Phenotypic case studies will aim at documenting phenotypic trends in life-history traits relevant for the demography and productivity of exploited salmon populations, thus focusing on maturation, reproductive effort, and growth. In order to assess the ubiquity of fisheries-induced adaptive changes, various exploited stocks from European and North American waters will be investigated. The studies will be based on long-term time series of field data, mostly hosted by national organizations responsible for fish stock assessment and advising for fisheries management. The general principle of the analyses will be to disentangle the plastic component of observed phenotypic trends from a potentially underlying evolutionary component, in order to assess the degree of reversibility of the fisheries-induced changes. The use of specifically tailored statistical methods, like probabilistic maturation reaction norms, will be critical in this respect. 2) Genetics analyses will aim to elucidate the genetic basis of fisheries-induced evolutionary changes suggested by phenotypic analysis. The work will be based on a two-pronged approach, thereby developing two complementary lines of research: (i)

	adaptive genetic changes affecting life-history traits under fisheries-induced selection will be assessed at the DNA level (candidate genes) and in terms of quantitative genetics using historical collections of biological tissues (otoliths) sampled in the field; (ii) artificial fisheries-induced selection experiments on a model species (*Poecilia reticulate*, the guppy) will be set up in order to corroborate molecular and quantitative genetic results in the wild. These studies will rely on the development of innovative molecular and statistical methodologies allowing tackling temporal adaptive genetic changes, instead of only investigating the neutral genetic differentiation that customarily was at the focus of previous genetics work. 3) Eco-genetic models will be designed for evaluating alternative hypotheses advanced to explain observed data; for assessing the ecological consequences of fisheries-induced evolution in terms of exploited stock dynamics, viability and recovery, as well as fisheries yield; and for comparing various management scenarios. These analyses will address features and dimensions that are particularly difficult to cover in empirical analyses: multi-trait evolution, sex-specific fisheries-induced evolution, and economic drivers of fishery dynamics. Models will be constructed by carefully integrating relevant genetic, ecological, and environmental details, so as to attain sufficient degrees of realism for predicting the speed of evolutionary changes, while also properly describing population dynamics and fishery dynamics. The following specific topics will be addressed: • Evolutionary determination of maturation reaction norms • Fisheries-induced multi-trait evolution • Evolutionary vulnerability of prototypical life histories • Sex-specific dimensions of fisheries-induced evolution • Fisheries-induced evolution of neutral and selected genetic markers • Fisheries-induced evolution of specific stocks • Implications for stock stability and recovery potential • Economic models of fisheries-induced evolution • Evolutionarily enlightened stock management
Dates during which research will take place	2007-2010
Area in which research will take place	FRS will focus on Scottish and Irish salmon stocks; however, fisheries data will be collected from across Europe, including along marine migration routes.
Estimated number and weight of salmon to be retained	N/A
Resources	

Estimated cost of the research project	Scotland: FRS cost: £155,000 Ireland: £10,000 (Travel and subsistence for project meetings only)
Number of participating scientists	FRS: 6 Total: 40+
Name and e-mail address of coordinating scientist in charge of project	*EU Project co-ordinator:* Ulf Dieckman dieckman@iiasa.ac.at *Scotland:* *FRS project leader:* John Gilbey J.Gilbey@marlab.ac.uk *Ireland*: Marine Institute project leader: Philip McGinnity P.McGinnity@ucc.ie
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	Austria: International Institute for Applied Systems Analysis (IIASA); Norway: Institute of Marine Research (IMR); France: French Research Institute for the Sustainable Exploitation of the Sea (Ifremer); Denmark: Danish Institute for Fisheries Research (DIFRES); Belgium: Catholic University of Leuven (KUL); UK: University of Wales (UW); UK: Fisheries Research Services (FRS); Norway: University of Tromsø (UT); Netherlands: Netherlands Institute for Fisheries Research (RIVO); Norway: University of Oslo (UO); Spain: Spanish National Research Council (CSIC); Finland: Finnish Game and Fisheries Research Institute (FGFRI); Germany: Johann Heinrich von Thünen-Institut (vTI), Federal Research Institute for Rural Areas, Forestry and Fisheries

Summary of Findings:

The first meeting of the FinE project was held near Bergen, Norway in September 2007. A follow-up meeting dedicated to salmon issues was held at Pitlochry, Scotland in March, 2008. This second meeting was devoted to mustering data sets, discussing preliminary analyses and planning the way forward for the main data analyses. Since this meeting data relating to Scottish salmon populations has been collated and analysis is ongoing. A meeting was held at IIASA in June 2008 where the details of the Atlantic salmon eco-genetic models were defined and a plan developed to build and use such models. The second annual project meeting was held at Biarritz in October 2008 where the progress of all tasks was presented and future directions discussed.

A further technical meeting was held in Newport, Ireland in February 2009. Further collaborative work has been undertaken during 2009/10. The project has now ended.

A major empirical analysis of the Scottish salmon data (from the River North Esk and from five other sites) has been completed and submitted. This work is providing crucial understanding of the dynamics and possible evolutionary changes underlying the Irish situation. An additional key study of the heritability of size in ranched Atlantic salmon was completed in collaboration with FinE colleagues from Ireland. The work suggests that size changes observed in Irish Atlantic salmon are more likely to be due to environ-mental causes than to Fishery Induced effects resulting from the salmon drift-nets off the Irish coast. A further empirical analysis of length, weight, condition, sea and river age of Scottish salmon over 44 years at 6 sites was undertaken to try to understand patterns of size change across temporal and spatial scales in Scotland.

A report has been produced summarising the data available for salmon stocks in Scotland, the Baltic, and Ireland. This includes data on the various wild populations, together with fisheries data from rods, nets and high-seas fisheries. A number of Scottish stocks were selected based on this. Detailed analyses focused on stocks from the River North Esk, which has been the site of scientific investigations into population structure, abundance, life-history characters, and exploitation rates since 1963. Secondary analyses were performed using data from the River Dee.

A tactical individual based eco-genetic model describing Atlantic salmon life history was developed and analysed. The model is based on Probabilistic Reaction Norm (PRN) and was used to examine whether fishery induced selective pressures are likely to have influenced the demographic and life-history changes observed in the empirical data. Fisheries induced responses in sea age at return to the river, return timing, age-specific size at re-turn, precocious maturation and smolt age were examined. Simulations were performed examining both the impact of fisheries, and the potential recovery after fisheries under different management scenarios.

The simulations suggested that selective fisheries could cause evolutionary changes in Atlantic salmon life-history characteristics, with fisheries associated evolution of genetic traits associated with both sea age at return and timing of return within sea age groups. The strength and type of evolutionary response seen was related to the particular selective pressure exercised by the individual fishery. A cessation of fishing pressure ends the evolutionary response, but very limited recovery of return age or run timing is apparent in the following 80 years. Inverted monthly exploitation rates, relaxing fishing pressure on early returning MSW fish, increase the ratio of MSW to grilse towards a pre-fishing state.

Publications:

Bacon PJ, Palmer SCF, MacLean JC, Smith GW, Whyte BDM, Gurney WSC & Youngson AF (2009). Empirical analyses of the length, weight, and condition of adult Atlantic salmon on return to the Scottish coast between 1963 and 2006. ICES Journal of Marine Science 66: 844-859.

Bacon PJ, McGinnity P, Ó Maoiléidigh N, Cotter D, Cullen A, Rogan G, Poole R, Fryer R, Ernande B, Gilbey J, Palmer SCF & Dieckmann U. (about to be submitted). Recent size and run-date trends in Irish Atlantic salmon (*Salmo salar L.*) were not responses to Fisheries management-Induced Evolution.

Gilbey J, Östergren J, Bacon P & Dieckmann U. (about to be submitted). Trends in life-history characteristics in Scottish Atlantic salmon (*Salmo salar L.*) examined using eco-genetic modelling: fisheries induced evolution or phenotypic plasticity? Evolutionary Applications.

Östergren J, Gilbey J, Bacon P & Dieckmann U. (about to be submitted). Evolutionary responses on return age and run timing in Atlantic salmon (*Salmo salar L.*) to varying fisheries management scenarios. Evolutionary Applications.

Project No. **Sc6** **Status:** **Ongoing**

Party or relevant jurisdiction	European Union – UK (Scotland)
Title of project	**Size and condition of returning grilse (1SW) and MSW salmon**
Objective of research project	Investigate decacaltrends in the size (length, weight) and condition (weight/length^3) of adult salmon returning to Scotland.
Brief description of research project	Biometric data spanning a forty year period at the North Esk, and shorter periods for 5 other sites, are being analysed to document fluctuations in the size and condition of age at return to breed. Complicated trends are evident, which differ between 1SW and MSW fish.
Dates during which research will take place	June 2007 – ongoing.
Area in which research will take place	Six locations inScotland, in particular the North Esk
Estimated number and weight of salmon to be retained	N/A
Resources	
Estimated cost of the research project	£30,000 per annum
Number of participating scientists	4 (also employed on other projects)
Name and e-mail address of coordinating scientist in charge of project	Philip Bacon Philip.Bacon@gov.scot
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	N/A
Details of any collaborating countries	Atlantic Salmon Trust

Summary of Progress:

Data from the North Esk show that recent reports by anglers of high proportions of thin grilse (1SW salmon) in their catches were an extreme of a longer term (five year) trend *(see also Smith et al 2007; Todd et al 2008*). However, the situation for MSW fish is dissimilar, and for both sea age classes, the trends since 2000 need interpreting in the light of former, decadal, fluctuations. The work is currently being extended to five other Scottish sites (with less complete data sets) to investigate the generality of the findings. Very weak correlations, probably indicating only indirect effects, are apparent with a variety of marine environmental data. Analysis of long term data is continuing.

Smith, G.W., MacLean, J.C. and Whyte, B.D.M. (2007). The presence of "small grilse" in the 2006 Scottish salmon catches: a historical perspective. ICES Working Group on North Atlantic Salmon. Working Paper No. 30/2007. Copenhagen 11th to 20th April 2007.

Todd, C.D., Hughes, S.L., Marshall, C.T., MacLean, J.C., Lonergan, M.E. and Biuw, E.M. 2008. Detrimental effects of recent ocean surface warming on growth condition of Atlantic salmon. Global Change Biology (2008) 14, 1–13 (pages refer to online version only).

Bacon, P. J., Palmer, S. C. F., MacLean, J. C., Smith, G. W., Whyte, B. D. M., Gurney, W. S. C., and Youngson, A. F. 2009. Empirical analyses of the length, weight, and condition of adult Atlantic salmon on return to the Scottish coast between 1963 and 2006. – ICES Journal of Marine Science, 66: 844–859.

Project No. Sc7 Status: Completed

Party or relevant jurisdiction	European Union – UK (Scotland)
Title of project	**Development of a General Spatial Model of Within River Population Structuring in Scottish Atlantic salmon (POPMOD)**
Objective of research project	To improve the scientific basis for - setting biologically appropriate conservation limits for salmon rivers in line with NASCO obligations - effectively regulate the salmon movements under the new Aquaculture and Fisheries Act - providing advice on conservation and restoration initiatives in support of the TWG process and Gs Contingency Planning, and the EU Habitats and Water Framework Directives - accurately and cost-effectively monitoring the status of salmon stocks The anticipated outcomes of the project are: • a general model which can be used to predict population structuring within any Scottish salmon rivers • an optimised, cost-effective methodology which can be used to test model predictions • an evaluation of the potential for using genetic estimates of effective numbers of breeders for monitoring the conservation status of breeding populations
Brief description of research project	Building on the information collected as part of previous MS and associated SNH, AST/AFT and DSFB contracts, and linked associated projects (FASMOP, SALSEA MERGE), microsatellite and mtDNA markers will be used to assess the spatial boundaries of Atlantic salmon selected Scottish river systems. The genetic information on the relatedness of salmon in the systems will be analysed and the number and spatial boundaries of salmon populations present within each river explored. The genetic information will be combined with biophysical information on river structure, including salmon habitat distribution, water chemistry, and presence of natural and man-made barriers, to develop a general predictive model. The generality of these associations will be explored and tested using GIS and Bayesian statistical methods. For identified populations, genetic data will be further analysed for each breeding population to determine the effective numbers of breeders contained in each population. The estimates derived will be compared with the spatial extent of the population and estimates of census size based on electrofishing, wetted area, and angling catches.

Dates during which research will take place	1 April 2008 to 31 March 2011
Area in which research will take place	River systems across Scotland
Estimated number and weight of salmon to be retained	Not applicable
Resources	
Estimated cost of the research project	Estimated Costs: FEC £800,883 Breakdown Staff Costs: £350,228 T&S: £6,000 Equipment: £32,000 Consummables: £78,000 Overheads: £367,740 100% public (SG) funded
Number of participating scientists	3
Name and e-mail address of coordinating scientist in charge of project	Dr. Eric Verspoor verspoor@marlab.ac.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	None used for work
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	None

Summary of Findings:

The information collected as part of previous MS and associated SNH, AST/AFT and DSFB contracts, and linked associated projects (FASMOP, SALSEA MERGE), microsatellite markers has been used to assess the spatial boundaries of Atlantic salmon populations in a set of 11 Scottish river systems. The relatedness of salmon in the systems has been analysed and the number and spatial boundaries of salmon populations present within each river explored. The genetic data has been combined with biophysical information on river structure, including salmon habitat distribution, water chemistry, and presence of natural and man-made barriers, and a general predictive model developed. The model's predictive capacity has been assessed using data from a further 8 river systems, and the generality of these associations has been explored and tested using GIS and Bayesian statistical methods. It was found that the genetic structure of salmon within systems seems to be defined on a system by system basis. Model parameters defined by one or a group of systems were not readily transferable to other systems. The only metric that seemed to be common across systems was the presence of a significant loch within the system. Such a feature was significant in the definition of the genetic structure of fish above and below it.

Project No. Sc8 Status: Completed

Party or relevant jurisdiction	European Union – UK (Scotland)
Title of project	**Focusing Atlantic salmon management on Atlantic salmon (FASMOP)**
Objective of research project	The project seeks to: • Establish the number and spatial boundaries of breeding populations of salmon within any Scottish river system using micro-satellite genetic markers; • Establish the ancestral relationships and functional biological differences between wild salmon stock components across Scottish rivers; • Use information and insights gained to improve local management practice and increase the of focus salmon management on local breeding populations as these are the fundamental biological units underpinning recruitment in river stocks
Brief description of research project	The project will: • Provide detailed local population structure insights for rivers within Fisheries Trust and DSFB areas for application in local management decision making through the analysis of molecular microsatellite DNA genetic markers; • Provide Atlantic salmon population structure information for river catchments across Scotland; • Contribute to the development of national and international scale knowledge and understanding of the factors underlying population structuring through the input of information into Marine Scotland Science projects and the SALSEA MERGE project.
Dates during which research will take place	1 April 2009 to end 2013.
Area in which research will take place	River systems across Scotland for which local fisheries trusts have responsibility; this encompasses 24 Scottish Trusts covering in the order of 90% of Scottish river systems with salmon.
Estimated number and weight of salmon to be retained	Sampling of tissue for DNA analysis will be collected by individual Trusts for the programme of work and will to a large extent be taken non-destructively from salmon fry and parr collected by Trusts by electrofishing but samples will also be taken from returning adults captured by anglers, including both killed and catch-and-release fish.
Party or relevant jurisdiction	European Union – UK (Scotland)
Title of project	Focusing Atlantic salmon management on Atlantic salmon (FASMOP)
Objective of research project	The project seeks to: • Establish the number and spatial boundaries of breeding populations of salmon within any Scottish river system using micro-satellite genetic markers;

	• Establish the ancestral relationships and functional biological differences between wild salmon stock components across Scottish rivers; • Use information and insights gained to improve local management practice and increase the of focus salmon management on local breeding populations as these are the fundamental biological units underpinning recruitment in river stocks
Brief description of research project	The project will: • Provide detailed local population structure insights for rivers within Fisheries Trust and DSFB areas for application in local management decision making through the analysis of molecular microsatellite DNA genetic markers; • Provide Atlantic salmon population structure information for river catchments across Scotland; • Contribute to the development of national and international scale knowledge and understanding of the factors underlying population structuring through the input of information into Marine Scotland Science projects and the SALSEA MERGE project.
Dates during which research will take place	1 April 2009 to end 2013, with a possibility of the project extension depending of the nature of the findings and the demand for further work from individual Trusts.
Area in which research will take place	River systems across Scotland for which local fisheries trusts have responsibility; this encompasses 24 Scottish Trusts covering in the order of 90% of Scottish river systems with salmon.
Estimated number and weight of salmon to be retained	Sampling of tissue for DNA analysis will be collected by individual Trusts for the programme of work and will to a large extent be taken non-destructively from salmon fry and parr collected by Trusts by electrofishing.
Resources	
Estimated cost of the research project	£280,000 over four and a half years, ie £62,000 per annum Staff costs: ~£146,000 Equipment costs: £20,000 Consumables costs: ~ £50,000 Overheads: ~ £50,000 (including both MS and RAFTS)
Number of participating scientists	1 post-doctoral research fellows and one part-time research assistant specifically employed for project work
Name and e-mail address of coordinating	Dr. Stuart Middlemas Stuart.middlemas@scotland.gsi.gov.uk

scientist in charge of project	Dr. Calum Sinclair callum@rafts.org.uk
Details of research vessels, e.g. name, registration, call sign and description of vessel	No research vessels used for work.
Type and amount of gear and other equipment to be used	No marine gear to be used
Details of any collaborating countries	No other collaborating countries

Summary of Findings:

The project has, in collaboration with the MSS POPMOD and EU SALSEA-Merge projects, screened over 20,000 juvenile salmon from 24 river trusts in Scotland for genetic variation at a suite of 17 microsatellite loci. The analysis of the data focused on the assessment of the structuring of individual river stocks into multiple distinct breeding populations. In light of the low levels of genetic differentiation observed in some of the larger river systems as revealed by the microsatellite analysis, where structuring is known from tagging work, the programme was extended, in collaboration with CIGENE (Centre for Integrative Genomics) to encompass the analysis of SNP (single nucleotide polymorphism) variation. Analysis of the SNP data has showed that this class of variation can provide significantly higher resolution of population structuring within rivers in some cases, but in many others levels of differentiation are still low and often not enough for reliable assignment of fish of unknown origin within river catchments.

4. NORWAY

Project No. N1 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**Identification of salmon by geochemical signatures; further development and testing of methods**
Objective of research project	The main objectives of this project were to: • test if geochemical signatures are stable from year to year • test if geochemical signatures of salmon scale samples can be used to discriminate among fish from different rivers • develop analytical procedures (otolith core sampling, chemical and statistical analyses) for application of this method in ecological studies on Atlantic salmon.
Brief description of research project	Analysis of the composition of trace elements in otoliths and other bone structures has proved to be a useful method for identifying the chemical milieu at the time the structures are formed. Trace elements may, therefore, provide a unique tool for identifying the natal origin of fish. In a sample of salmon parr from 14 rivers feeding into the Trondheimsfjord, 87.5% of the fish were correctly classified by a discriminant analysis based on six elements. In this project we will test some of the assumptions that the method is based on.
Dates during which research took place	2002
Area in which research took place	
Estimated number and weight of salmon retained	-
Resources	
Estimated cost of the research project	£ 30,000
Number of participating scientists	2
Name of coordinating scientist in charge of project	Peder Fiske
Details of research vessels, e.g. name, registration, call sign and description of vessel	-
Type and amount of gear and other equipment used	-
Details of any collaborating countries	-

Summary of Findings:

The initial results suggested that salmon parr from different rivers could be differentiated based on the composition of trace elements in their otoliths. However, we could not classify new samples taken at a different time to the correct rivers using the discriminant functions based on the first sample. This suggests that there are year to year variations in the chemical composition of the otholiths, and that if the method should be used to identify salmon of unknown origin one would need year-specific samples from the possible rivers of origin. The usefulness of the method to identify salmon from mixed-stock fisheries to the river of origin therefore seems limited.

Project No. **N2** **Status:** **Completed**

Party or relevant jurisdiction	Norway
Title of project	**Development of models to predict marine survival and return of salmon to Norway**
Objective of research project	Develop models to predict marine survival and return of Atlantic salmon to Norway.
Brief description of research project	1. Identify and examine the feasibility of applying time series of marine environmental data, zooplankton productivity, productivity of pelagic fish, and salmon life-history information for model development. 2. Develop appropriate models 3. Cooperate with scientists from other countries working with similar research.
Dates during which research took place	2002-2005
Area in which research took place	Desk Study utilizing information already available
Estimated number and weight of salmon retained	None
Resources	
Estimated cost of the research project	£50,000 - £60,000 per annum
Number of participating scientists	7-10
Name of coordinating scientist in charge of project	Lars Petter Hansen l.p.hansen@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	-
Type and amount of gear and other equipment used	-
Details of any collaborating countries	Umass/NOAA CMER Program, University of Massachussetts, Amherst, MA USA Dep. Fisheries and Oceans, Newfoundland, Canada, Scientists from EU

Smmary of Findings:

A large amount of material on time series of hydrography, plankton production, biomass and condition of pelagic marine fish species and of salmon growth and survival indices (e.g. catches, estimated marine survival rates) has been analysed. A method to estimate the number of salmon entering the coast before exploitation (pre-fishery-abundance, or PFA) has been developed. Models were developed to forecast runs and PFA of 2- and 3SW salmon in years i+1 and i+2 based on the run of 1SW fish in year i. This approach is independent of smolt production. Models to forecast 1SW salmon were developed from environmental variables, plankton production and condition factor and biomass of herring. This approach is based on the assumption that the smolt production is the same every year. The precision of the forecasts were variable, lowest in south Norway and highest in north Norway. This has been the first approach to forecast salmon runs to Norway, and there is a significant potential to improve the predictions by further development of models. Important in this aspect is to maintain, improve and standardise the sampling of data so that the quality of appropriate time series would be less variable.

Project No. N3 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**By-catch in pelagic fisheries as a population-regulating factor in wild salmon stocks**
Objective of research project	Concentrated migration paths of post-smolt Atlantic salmon of Norwegian and southern European origin have been described in the North-East Atlantic during the last 10 years. The post-smolts typically migrate northwards in the major slope currents outside the continental shelf in May-June with dispersal over large areas in the Norwegian Sea in July-August. One of the major migration paths described overlaps in time and geography with a pelagic trawl fishery for mackerel harvesting, in total, 50,000 tonnes a year during a short period of the summer. Based on preliminary observations made by the Institute of Marine Research (IMR) - research vessels there is good reason to believe that significant numbers of post-smolt salmon are caught in this fishery. The main aim of this project was to carry out investigations to estimate the extent of such by-catch and, through cooperation with Russian scientists, to carry out investigations in order to estimate the by-catch and to develop management advice which could reduce by-catch of salmon while, at the same time, maintaining the catch rates in the mackerel fishery.
Brief description of research project	The ongoing Norwegian investigations on marine migrations paths of post-smolt Atlantic salmon were intensified and focused in areas where interceptory fisheries have been described. Based on the data obtained, combined with data from the commercial fisheries, management advice which could lead to reduced salmon by-catch in the mackerel fisheries while maintaining the catch rates of the fishing fleet, was sought.
Dates during which research took place	2001 - 2005
Area in which research took place	Norwegian Sea
Estimated number and weight of salmon retained	500-1,000 fish pr year 500-3,000 kg pr year
Resources	
Estimated cost of the research project	Approx £80,000 per annum
Number of participating scientists	3-5
Name of coordinating scientist in charge of project	Jens Christian Holst jens.christian.holst@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	R/V Johan Hjort (65 m) R/V G.O.Sars (70 m)

Type and amount of gear and other equipment used	Pelagic trawls Ocean Fish Lift (Live catching device for trawls) Underwater video techniques
Details of any collaborating countries	PINRO, Murmansk Scotland
Summary of Findings: No summary provided.	

Project No. N4 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**Sea lice as a population-regulating factor in Norwegian salmon: status, effects of measures taken and future management**
Objective of research project	Sea lice are regarded as the major population-regulating factor in many Norwegian salmon and sea trout stocks, with documented mortality ranging up to over 95% in salmon. This project involved broad cooperation between the leading Norwegian institutions on sea lice/wild salmon interaction studies with the object of further clarifying the effects of sea lice on wild salmon populations, suggesting further actions and measures to reduce sea lice infections in wild salmon and developing alternative methods for critically affected stocks.
Brief description of research project	The project is a combined field and modelling exercise of interactions between farmed fish, wild fish and sea lice. The project included estimating the mortality in seaward-migrating post-smolts due to sea lice infections in major fjordic systems, counting of sea lice infections in wild and farmed salmon in the areas studied and developing a sea lice/salmon interaction management model and the development of additional measures for critically affected wild salmon stocks.
Dates during which research took place	2002-2005.
Area in which research took place	Sognefjord and Altafjord
Estimated number and weight of salmon retained	Up to 3,000 post-smolts per year (Maximum weight 60 kg)
Resources	
Estimated cost of the research project	Approx £140,000 per annum
Number of participating scientists	7
Name of coordinating scientist in charge of project	Jens Christian Holst (IMR) jens.christian.holst@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	R/V Johan Hjort (65 m) R/V Fangst (17 m) R/V Hyas (15 m) R/V Johan Ruud (45 m) R/V G.M.Dannevig (20 m)
Type and amount of gear and other equipment used	Pelagic trawl Ocean-Fish-Lift (live catching device for trawls) CTD
Details of any collaborating countries	

Summary of Findings:

No summary provided.

Project No. N5 Status: Completed

Party or relevant jurisdiction	Norway, Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen
Title of project	**Distribution of salmon in relation to environmental parameters and origin in the North Atlantic- capture, tagging and release of salmon with data storage tags (DSTs)**
Objective of research project	Investigate the temporal and spatial distribution of DST- tagged salmon in the Norwegian Sea and adjacent areas with special emphasis on: Spatial distribution and temperature preferences Growth in relation to environmental parameters - Vertical distribution of salmon during day and night (relating to possibility of intercepting fisheries)
Brief description of research project	The project was a joint effort between Norway, the Faroes and Iceland, and was based on earlier experiences in these countries. The project was partly funded by the Nordic Council of Ministers. The fish were captured with a special salmon trawl with live-capture device. Viable fish (approx. 2/3 of the catch) were tagged with DSTs inserted into the stomach and released. The research was in the Northern Norwegian Sea, in October in the Faroes' EEZ and in January-February in Iceland's EEZ. An important part of the investigation consisted of retrieving tags and recapture data from angling catches in home-waters.
Dates during which research took place	2003 – 2006 (Data analysis only in 2005/2006.
Area in which research took place	The Northern North Sea - the Norwegian Sea; the Iceland Sea, the Greenland Sea
Estimated number and weight of salmon retained	30-100 large post-smolts and older salmon (approx. 50-250 kg annually)
Resources	
Estimated cost of the research project	£ 210,000 per annum in 2003 and 2004 £12,000 in 2005; £4,000 in 2006
Number of participating scientists	5 scientists
Name of coordinating scientist in charge of project	Marianne Holm, Senior Scientific Officer marianne.holm@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	R/V "Johan Hjort", Norway, LDGJ R/V "Magnus Heinason", Faroes Islands R/V "Arni Fridriksson", Iceland
Type and amount of gear and other equipment used	The ships were equipped with a specially designed trawl with live fish capture device attached to the cod end (Fish Lifter MKII, Holst & MacDonald 2000).
Details of any collaborating countries	Fisheries Research Institute, Torshavn, The Faroes The Marine Research Institute of Iceland, Reykjavik

Summary of Findings:

Within the framework of the Nordic project, 741 large post-smolts (October captures) and 1-2SW salmon had been captured in the North Atlantic by January 2005. Of these, 478 were captured and 293 were tagged with DSTs and released north of the Faroes, 28 captured and 11 tagged and released south-east of Iceland and 225 captured and 109 tagged and released in the Norwegian Sea. By January 2005, 5 of the tagged fish released in the Norwegian Sea had been recaptured. Two were re-captured in the Namsen fjord in mid-Norway after 18 and 74 days respectively and around 500 km of travel (shortest distance). Another salmon was recovered in the Trondheim fjord in June 2004 after 48 days at sea and ~ 480 km of travel. The fourth recapture was made in the Surna river after 122 days and ~ 500 km. The fifth fish was taken in the river Ätran on the Swedish west coast. This fish had travelled around 1,400 km in 127 days. 5 adipose fin-clipped salmon were found, but none of them carried a microtag. Most fish captured in April 2004 in the Norwegian Sea had entered the sea as 1-2 year-old smolts. The scale material from the Faroese catch will be analysed in 2005. Genetic samples and scales have been taken from most of the fish. In 2003 and 2004 all released salmon had an additional external yellow numbered tag (T-bar anchor) attached under the dorsal fin. In September 2004 the recapture of one such tag was reported from Scotland; unfortunately, however, the DST was either removed with the viscera or it had grown out through the body wall and shed, because it was never found. Data have been analysed in 2005 and two publications are in preparation.

Project No. N6 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**Temporal variation in abundance of the northern-most populations of Atlantic salmon with emphasis on the River Tana**
Objective of research project	The main objective of this project was to examine the importance of ocean climate, predation, marine fisheries, and smolt production as primary factors influencing the abundance of the northern-most and highly productive populations of Atlantic salmon (*Salmo salar*), with emphasis on the River Tana. Sub-goals: - • Examine the influence of ocean climate on temporal variation in Atlantic salmon abundance and life-history parameters of River Tana salmon and co-variation with salmon from other northern rivers • Evaluate the impact of predation by marine fish and birds on the abundance of River Tana salmon • Determine smolt and adult salmon abundance, initially from one tributary, as an index of marine survival for the River Tana system • Develop management plans for northern Atlantic salmon rivers by integrating biological and local knowledge of the resource.
Brief description of research project	Salmon rivers in northern-most Norway, Finland and the Kola peninsula (Russia), support important fisheries, both in coastal areas and in the rivers themselves, and contribute more than 40% of the world's freshwater catch of wild Atlantic salmon (*Salmo salar*). The River Tana, a large complex system that forms the border between northern-most Norway and Finland, at present supports the largest wild Atlantic salmon stock in the world and is also of particular importance to the Sami people. With the potential for increased exploitation of this and other northern stocks, interactions or impacts resulting from the proposed expansion of salmonid aquaculture into these northern areas, and uncertain consequences resulting from global climate change, it is important to study the dynamics of the world's largest salmon-producing rivers. Consequently, the objective of this proposal is to examine the importance of ocean climate, predation, marine fisheries, and smolt production as primary factors influencing the abundance of the northern-most and highly productive populations of Atlantic salmon, with emphasis on the River Tana. Biological knowledge gained from this project will be used in designing management strategies in cooperation with local managers.
Dates during which research took place	2002-2006
Area in which research took place	River Tana
Estimated number and weight of salmon retained	

Resources	
Estimated cost of the research project	£ 60,000 per annum
Number of participating scientists	4-6
Name of coordinating scientist in charge of project	Martin Svenning martin.svenning@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	
Details of any collaborating countries	Finland, Russia, Canada
Summary of Findings: No summary provided.	

Project No. N7 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**The importance of early marine feeding on the growth and survival of Atlantic salmon post-smolts in Norwegian fjords**
Objective of research project	The principal objective of the project (2002-2006) was to study the importance of early marine feeding on post-smolt growth and survival in coastal areas. The sub-goals were to: • Analyse spatial variation in early marine post-smolt feeding and growth along a north-south geographic scale (comparative study) • Investigate how post-smolt feeding and growth is associated with: timing of smolt descent, marine prey availability, parasite infection, fjord migration and abiotic factors (case study)
Brief description of research project	Much of the variation observed in marine survival of Atlantic salmon may be explained by differences in early post-smolt feeding and subsequent growth. Results from a pre-project indicate a prolonged fjord migration of post-smolts and extensive feeding on energy rich marine prey in northern Norway, while results from southern Norway suggest a shorter fjord residency and lower degree of feeding. However, feeding intensity varied annually within several of the systems, which may be related to variability in prey abundance on both temporal and spatial scales. We hypothesised that this may help explain why large variation in relative abundance is observed among years and why salmon populations are generally regarded as less sustainable in the south. This project studied: (A) the importance of early marine feeding and growth of post-smolts on a north-south geographical scale (comparative study). Furthermore, a detailed explanatory case study (B) provided complementary results to assist in evaluating important relationships among smolt run timing, marine prey availability, fjord migratory behaviour, incidence of marine parasites, and abiotic factors as they possibly relate to the subsequent growth and variation in abundance of adult salmon. This approach generated new knowledge important for future management of salmon populations, and contributed to a better understanding of the fluctuations in return rates of adult salmon.
Dates during which research took place	2002 - 2007
Area in which research took place	Central and Northern Norway
Estimated number and weight of salmon retained	

Resources	
Estimated cost of the research project	Total expenditure: 2002 - £130,500; 2003 - £167,000; 2004 - £153,000; 2005 - £113,750; 2006 - £68,250; 2007 - £0 (publication of results only)
Number of participating scientists	8
Name of coordinating scientist in charge of project	Bengt Finstad bengt.finstad@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	F/F Hyas and F/F Johan Ruud
Type and amount of gear and other equipment used	Fish lift trawl
Details of any collaborating countries	Department of Fisheries and Oceans, Newfoundland, Canada

Summary of Findings:

Post-smolts from southern Norway showed low feeding intensity in the fjords, whereas extensive feeding was observed in fjords in northern and middle parts of Norway. The results indicate that extensive feeding immediately after sea entrance may be more common for post-smolts in the northern and middle parts of Norway than in southern fjords. The observed differences in post-smolt feeding may be due to spatial and temporal differences in prey availability within and between different types of fjord systems, and this might influence post-smolt growth and survival. More information from these studies is given in: Rikardsen, A.H., Haugland, M., Bjørn, P.A., Finstad, B., Knudsen, R., Dempson, J.B., Holst, J.C., Hvidsten, N.A. & Holm, M. 2004. Geographical differences in early marine feeding of Atlantic salmon post-smolts in Norwegian fjords. J. Fish. Biol. 64: 1655-1679.

In another paper from the present project by Knudsen, R., Rikardsen, A.H., Dempson, J.B., Bjørn, P.A., Finstad, B., Holm, M & Amundsen, P.A. 2005. Tropically transmitted parasites in wild Atlantic salmon post-smolts from Norwegian fjords. J. Fish. Biol. 66: 758-772, it was shown that parasites of both freshwater and marine origin appear to be suitable as bio-indicators of feeding and migratory pattern of Atlantic salmon post-smolts and preadults during their seaward migration.

A third paper from this project is in press: Bjørn. P.A., Finstad, B., Kristoffersen, R., Rikardsen, A.H. & McKinley, R.S. (ICES J. Mar. Sci.). Differences in risks and consequences of salmon lice, *Lepeophtheirus salmonis* (Krøyer) infection on sympatric populations of Atlantic salmon, brown trout and Arctic charr within northern fjords. Results from this study indicate that Atlantic salmon seemingly may have a mismatch between time of lice infection and their post-smolt fjord migration in northern fjords. In contrast, brown trout and Arctic charr feed within the fjords throughout the summer and consequently have a higher risk of harmful infections in years with suitable environmental conditions for salmon lice development, especially in fish-farming areas.

For 2007, 3-4 more papers will be published from this project.

Project No. N8 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**Distribution and ecology of post-smolts and salmon at sea**
Objective of research project	By analysing age, growth, migratory paths in relation to environmental conditions and competitors, describe and expand the understanding of salmon marine life history in order to provide explanations to observed variations in salmon survival. Test hypotheses on: 1. Independence of relationships between food availability and post-smolt feeding and growth 2. Post-smolt migration and distribution in time and space 3. Salmon stock separation/overlap in time and space
Brief description of research project	The oceanic phase of the Atlantic salmon and the influence of the marine environment encountered upon growth and survival of salmon stocks is increasingly recognised as an important stock regulatory factor among salmon scientists and managers. Knowledge of the migrations, the geographic distribution and general ecology of post-smolts and larger Atlantic salmon in oceanic waters is still sparse. The project followed up on and expanded a project started in 1995. Based on data needs identified during 1995 – 2002, new data were collected on cruises in 2003- 2005 and the project also provided historical and new post-smolt data to several other projects. Within the scope of a post-graduate fellowship, growth potential and patterns of post-smolts were examined by energetic content in fish and feed, and by computer-based image analysis of scale samples to assess influences of environmental traits on post-smolt growth and survival and to assess if it is possible to separate northern and southern European salmon stocks.
Dates during which research took place	2002 – 2007
Area in which research took place	West of Ireland – Faroes, northern North Sea, the Norwegian Sea
Estimated number and weight of salmon retained	• 5-10 salmon, total 30kg • 150-250 post-smolts, total 15kg
Resources	
Estimated cost of the research project	£120,000 per annum, including Ph.D. grant, and running costs, matching funds for ships and scientists at IMR and cooperative institutes
Number of participating scientists	8 scientists
Name of coordinating scientist in charge of project	Marianne Holm, marianne.holm@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	• R/V “Johan Hjort”, Norway, LDGJ

Type and amount of gear and other equipment used	The ship was equipped with a specially designed trawl with live fish capture device attached to the cod end (Fish Lifter MKII, Holst & MacDonald 2000).
Details of any collaborating countries	Fisheries Research Institute, Torshavn, Faroe Islands

Summary of Findings:

By June 2004 a total of 1,767 post-smolts (850 and 917 in 2002 and 2003 respectively) and 124 adults have been captured since 2002 within this project. Of the adults, 27 have been tagged and released (cfr. project N5). The age structure of these fish is in conformity with earlier observations and, except for near the Norwegian coastline, smolt ages 1 and 2 are dominating the captures, i.e. these are fish of "southern origin". The post-smolts have been distributed over the same areas as previously recorded. The northern extension of the densest cohorts in recorded in June-July may vary somewhat within a couple of weeks, probably influenced by conditions at the time of migration and meteorological conditions at sea. Within the framework of the PhD scholarship the stomach contents have been analysed and fish larvae/0-group of varying species followed by amphipods seem to be dominating the diet. In 2002 when the herring larvae were abundant, the condition factor of the post-smolts was 1.19 on average, the highest recorded since the start of the marine investigations in 1995. In 2002 and 2003, 9 Irish, 1 Norwegian and 4 Irish microtags were recovered from the Norwegian Sea. High catches of mackerel have been recorded in the same hauls as post-smolts. In May – June 2004 around a hundred post-smolts were captured during a mackerel survey going from northwest Ireland to the Faroes. The salmon trawl was used for mackerel sampling. Results from the project are published in ICES reports, several scientific journals and 2 books.

Due to a reduction in available ship time, there was no cruise dedicated to post-smolt surveys in 2006. However, in 2006, 7 adults and 46 post-smolts were captured as by-catch in 4 different pelagic cruises. All fish except one adult taken in a SW- Norwegian fjord, were caught in the Norwegian Sea between 69.9 – 74.5 °N. The fish were caught in May (1 adult), June (5 adults), August (46 post-smolts) and November (1 adult). The post-smolts were all taken in one haul in one of the northern-most positions ever recorded during the salmon surveys. Within the framework of a PhD scholarship, the stomach contents have been analysed. Fish larvae/0-group of various species appear to dominate the diet followed by amphipods. In 2002 when the herring larvae were abundant, the condition factor of the post-smolts was, on average, 1.19, the highest recorded since the start of the marine investigations in 1995. Results from the project have been published in ICES reports, several scientific journals and two books. No ship time has been allocated for dedicated salmon investigations in 2007 and only occasional captures of salmon can be expected from surveys for pelagic fish other than salmon.

Project No. N9 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**Dispersal of salmon lice in Norwegian fjords**
Objective of research project	Estimate and describe to what extent free-living salmon lice larvae disperse from wild and farmed sources within and between areas.
Brief description of research project	1) Sentinel cages containing farmed salmon smolts free of salmon lice are used as passive traps to estimate the level of free living salmon lice larvae along the geographical length of the Hardanger fjord (16 in total). 2) Hydrographical measurements and other measure methods are used to make physical oceanographic models of currents. A particle model is developed to predict the dispersal of larvae.
Dates during which research took place	2007 Two surveys, one in May and one in June.
Area in which research took place	Hardangerfjord, Norway
Estimated number and weight of salmon retained	None, only farmed fish will be used
Resources	
Estimated cost of the research project	£131,000
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Karin Kroon Boxaspen karinb@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	R/V G.M Dannevig,
Type and amount of gear and other equipment used	Sentinel cages, equipment for hydrographical measurements
Details of any collaborating countries	
Summary of Findings: No summary provided.	

Project No. N10 Status: Completed

Party or relevant jurisdiction	Norway, Scotland
Title of project	**Experimental tagging programme for investigating the behaviour of escaped farmed salmon: pilot study**
Objective of research project	The objective was to examine migration of escaped large farmed salmon and to test if they are transported with the currents and appear in Norwegian waters.
Brief description of research project	
Dates during which research will take place	2006 - 2007
Area in which research will take place	
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	Lars Petter Hansen (l.p.hansen@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	

Summary of Findings:

Farmed Atlantic salmon reared at Ardmair near Ullapool in Scotland and at Rognaldsvåg outside Florø in Norway were individually tagged with external Lea tags and released from the fish farms in the spring of 2006 (Ardmair: 678 with mean length of 719 mm; Rognaldsvåg: 597 with mean lenth of 721 mm). Most of the salmon were expected to be sexually mature the autumn of 2006.

Five tags from the Scottish release (0.6% of the total number relased) have been reported recaptured, one was found on a beach in Scotland a bit north of the release site. Another tag was found on a beach in Shetland. A tagged salmon from the same batch was recaptured on the in the Göta River on the west coast of Sweden, and another was recaptured at the outlet of the Hardangerfjord in south west Norway. The fifth one was recaptured at the Lofoten area in north Norway.

Of the fish released from the Norwegian fish farm 42 have been recaptured (7 % of the number released). Most of the fish moved relatively quickly into nearby fjords and entered rivers there, only one individual moved a large distance, and was recaptured in the Drammenfjord in south east Norway. Salmon released from the Norwegian fish farm showed a much higher survival that the fish released at the Scottish farm and their migration pattern was very local. The migration pattern of the salmon released in Scotland can be explained by transport with the currents, and therefore some large salmon escaping from fish farms in this area in the spring may turn up in Norway and west coast of Sweden.

Project No. N11 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**Individual assignment of salmon caught in the ocean to region of origin**
Objective of research project	Investigate genetic variation in Norwegian Atlantic salmon populations on different spatial scales; national, regional and within-river. Provide calibrated data on microsatellite markers for a database. Conduct genetic analysis of samples of ocean-caught salmon and attempt assignment of these samples to country/region of origin.
Brief description of research project	Samples were collected from approximately 30 Norwegian salmon rivers, spanning all geographical regions. One region was investigated in more detail, with sampling of all major rivers in the region and one river system was also sampled in more detail, covering all tributaries. All samples were analysed for the set of 15 SALMAN microsatellites. The variation in these markers on three spatial scales were investigated, to see if composite genetic signatures of rivers and regions can be built by aggregating data from individual components. The data were calibrated and made available for a common database of salmon populations. A collection of ocean samples of salmon was analysed, and assignment of these samples to country, region or river of origin was attempted.
Dates during which research took place	January 2006 – March 2009
Area in which research took place	Norway, nationwide
Estimated number and weight of salmon retained	3,000 parr, 30 kg
Resources	
Estimated cost of the research project	Total cost: £320,000 Staff costs (incl. overheads): £258,000 (Overheads: £88,000 Consumables, field work, meetings, and equipment: £55,000 Purchase R&D services: £7,000
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	Øystein Skaala Oystein.Skaala@imr.no Vidar Wennevik Vidar.Wennevik@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	Electrofishing equipment. Molecular biology laboratory at the Institute of Marine Research, Bergen, Norway

Details of any collaborating countries	Finland (Craig Primmer and Anti Vasemägi, University of Turku, Finland. Investigation of variation in EST-markers in Norwegian salmon populations)

Summary of Findings:

The project was originally intended to be completed by December 2008, but was extended to March 30 2009. During the projects final year, genotyping for 15 microsatellite markers has been completed for 35 Norwegian rivers, as well as for 1800 samples from ocean caught salmon. Further, a selection of samples from 8 different rivers, with differing environmental conditions, have been screened for a large number of EST-microsatellites and indel-markers in cooperation with the University of Turku, Finland. Presently data are being readied for analysis, and inclusion into the pan-European database developed for the EU-project SALSEA-Merge.

Project No. N12 Status: Completed

Party or relevant jurisdiction	Norway, Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway
Title of project	**Migratory behaviour of smolts and post-smolts of cultured Atlantic salmon**
Objective of research project	To study the change in migratory behaviour from smolts during the post-smolt stages in cultured Atlantic salmon.
Brief description of research project	Cultured 1+ smolts and groups of cage-reared postsmolts were tagged with acoustic transmitters and released at various dates from May to October 2008 from Matre Research Station. Cultured 0+ (autumn) smolts and post-smolts were tagged and released from September to December 2008.Their migratory behaviour was recorded by receivers covering the 22 km long Masfjorden.
Dates during which research took place	May 2008 – January 2009
Area in which research took place	Masfjorden, western Norway
Estimated number and weight of salmon retained	
Resources	
Estimated cost of the research project	Total 2008: £100,000: £22,500; salary: £22,500; equipment: £50,000; other costs: £5,000 Total 2009: £40,000; overheads: £20,000; salary: £20,000
Number of participating scientists	2
Name and e-mail address of coordinating scientist in charge of project	Ove Skilbrei ove.skilbrei@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment used	
Details of any collaborating countries	

Summary of Findings:

Results have been submitted for publication. Migratory behaviour was highly developed in 1+ smolts and in post-smolts released 6 weeks later, but was gradually lost during autumn, when many fish resided and were recaptured in the fjord. Data on 0+ smolts not analyzed yet.

Project No. N13 Status: Ongoing

Party or relevant jurisdiction	Norway, Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway
Title of project	**Significance of salmon lice for growth and survival of salmon in the sea**
Objective of research project	To estimate the effects of salmon lice on post-smolt growth and survival, dependent on release site, and time and year of release.
Brief description of research project	Cultured smolts have been treated against salmon lice, tagged with microtags and released in the River Dale, western Norway, each year from 2002 to 2010. The effect of the time of "escape" is studied by releasing T-bar anchor tagged smolts and post-smolts from May to August from Matre Research Station in 2005, 2007 - 2010. A comparison of the effect of salmon lice in fjord versus coastal areas is done by releasing smolts in both environments; from Matre and at the nearby coast in 2006 and 2007, and from Dale River and at the coast from 2007 to 2017. Further releases will occur in 2018.
Dates during which research will take place	2006 –
Area in which research will take place	Western Norway; River Dale, Matre Aquaculture Station and nearby coast.
Estimated number and weight of salmon to be retained	Catch of adult tagged fish: 30-300 fish each year.
Resources	
Estimated cost of the research project	Total: £75,000 per annum; overheads: £25,000; salary: £33,000; equipment: £13,000; other costs: £4,000
Number of participating scientists	3
Name and e-mail address of coordinating scientist in charge of project	Vidar Wennevik, vidar.wennevik@imr.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	No vessels
Type and amount of gear and other equipment to be used	Tags; 25,000 microtags,
Details of any collaborating countries	

Summary of Progress:

Returns of grilse to the River Dale were sufficient for statistical analysis in 2002 and 2003 and an effect of salmon lice was observed. The marine survival of smolts seems to have been very low in the following years, with no differences between treated and control groups, except for a higher survival and significant benefit for treated smolts released at the coast 2007. The sizes of 1-SW and 2-SW of released fish and wild fish of the River Dale stock have been have decreased markedly during the last 7 years and the ratio between 1-SW and older fish has also decreased – pointing to the possibility that the conditions in the sea has become poorer during recent years.

Results from the project have been published in:

Skilbrei, O. T., Finstad, B., Urdal, K., Bakke, G., Kroglund, F., & Strand, R. 2013. Impact of early salmon louse, Lepeophtheirus salmonis, infestation and differences in survival and marine growth of sea-ranched Atlantic salmon, Salmo salar L., smolts 1997–2009. Journal of Fish Diseases, 36: 249-260.

Krkošek, M., Revie, C. W., Gargan, P. G., Skilbrei, O. T., Finstad, B., & Todd, C. D. 2013. Impact of parasites on salmon recruitment in the Northeast Atlantic Ocean. Proceedings of the Royal Society B: Biological Sciences, 280.

Vollset, K. W., Barlaup, B. T., Skoglund, H., Normann, E. S., & Skilbrei, O. T. 2014. Salmon lice increase the age of returning Atlantic salmon. Biology Letters, 10.

Vollset, K. W., Barlaup, B. T., Mahlum, S., Bjørn, P. A., & Skilbrei, O. T. 2016. Estimating the temporal overlap between post-smolt migration of Atlantic salmon and salmon lice infestation pressure from fish farms. Aquaculture Environment Interactions, 8: 511-525.

Project No. N14 Status: Ongoing

Party or relevant jurisdiction	Norway
Title of project	**Marine survival, growth and exploitation of salmon from the Rivers Figgjo, Imsa, Drammenselv and Halselv**
Objective of research project	1. Estimation of marine survival 2. Estimation of marine growth 3. Estimation of marine exploitation 4. Data input in predictive models 5. Monitoring
Brief description of research project	Maintain time series of smolt taggings (wild and hatchery-reared) and tag returns in index rivers. Use the information to study fluctuations in marine survival and growth as well as describe changes in marine exploitation.
Dates during which research will take place	Long-term ongoing monitoring project
Area in which research will take place	Tagging in rivers Figgjo, Imsa, Drammenselv and Halselv with tag recovery programme in fisheries along Norwegian coast and elsewhere. Tagging with PIT tags in other rivers along the Norwegian coast.
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	Approximately £134,000 per annum
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	Peder Fiske peder.fiske@nina.no Nina Jonsson nina.jonsson@nina.no Arne Johan Jensen Arne.jensen@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Fish traps, electric fishing
Details of any collaborating countries	

Summary of Progress:

The long-term monitoring of salmon from the four rivers has revealed that marine survival has improved compared with the poor survival in the late 1990s. Survival rates of wild and hatchery-reared salmon are correlated. Survival rates of 1SW fish are correlated with survival rates of 2- and 3SW fish from the same smolt cohort. There is a significant relationship between growth and survival, and slow-growing individuals tend to become sexually mature at a higher sea age than fast-growing individuals. In recent years the marine growth of returning grilse have decreased.

The marine exploitation rates have continued to decrease. In the River Halselv a significant correlation has been found between return rates of first-time migrants of sea trout and sea charr, and return rates of salmon of the same smolt year class. No smolts were tagged in River Halselv and River Drammenselv since 2011, and the registration of returning fish in River Halselv has ceased. There has been no tagging in the river Figgjo since 2015.

Work is underway to increase the number of rivers in Norway where at sea survival are studied by using PIT-tagged smolts and automated antennas in the lower parts of the rivers. In 2016 wild smolts were tagged in two Norwegian rivers (Vigda and Moaelva), and PIT-antennas to monitor their movements were installed. In 2017, wild smolt were tagged in six rivers (Vigda, Moaelva, Kongfjordelva, Gaula (Sunnfjord), Etne and Vegårdsvassdraget). In Imsa both Carlin and PIT- tagged smolts were released. Returning one-sea-winter fish were registrered in Vigda and Moaelva. In 2018 the PIT-tagging will continue.

Project No. N15 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**Population-limiting mechanisms for Atlantic salmon during early estuarine and coastal migration (SalPoP)**
Objective of research project	The main objectives of the project are to: o Map migratory behaviour and quantify where, when and why mortalities of Atlantic salmon post-smolt occur. o Correlate data on migration and mortalities with health status and major population-limiting factors. o Significantly contribute to the future sustainability of Atlantic salmon populations by developing improved mitigating actions and management strategies.
Brief description of research project	The proposed project consists of five integrated workpackages (WPs). The first four WPs are aimed at examining specific population limiting factors, while WP5 is aimed at summarising the results in order to evaluate actions and management strategies for maintenance and re-establishment of wild Atlantic salmon populations. Groups of smolt will be exposed to various contaminants using a common protocol to establish dose response relationships affecting smolt health. Fish health will be assessed on basis of physiological, immunological and morphometric measurements. Movements, behaviour and survival will be studied with both acoustic telemetry methodology for smaller sub-samples and with external tagging methodology for some larger sub-samples. The use of telemetry will provide more detailed and comprehensive knowledge regarding survival and behaviour of the post-smolt than has been possible in earlier large scale external tagging studies.
Dates during which research will take place	January 2008 – January 2012
Area in which research will take place	Eresfjord in Møre and Romsdal, middle Norway
Estimated number and weight of salmon to be retained	Wild and farmed salmonids
Resources	
Estimated cost of the research project	Funding from the Norwegian Research Council, Statkraft Energy AS and The Norwegian Directorate for Nature Management: 2008: £191,200 (NOK 1,950 000) 2009: £209,800 (NOK 2,140 000) 2010: £200,000 (NOK 2,040 000) 2011: £124,500 (NOK 1,270 000)
Number of participating scientists	15

Name and e-mail address of coordinating scientist in charge of project	Bengt Finstad bengt.finstad@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	Prof. Thrandur Björnsson and Dr. Ingibjörg E. Einarsdottir - Göteborg University (GU) Dr. Andy Moore – Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Prof. Robert Scott McKinley - University of British Columbia (UBC)

Summary of Findings:

Both the telemetry (acoustic) and laboratory experiments (contaminants) have been performed in the 2010 field season and a progress report to the Norwegian Research Council has been submitted and approved by the Council. 2011 will be used for reporting and publishing of results from the present project. Data from the present project was presented at the 1st International Conference on Fish Telemetry in Japan summer of 2011. Results from the project are presented in two recent papers:

Thorstad, E. B., Uglem, I., Finstad, B., Chittenden, C. M., Nilsen, R., Økland, F., & Bjørn, P. A. 2012. Stocking location and predation by marine fishes affect survival of hatchery-reared Atlantic salmon smolts. Fisheries Management and Ecology, 19: 400-409.

Thorstad, E.B., *et al*., Reduced marine survival of hatchery-reared Atlantic salmon post-smolts exposed to aluminium and moderate acidification in freshwater, Estuarine, Coastal and Shelf Science (2013), http://dx.doi.org/10.1016/j.ecss.2013.03.021

Project No. N16 Status: Completed

Party or relevant jurisdiction	Norway
Title of project	**The Hardangerfjord salmon lice project**
Objective of research project	Even though strategies for lice treatment in fish farms have been greatly improved during recent years there still remain episodes of high lice infestation on wild salmonids in the Hardangerfjord system. Therefore, there is a need to extend the time series to cover more combinations of environmental and management factors which influence salmon lice levels on the different salmonid populations. This will enable us to obtain a better understanding of the fjord system by: 1. Improving sea lice monitoring and management on individual farms and the region in general by fjord integrated pest management and synchronized delousing processes. 2. Evaluating the success of sea lice management strategies in the Hardangerfjord through investigation of the infection level on farmed and wild fish. 3. Quantifying the abundance and distribution of salmon lice in the Hardangerfjord area based on the physical oceanographical and meteorological conditions for a given salmon lice production. 4. Analyzing data sets being collected at the Hardangerjord for possible risk factors associated with varying lice infection pressure with the aim of developing a mathematical population model for the Hardangerfjord system. Results obtained in this project can also be used for other fjord systems globally in management schemes aimed at minimising the risk of salmon lice infestation on wild and farmed fish stocks.
Brief description of research project	This three-year research effort will focus on the interactions of salmon lice between farmed and wild salmonids in the Hardangerfjord and will be a continuum of the project which was initiated in 2004 (see: http://www.nina.no and the attachment to the present application; NFRProgressReportHardanger2005). The applied project consists of four closely linked workpackages: 1) Salmon lice abundance on wild and escaped salmonids; 2) Optimised salmon lice monitoring and control strategies in farms; 3) Understanding the physical oceanographical factors on salmon lice abundance and distribution in the Hardangerfjord and 4) Development of a mathematical population model for the Hardangerfjord system. The Hardangerfjord has the largest density of fish farms in Norway. However, even though strategies for lice treatment in fish farms have been greatly improved during the present project, we still experience episodes of high lice infestation on wild salmonids in this fjord. Therefore, there is a great need to extend the time series to cover and understand more of the different combinations of environmental and managemental factors which influence salmon lice levels on the different salmonid populations. By using and combining the long-time results from the project our overall goal is to develop a mathematical population model for the Hardangerfjord system which can be used in management schemes aimed at minimising the risk of salmon lice infestation on wild and farmed fish stocks.

	Epidemiological models in combination with lice dispersal models is vital to understand the complex relationship between hosts, parasites, environment and measures taken in fish farms. Modelling will also give advice to the industry for optimal placement of fish farms within a fjord system. The degree of international collaboration also shows that results obtained in this project can be used for other fjord systems globally in management schemes aimed at minimising the risk of salmon lice infestation on wild and farmed fish stocks.
Dates during which research will take place	January 2007- June 2010
Area in which research will take place	Hardangerfjord at the Norwegian West Coast
Estimated number and weight of salmon to be retained	Wild- and farmed salmonids
Resources	
Estimated cost of the research project	Funding from The Norwegian Fisheries and Aquaculture Research Fund and the Norwegian Research Council: 2007: £143,600 (NOK 1,465 000) 2008: £151,000 (NOK 1,540 000) 2009: £149,000 (NOK 1,520 000)
Number of participating scientists	14
Name and e-mail address of coordinating scientist in charge of project	Bengt Finstad bengt.finstad@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	Prof. Robert Scott McKinley, University of British Columbia (UBC) Dr. Crawford Revie and Prof. George Gettinby, University of Strathclyde

Summary of Findings:

All 4 work packages (see above) have been performed in the 2009 field season and a progress report to the Norwegian Research Council has been submitted and approved by the Council. A final report for the project period has been delivered and can be obtained at the website www.fiskerifond.no “alle nyheter” page 2 “Bærekraftig lusesituasjon i Hardanger?” Results from this project are also in press in Aquaculture (e.g. Gettinby *et al*. 2011).

Project No. N17 Status: Completed

Party or relevant jurisdiction	Norway, Norwegian Institute for Nature Research, Trondheim, Norway
Title of project	**Origin of Atlantic salmon off Svalbard**
Objective of research project	To identify the origin of Atlantic salmon occurring in gill net fisheries at Isfjorden, Spitsbergen, by life history (age, growth) and genetic analyses.
Brief description of research project	Some individuals of Atlantic salmon were caught as by-catch in a gill net fishery outside Longyearbyen, Svalbard during the years 2008-2010. During these three years, 42, 41, and 56 samples were collected, respectively. Life history (age, growth) and genetic analyses of these individuals have been analysed.
Dates during which research will take place	September 2008 – February 2012
Area in which research will take place	Isfjorden, Spitsbergen
Estimated number and weight of salmon to be retained	130
Resources	
Estimated cost of the research project	£22,500 (i.e. £7,500 per year)
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	Arne Johan Jensen (arne.jensen@nina.no)
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Gill nets
Details of any collaborating countries	

Summary of Findings:

In total, 139 Atlantic salmon were caught. The mean length was 652 ± 8 mm (variation 500-925 mm), with a sea age distribution of 71% 1SW and 29% 2SW fish. Predominating smolt ages were 3 and 4 years (variation 2-5 years). Seven individuals were escapees from the fish farming industry, while most of the other individuals were genetically assigned to northern Norway. Results from the project have been published in:

Jensen, A. J., Karlsson, S., Fiske, P., Hansen, L. P., Hindar, K., & Østborg, G. M. 2013. Escaped farmed Atlantic salmon grow, migrate and disperse throughout the Arctic Ocean like wild salmon. Aquaculture Environment Interactions, 3: 223-229.

Jensen, A. J., Karlsson, S., Fiske, P., Hansen, L. P., Østborg, G. M., & Hindar, K. 2014. Origin and life history of Atlantic salmon (Salmo salar) near their northernmost oceanic limit. Canadian Journal of Fisheries and Aquatic Sciences, 71: 1740-1746.

Project No. N18 Status: Completed

Party or relevant jurisdiction	Norway, Tromsø
Title of project	**SALMOTRACK - Electronic tracking of northern anadromous salmonids**
Objective of research project	To track different life-stages of northern Atlantic salmon and other anadromous species in river, fjord and open ocean.
Brief description of research project	The open ocean migration is the main production phase of Atlantic salmon, but also the least understood of the species life cycle. Only small ecosystem changes affecting growth and survival can have dramatic effects, as seen for this species in the last years. Mapping the population specific marine feeding areas and understanding the temporal and spatial factors affecting salmon abundance are therefore probably the biggest challenges in salmon ecology today. New development within satellite tracking technology has now for the first time made it possible to track ocean migrating salmon with miniaturized pop-up satellite tags (PSATs) over long periods. By utilizing a combination of new data and data collected from a very recent large-scale project, combined with extensive national and international cooperation and one postdoc position, the present project aim to 1) model the individual complete migration pattern of salmon from different locations around and in the North Atlantic Ocean. We will further 2) analyse the vertical diving patterns and model marine growth, as well as 3) estimate the main area and time of mortality and identify their possible main predators. Finally we will 4) test if nesting success of sea bird colonies can assist in making salmon survival prognosis. In sum the suggested project will add unique and new information about salmon migration in the open ocean, which will be important as basic knowledge to understand the present situation, temporal trends and assist in risk assessments for the future of salmon populations. It will also assist in the management and conservation of this economically important species.
Dates during which research will take place	2006-2012 and 2013-2017
Area in which research will take place	Northern Norway (Alta, Neiden, Tana, Skibotn, 2007-2012), Middle Norway (Orkla, 2010), Western Norway (Hardangerfjord, 2006).
Estimated number and weight of salmon to be retained	Electronic tagging of all stages from parr and smolts to adults.
Resources	
Estimated cost of the research project	Approximately £250,000 per annum No expenditure in 2017; publications of findings only.
Number of participating scientists	About 25 Norway: University of Tromsø (9), Norwegian Institute of Nature Research (5) and the Norwegian Institute of Marine Research (2) Several international participants, see below
Name and e-mail address of coordinating scientist in charge of project	Audun H. Rikardsen, audun.rikardsen@uit..no

Details of research vessels, e.g. name, registration, call sign and description of vessel	22 ft Buster Magnum with 150 HP engine (on trailer) FF Johan Ruud (100 ft trawler)
Type and amount of gear and other equipment to be used	Different telemetry equipment and tags (PIT, acoustic, radio, archival, PSAT's)
Details of any collaborating countries	Kim Aarestrup (Denmark), David Righton (UK), Paddy Gargan (Ireland), R. Scott McKinley (Canada), Brian Dempson (Canada), Jaakko Erkinaro (Finland), Ben Letcher (US), Hiro Mitamura (Japan)

Summary of Progress:

The project has so far been very successful, and has already obtained new and important information related to migratory behaviour of northern salmonids. In total, more that 1,900 fish (mostly salmon, but also charr, trout, pike and eel) have been tagged with electronic tags (acoustic, archival, radio, satellite pop-up archival tags) from 2006 to 2010. In addition, 4,000 salmon parr have been tagged with PIT-tags. Work is underway to report the salmon migration results in international publications. Results from the study have been published in:

Hedger, R. D., Rikardsen, A. H., & Thorstad, E. B. 2017. Pop-up satellite archival tag effects on the diving behaviour, growth and survival of adult Atlantic salmon Salmo salar at sea. Journal of Fish Biology, 90: 294-310.

Strøm, J. F., Thorstad, E. B., Hedger, R., & Rikardsen, A. H. 2018. Revealing the full ocean migration of individual Atlantic salmon. Animal Biotelemetry, 6: in press.

Project No. N19 Status: Completed

Party or relevant jurisdiction	Norway, Finland and Russia Lead partner: The Office of the Finnmark County Governor of, Norway
Title of project	**Trilateral cooperation on our common resource; the Atlantic salmon in the Barents region ("Kolarctic salmon 2011-2013")**
Objective of research project	The project aims to: • develop an integrated, long-term management of Atlantic salmon in the northernmost distribution areas of the species. • provide data to implement customized, sustainable, knowledge-based harvesting regimes, and to preserve the rich traditions of fishing and coastal culture. The number of escaped salmon will be systematically identified and the information used to make recommendations on dealing with these. • unite empirical knowledge (local and traditional) with scientific knowledge. • provide synthesized and new knowledge about Atlantic salmon, its adaptation to climate change and its migration along the coast.
Brief description of research project	The project will apply genetic methods to identify river of origin of salmon caught in coastal fisheries in North Norway and Russia. A genetic baseline covering about 150 rivers is under development. Investigating the catch composition of mixed-stock coastal fisheries in time and space will provide a better understanding of migration routes and timing of spawning runs for rivers in different regions, and provide knowledge that will allow more targeted fisheries regulations in the northern regions of Europe.
Dates during which research will take place	Jan 2011 – Dec 2013
Area in which research will take place	Barents region; Northern Norway, Finland and Russia
Estimated number and weight of salmon to be retained	3,000 fry and parr
Resources	
Estimated cost of the research project	£2,400,000 50% National funding from Finland, Russia, Norway, 50% from the Kolarctic ENPI CBC programme
Number of participating scientists	ca 12
Name and e-mail address of coordinating scientist in charge of project	Project leader: Bente Christiansen, fmfibch@fylkesmannen.no Project coordinator: Tiia Kalske, fmfithk@fylkesmannen.no, Fylkesmannen i Finnmark/ The Office of the Finnmark County Governor

Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Electrofishing equipment, collection of samples from commercial bag nets and bend nets (just in Finnmark) in coastal waters, research fishery nest in Russian Kola Peninsula estuarine and coastal waters, traditional coastal and estuarine fishing nets on the Russian White Sea coast.
Details of any collaborating countries	Finland, Russian Federation. Norwegian Institute for Nature Research (NINA), Norway, Institute of Marine Research (IMR), Norway, University of Turku – Kevo Research Station (UTU-Kevo), Finland, Finnish Game and Fisheries Research Institute (FGFRI), Finland, Polar Research Institute for Marine Fisheries and Oceanography – Murmansk and Archangelsk PINRO, Russia
Summary of Findings: For more details visit the project web site: www.fylkesmannen.no/kolarcticsalmon	

Project No. N20 Status: Completed

Party or relevant jurisdiction	Norway, Scotland
Title of project	**Effects of salmon lice on wild salmonid populations; filling in knowledge gaps (LicePop)**
Objective of research project	Some of the most important knowledge gaps can be summarised by the following questions: Q1) To what extent do lice from farms occur on wild fish? i.e. to what extent do farms increase abundance of lice on wild fish? Q2) How many lice does a wild fish tolerate under natural conditions before its viability is compromised? Q3) To what extent are wild fish able to combat lice infection through adaptations aimed at reducing infestations? Q4) Can, or to what extent can, sea lice reduce or regulate wild populations of salmonids?
Brief description of research project	This project will provide new empirical knowledge that is essential for understanding how and to what extent salmon lice from fish farms affect wild salmonid populations. Questions raised in this study are: Q1) To what extent do lice from farms occur on wild fish? i.e. to what extent do farms increase abundance of lice on wild fish; Q2) How many lice does a wild fish tolerate under natural conditions before its viability is compromised; Q3) To what extent are wild fish able to combat lice infection through adaptations aimed at reducing infestations; Q4) To what extent can sea lice reduce or regulate wild populations of salmonids. These questions will be answered through a combination of field and laboratory studies and through modelling of population effects. The project consists of three work packages: WP1) Test the tolerance levels for sea lice in wild salmonids – by laboratory studies; WP2) Determine natural adaptations of wild salmonids to reduce infection levels – by behavioural studies in the wild; WP3) Determine whether, or to what extent, sea lice reduce or regulate wild populations of salmonids – by modelling.
Dates during which research will take place	Jan 2013 – Dec 2015
Area in which research will take place	Hardangerfjord, Norway
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	£900,000
Number of participating scientists	ca 17

Name and e-mail address of coordinating scientist in charge of project	Bengt Finstad, bengt.finstad@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	
Type and amount of gear and other equipment to be used	Telemetry,
Details of any collaborating countries	Norway: Norwegian Institute for Nature Research (NINA), Institute of Marine Research (IMR), Norwegian Veterinary Institute (NVI) New Zealand: University of Otago (UoO) UK(Scotland): University of St. Andrews (USTAN)

Summary of Findings:

Results from the project have been published in:

Arechavala-Lopez, P., Thorstad, E. B., Todd, C. D., Uglem, I., Bjørn, P. A., Gargan, P., Vollset, K. W., Halttunen, E., Kålås, S., Berg, M., & Finstad, B. 2015. Efectos del piojo del salmón Lepeophtheirus salmonis (Copepoda: Caligidae) en las poblaciones de truchas (Salmo trutta) de la costa NE Atlántica. Effects of salmon lice Lepeophtheirus salmonis (Copepoda: Caligidae) on sea trout (Salmo trutta) populations from the NE Atlantic coast. Revista de Biología Marina y Oceanografía, 50: 411-426.

Arechavala-Lopez, P., Uglem, I., Berg, M., Bjørn, P. A., & Finstad, B. 2016. Large-scale use of fish traps for monitoring sea trout (Salmo trutta) smolts and sea lice (Lepeophtheirus salmonis) infestations: efficiency and reliability. Marine Biology Research, 12: 76-84.

Arechavala-Lopez, P., Berg, M., Uglem, I., Bjørn, P.-A., & Finstad, B. 2016. Variations in coastal fish species composition captured by traps in Romsdalsfjord, Western Norway. International Aquatic Research, 8: 109-119.

Gjelland, K., Serra-Llinares, R. M., Hedger, R. D., Arechavala-Lopez, P., Nilsen, R., Finstad, B., Uglem, I., Skilbrei, O. T., & Bjørn, P. A. 2014. Effects of salmon lice infection on the behaviour of sea trout in the marine phase. Aquaculture Environment Interactions, 5: 221-233.

Project No. N21 Status: Ongoing

Party or relevant jurisdiction	Norway
Title of project	**Salmon migrating through a maze in a changing world: building a dynamic management regime for a multi-stock system affected by extensive mixed-stock fisheries**
Objective of research project	Analyze and explain the historical variation and recent decline in the abundance of Atlantic salmon from different sub-populations of the Tana complex
Brief description of research project	The study will apply a comprehensive Atlantic salmon genetic baseline to identify and estimate the contribution of individual stock components of the mixed-stock fishery, both in North-Norwegian coastal areas, and within the River Tana itself. The same genetic methods would be used to develop a temporal and spatial stock-migration model for the largest salmon stocks in the Barents Sea.
Dates during which research will take place	January 2015-2018
Area in which research will take place	Barents Sea and Tana river
Estimated number and weight of salmon to be retained	Historical data includes ca. 30 000 salmon (no “new” salmon will be captured/retained)
Resources	
Estimated cost of the research project	The total cost of the project is approximately £653,000, of which £466,500 is financed from the Norwegian Research Council, and £186,500 From NINA (own funding). Most of the cost is contributed to salary.
Number of participating scientists	8 researchers
Name and e-mail address of coordinating scientist in charge of project	Martin-A. Svenning martin.svenning@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	No vessel
Type and amount of gear and other equipment to be used	No new sampling
Details of any collaborating countries	Main collaborating countries are Norway, Finland and Canada

Summary of Progress:

The results achieved so far show that exploitation varies strongly among stocks. The estimated proportions of the pre-fishery abundance in the coastal fisheries for Tana salmon were for instance less than 15 %, while the exploitation rates for Alta salmon were close to 50 %.

The migration patterns also seem to differ strongly among populations. The Målselv salmon reach the coast in a narrow pattern from the west, with a minimum navigation along the outer coast, whereas Tana salmon, as opposed to both Målselv and Alta salmon, was present in the outer coastal catches from nearly all fishing locations along the North-Norwegian coast.

Project No. N22 Status: New Entry

Party or relevant jurisdiction	Norway
Title of project	**ATLANTIC SALMON AT SEA - factors affecting their growth and survival (*SeaSalar*)**
Objective of research project	Examine sources of temporal and spatial variation in the survival of Atlantic salmon at sea, and establish a long-term inter-institutional collaboration platform, as a hub for present and future projects with strengthened collaborative use of data
Brief description of research project	Atlantic salmon is an important source of local income through fisheries, and a symbol of environmental quality and sustainability. Population sizes on both sides of the Atlantic have declined since the 1980s, both because of human impacts in rivers and coastal areas - and ecosystem effects in the ocean causing increased marine mortality. Although Atlantic salmon is a well-studied species, there is still lack of understanding of why the marine mortality has increased. The main objectives of this new project are to examine sources of temporal and spatial variation in the survival of Atlantic salmon at sea, and establish a long-term inter-institutional collaboration platform, as a hub for present and future projects with strengthened collaborative use of data. The project is funded by the Norwegian Research Council (NOK 21 mill.) and own funding from the institutions involved (NOK 15 mill.). The Norwegian Institute for Nature Research (NINA), the Institute of Marine Research (IMR) and the Arctic University of Norway (UiT) are the lead institutions of the project. Together with experts in the field from several other Norwegian (UNI Research and Rådgivende Biologer) and international research institutions, they have formed a consortium aiming to build a knowledge platform and study how the marine survival of Atlantic salmon is affected by abiotic and biotic variables in the ocean. This will be done by examining the physical and biological environment at sea that can potentially influence Atlantic salmon growth and survival, mapping the marine distribution and migration routes, analyse the variation in growth and survival over time and geographic areas, and combining data to identify factors affecting marine survival. International collaborators in the project are Prof. Jeffrey Hutchings, Dalhousie University Canada, Prof. Michael Power, University of Waterloo Canada, Dr. David Righton, CEFAS UK, Dr. Philip McGinnity, University College Cork Ireland, Dr. Jens Carlsson, University College Dublin Ireland, Prof. Eric Verspoor, University of Highlands and Islands Inverness College Scotland and Dr. John Gilbey, Marine Scotland. An important part of the project is to utilise existing data and activities to reach these objectives - including salmon collected at sea, genetic material, archival scale samples, survival data, population size data, migration data, and data series on other marine species and oceanic ecosystems. The project will also apply new genetic, stable isotope and electronic tagging technologies and modelling to provide novel results.

Dates during which research will take place	August 2018-2022
Area in which research will take place	Atlantic Ocean and Barents Sea
Estimated number and weight of salmon to be retained	
Resources	
Estimated cost of the research project	The total cost of the project is approximately £ 3.3 mill, of which £ 1.9 mill is financed from the Norwegian Research Council, and £1.4 mill from the participating institutions (own funding).
Number of participating scientists	Approximately 20 researchers
Name and e-mail address of coordinating scientist in charge of project	Eva B. Thorstad Eva.Thorstad@nina.no
Details of research vessels, e.g. name, registration, call sign and description of vessel	Vessels from IMR and Arctic University of Norway (UiT)
Type and amount of gear and other equipment to be used	
Details of any collaborating countries	Main collaborating countries are Norway, Canada, Ireland and UK
Summary of Progress: The project will start in august 2018. In addition to the collection of new data and salmon scales from ongoing surveillance programs, the project will utilize data collected in the projects No. N13, N14 and N18.	

5. RUSSIAN FEDERATION

Project No. R1 Status: Completed

Party or relevant jurisdiction	Russian Federation
Title of project	**Assessment of by-catch of post-smolts of Atlantic salmon in pelagic fisheries in the Norwegian Sea**
Objective of research project	Assess occurrence of post-smolts in catches by Russian vessels engaged in the pelagic fisheries for mackerel, blue whiting and herring.
Brief description of research project	Catches were screened for post-smolts. Materials were collected in accordance with the methods applied for biological sampling. In addition, all information relating to vessel name, haul serial number, trawl type, surface temperature, duration of haul (start-end), depth of haul (min-max), trawling speed, trawl details, positions, catch, sample size, etc. was recorded.
Dates during which research took place	2002 – 2007
Area in which research took place	The Norwegian Sea
Estimated number and weight of salmon retained	N/A
Resources	
Estimated cost of the research project	Approximately £80,000 per annum
Number of participating scientists	Variable
Name of coordinating scientist in charge of project	Boris Prischepa (PINRO) elena@pinro.ru Alexander Zubchenko (PINRO) zav@pinro.ru
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment used	Standard pelagic trawl
Details of any collaborating countries	N/A

Summary of Findings

Results from surveys to map the distribution of post-smolts of Atlantic salmon in the Norwegian Sea conducted by IMR (Institute of Marine Research, Bergen, Norway) on a regular basis since 1995 (Holm et al., 2000) enabled WGNAS to conclude that areas of the distribution of post-smolts and mackerel in the Norwegian Sea in June-August overlap (ICES 2000/ACFM:13). Both species migrate in a surface layer: mackerel in the depth interval 0-50 m (ICES 2002/G:03), while post-smolts are found more frequently between 0 and 1 m (ICES 2002/ACFM:14). Targeted surveys conducted by IMR between 13 and 17 June 2001 in the Norwegian Sea in the vicinity of the area, where an intensive commercial fishery of mackerel took place later, showed simultaneous occurrence of mackerel and post-smolts in catches taken by the salmon survey trawl specifically designed for sampling post-smolts in the surface layer (ICES 2002/ACFM:14). Their findings gave rise to speculations that mackerel fishery in the

Norwegian Sea in June-August can be viewed as the most precarious in terms of by-catch of post-smolts of Atlantic salmon.

In the light of this, the Russian Federation carried out a programme in 2002-2006 to study the Atlantic salmon post-smolt potential by-catch in the Russian mackerel fishery in the Norwegian Sea.

Scientific observers and fisheries inspectors worked onboard Russian fishing vessels that fished mackerel in the Faeroese fishing zone and international waters of the Norwegian Sea. Usually 2-5 Russian inspectors and 5-7 scientific observers stayed permanently onboard the vessels during the season. They checked licenses, logbooks, gear, catches and collected biological samples. Their tasks included also screening of the mackerel catch for potential by-catch of post-smolts and adult Atlantic salmon. The vessel's crew assisted in the work. The catches were screened immediately after retrieval of the trawl, during discharge of the fish into bins and at a ship factory during grading. All Russian trawlers had a factory and every single catch was graded onboard. The entire Russian commercial catch of mackerel was used for human consumption and most vessels froze and stored their products onboard. Consequently all catches were sorted and packed by species in standard boxes. Some of the vessels also produced canned fish. In all cases the catch was loaded from the trawl onto an accumulation conveyor at the vessel's factory immediately and sorted by the crew, which implied that the fish were handled more or less individually before packing or milling.

Calculation of the ratio of total number of post-smolts per tonne of mackerel in the international zone gave an estimated of 0.0015 post-smolts per metric tonne captured in the commercial fishery in 2002, and 0.0003 in 2003. The ratio of total number of adults per 1 tonne of mackerel in the international zone was 0.0019 in 2002 and 0.0039 in 2003. No adult salmon or post-smolts were recorded in 2004. Like in 2002 and 2003 the results from 2005 and 2006 suggested very low numbers of post-smolts and adult salmon caught in the mackerel fishery in July-August in the Norwegian Sea.

Such a low by-catch could, apparently, be explained by two reasons: first, most post-smolts pass the international waters before a large-scale fishery of mackerel starts there, second, commercial pelagic trawl practically does not capture post-smolts, migrating very close to the surface, which can be attributed to both specific features of its design and fishing technique for mackerel, these include the overall size, towing speed, ratios of width to height and the mesh sizes used in the construction, particularly in the fore part of the net.

The main design parameter of concern is the mesh sizes used in the front part of the trawl. The mesh sizes range from 0.8 m for the salmon survey trawl up to 50 m for the largest commercial net. With a commercial pelagic trawl mackerel are fished in the 0-5 m layer and down to 50-70 m from the sea surface. Post-smolts inhabit the upper 10 m of the surface, which is only filtered by the section of the net with the largest meshes. It is thought that the smolts simply pass through the large meshes, while mackerel tend to dive in response to a vessel and are visually herded by the netting bars.The presence of significant quantities of post-smolts in the salmon survey trawl, which only covers the top 10 m of the surface and is designed specifically for the capture of post-smolts, supports this.

As regards the post-smolt run timing, it could be suggested, that the majority of post-smolts among those migrating with the western branch of the Norwegian current pass the international waters before a large-scale fishery of mackerel begins, it usually starts in July. In addition, as the map of distribution of post-smolts in the Norwegian Sea shows (ICES 2002/ACFM:14), the main route of post-smolt northward migration is to the east of the area where the fishery is prosecuted.

All said above suggests a conclusion that the pelagic fisheries in the Norwegian Sea and, of mackerel in particular, cannot be considered as a significant source of post-smolt mortality. This is also supported by assessments undertaken by ICES.

Project No. R2 Status: Ongoing

Party or relevant jurisdiction	Russian Federation
Title of project	**Monitoring of the stock status, abundance assessment and provision of advice on the allowable level of harvest of Atlantic salmon**
Objective of research project	Derive estimates of survival of juveniles and adult return rates, estimates of natural and fishing mortality, study the dynamics of population characteristics, assess population sizes and spawning escapement, estimate allowable catch.
Brief description of research project	Research fishing is conducted. Data is collected on the Atlantic salmon population characteristics (age structure, size distribution, sex composition, fecundity, proportion of various salmon groups in the spawning run). Adults and smolts are marked with tags to assess population size and survival rates. The dynamics of the smolt migration and the spawning run, and the behaviour of adults are studied. The quality of Atlantic salmon spawning habitat and the impact of human activities on the habitat are assessed.
Dates during which research will take place	Annual monitoring programmes (May-December).
Area in which research will take place	Atlantic salmon rivers of the Murmansk region, Archangelsk Region, Nenets Autonomous Okrug, Republic of Komi and Republic of Karelia.
Estimated number and weight of salmon to be retained	About 1,500 adult salmon (6 tonnes) and 5,000 parr and smolts
Resources	
Estimated cost of the research project	Approximately £60,000 per annum
Number of participating scientists	~ 25 scientists from PINRO
Name of coordinating scientist in charge of project	Sergey Prusov (PINRO) prusov@pinro.ru Igor Studenov (PINRO) studenov@pinro.ru
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Barrier fences, gill nets, electrofishing units, smolt traps, external tags
Details of any collaborating countries	N/A

Summary of Progress

Adult returns in 2017 to home waters were assessed. The level of attainment of spawning requirements was determined, the condition and success of spawning was assessed, and estimates of parr densities were derived. The harvestable surplus was determined. Recommendations on catch limits for 2018-2019 salmon fisheries were developed for the Federal Agency for Fisheries of the Russian Federation and for the Regional Commissions on regulation of harvesting the anadromous fish.

Project No. R3 Status: Completed

Party or relevant jurisdiction	Russian Federation and Norway
Title of project	**Establishing a genetic baseline of northern salmon populations across the Russian – Norwegian border for management purposes**
Objective of research project	Establish a genetic baseline of sufficient resolution for the purposes of partitioning bag net catches between Russian and Norwegian regions.
Brief description of research project	In northern Norway, salmon are caught in bag net fisheries along the coast. Tagging studies conducted in the 1960s and 1970s demonstrated that these fisheries were mixed-stock fisheries (Prusov&Zubchenko 2009, Hansen *et al.* in prep.), intercepting salmon returning to a large number of rivers, both in Russia and Norway. Though fishing effort in marine fisheries for salmon has decreased since these studies were conducted, there is still a substantial marine fishery in Norway's two northernmost counties with a catch totalling 44,414 salmon (55% of the total marine fishery) in 2008 (ICES 2009). The proportion of Russian salmon in these catches is unknown, and whether the proportions observed in earlier tagging studies are stable over this time period is also uncertain. The development of a genetic baseline of Norwegian and Russian salmon populations provides an opportunity for applying genetic methods to investigate the present distribution of different salmon populations contributing to the coastal fisheries. The development of the baseline will be conducted in cooperation between PINRO, IMR and NINA. DNA will be extracted from the samples using commercial kits such as QiagenDNEasy, which gives high quality DNA for long-term storage. The samples will be amplified for the selected multiplexed markers and fragment analysis will be conducted on ABI 3130XL (NINA) and ABI 3730XL (IMR) Genetic Analyzers. DNA will be analyzed for variation in 18-25 microsatellite markers The analyses of bag net sampled fish will be conducted at IMR. The statistical analysis and assignment will be conducted in cooperation between NINA and IMR, with participation from PINRO. The common dataset of Norwegian and Russian rivers will be made available for the purposes of the SALSEA-Merge project. The data will also be used for constructing a national genetic baseline for Norwegian and Russian Atlantic salmon populations.
Dates during which research will take place	2009-2010
Area in which research will take place	Northern Norway, North-West of the Russian Federation
Estimated number and weight of salmon to be retained	N/A

Resources	
Estimated cost of the research project	

	Norway	Russia
Collection of samples	£3,400	£33,600
Meetings & Travel	£5,600	£1,100
Analyses (incl. labour)	£50,500	-
Evaluating results	£13,500	-
Analysis of bagnet samples	£25,250	-
Assignment/Mixed stock analysis and report	£9,000	-
Total	£107,250	£34,700
Total: £141,950		

Number of participating scientists	Norway – 4, Russian Federation – 3.
Name and e-mail address of coordinating scientist in charge of project	Vidar Wennevik (IMR) vidar.wennevik@imr.no Sergey Prusov (PINRO) prusov@pinro.ru
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Electrofishing units – 5 (PINRO, IMR) Smolt traps – 2 (PINRO) Genetic Analyzer ABI 3730XL – 1 (IMR) Genetic Analyzer ABI 3130XL – 1 (NINA)
Details of any collaborating countries	Norway

Summary of Findings

A comprehensive genetic baseline for northern populations of Atlantic salmon has been developed. Samples from 51 rivers from the White Sea to Troms county in Norway have been analysed for variation in 18 microsatellite markers. Also, 1500 samples from coastal fisheries in Troms and Finnmark counties in Norway have been analysed for the same genetic markers and compared against this baseline. Evaluation and simulations of the assignment power of the baseline shows that assignment to river is possible for around 50% of the fish. Assignment to region with high precision is possible for mist individuals. Preliminary investigation of the composition of the mixed-stock fisheries indicate that Russian salmon constitute a significant proportion of the catches in Norwegian coastal fisheries in the eastern part of Finnmark. Also, the results show that bag nets located near the coast catch fish from a higher number of stocks than bag nets located in the fjords.

Findings of the pilot project are published in the report:

M.-A. Svenning, V. Wennevik, S. Prusov, E. Niemelä and J-P Vähä. Sjølaksefiske i Finnmark: Ressurs og potensial Del II. Genetisk opphav hos atlantisk laks (Salmo salar) fanga av sjølaksefiskere langs kysten av Finnmark sommeren og høsten 2008. – Rapport: Fisken og Havet, Nr. – År 3-2011. – 35 c.

6. UNITED STATES OF AMERICA

Project No. U1 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Forecasts of Atlantic salmon transoceanic migration: climate change scenarios and anadromy in the North Atlantic**
Objective of research project	1) develop and evaluate marine migration models for Atlantic salmon from North American and European stocks 2) evaluate the potential effects of climate change on migration patterns for Atlantic salmon
Brief description of research project	Atlantic salmon undertake transoceanic migrations as part of their complex anadromous life history. In addition to the impact of climate on growth, maturation, and distribution in the ocean, salmon must home to their natal rivers to spawn, the success of which is likely impacted by ocean conditions. After rearing in fresh water, salmon juveniles employ a range of migration cues to time their seaward migrations. Since they are entering a new set of habitat regimes, the climate-related timing of this migration and the conditions they find in the coastal ocean are critical. We have developed a migration model that can be validated for most stocks of Atlantic salmon from North America and Europe. The probability of migration distribution is determined as a function of swimming potential, current vectors, and migration orientation. The absence of foraging behavior in the model has not significantly compromised its performance, owning to the likelihood that prey co-vary with other environmental variables. The model was run with forecasted surface temperature and currents for the North Atlantic segment of the Climate System Model developed at the National Center for Atmospheric Research. These simulations attempt to define the range of possible impacts climate change may have on salmon populations.
Dates during which research took place	2002-2004
Area in which research took place	Area modelled included North Atlantic Ocean
Estimated number and weight of salmon to be retained	No Atlantic salmon were sampled or retained during the course of this project.
Resources	
Estimated cost of the research project	
Number of participating scientists	1
Name of coordinating scientist in charge of project	Dr. Kevin Friedland friedlandk@forwild.umass.edu
Details of research vessels, e.g. name, registration, call	None

sign and description of vessel	
Type and amount of gear and other equipment used	Computers, Databases
Details of any collaborating countries	Some collaboration with Canadian investigators
Summary of Findings: No summary provided.	

Project No. U2 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Stable isotope composition of Atlantic salmon scales**
Objective of research project	The objective of this study was to develop a retrospective time series of stable isotope ratios for the DPS in Maine and the mixed-stock samples from the continental stock complex to evaluate the feeding patterns of the stocks over time.
Brief description of research project	Atlantic salmon populations in the North Atlantic have experienced unprecedented declines in abundance during the past two decades. Of greater concern for the management of US salmon populations are the trends in the two-sea-winter salmon, especially those comprising the populations in the ESA distinct population segment. Although studies of climate and salmon survival suggest recruitment is patterned by events early in the post-smolt year, the apparent tele-connection between stock complexes suggests that factors related to life history events later in the post-smolt year or during the one-sea-winter year may be important as well. If growth has decreased in salmon during the post-smolt or one-sea-winter years, survival would likely be negatively impacted. Concomitant with the decline in stock abundance of salmon in the North Atlantic, a number of lines of evidence suggest that growth has also declined in the same time period. It is not known if this decline in size-at-age is a reflection of decreased growth during the post-smolt year or a decline in feeding opportunity when the fish are on the feeding grounds as one-sea-winter salmon. It is also not known if fish from the DPS are suffering the same decreased growth and tracking with the general pool of salmon in the Northwest Atlantic. There is no direct feeding data to approach these problems; however, many investigators have had success in evaluating feeding position with the analysis of stable isotopes in fish hard parts, such as scales. Furthermore, retrospective time series of growth were developed to provide an explanatory variable in regard to the feeding patterns.
Dates during which research took place	2001-2002
Area in which research took place	Scale samples collected during West Greenland sampling programme and from returning adults in the United States.
Estimated number and weight of salmon retained	No Atlantic salmon were retained during this project.

Resources	
Estimated cost of the research project	
Number of participating scientists	1
Name of coordinating scientist in charge of project	Dr. Kevin Friedland, NOAA Fisheries, Amherst, MA friedlandk@forwild.umass.edu
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment used	Standard laboratory and isotope analysis equipment
Details of any collaborating countries	Collaboration with some international investigators to secure scale samples.
Summary of Findings: No summary provided.	

Project No. U3 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Ultrasonic telemetry of smolts and post-smolts in the Narraguagus River and Narraguagus Bay**
Objective of research project	1) evaluate migration timing and pathways in the lower Narraguagus River and Narraguagus Bay 2) estimate survival of migrating smolts and post-smolts
Brief description of research project	Telemetry data was collected on wild outmigrating Atlantic salmon smolts from 1997-1999 and 2002-2005 in the Narraguagus River, Maine, USA. During these years, 60-100 wild Atlantic salmon smolts annually were surgically implanted with ultrasonic tags. In 2005, Automated Pinger Detection Units (APDU) were deployed through the Narraguagus River (5), Estuary (10), Bay and nearshore environment (6), excluding the coastal arrays established in 2002 to evaluate the number of smolts passing ecological transition zones.
Dates during which research took place	2002-2009 Fieldwork in 2002-2005. Data analysis and publication in 2005-2008.
Area in which research took place	Narraguagus River (1997-1999, 2002-2005) Narraguagus Bay (1997-1999, 2002-2005) Gulf of Maine (2002-2004)
Estimated number and weight of salmon retained	It is anticipated that no Atlantic salmon will be retained during this project.
Resources	
Estimated cost of the research project	Approximately £49,000 per annum (public funding)
Number of participating scientists	~3
Name and e-mail address of coordinating scientist in charge of project	James Hawkes James.Hawkes@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	Equipment deployed from small research boats and leased commercial vessels. Vessel use is subject to change annually.
Type and amount of gear and other equipment used	Ultrasonic Telemetry Tags (~60-100 annually) Automated Pinger Detection Units (20-60 annually)
Details of any collaborating countries	Automated Pinger Detection arrays deployed by Canadian investigators were capable of detecting and recording tagged fish. Automated Pinger Detection arrays deployed for this study were capable of detecting and recording Canadian tagged fish.

Summary of Findings:

Kocik, J. F., J. P. Hawkes, T. F. Sheehan, P.A. Music and K. F. Beland. 2009. Assessing estuarine and coastal migration and survival of wild Atlantic salmon smolts from the Narraguagus River, Maine using ultrasonic telemetry. In: Haro, A. J., K. L. Smith, R. A. Rulifson, C. M. Moffitt, R. J. Klauda, M. J. Dadswell, R. A. Cunjak, J. E. Cooper, K. L. Beal, and T. S. Avery, editors. Challenges for Diadromous Fishes in a Dynamic Global Environment. American Fisheries Society Symposium 69. Bethesda, Maryland. pp 293-310.

Project No. U4 Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	**Penobscot hatchery versus wild smolt telemetry**
Objective of research project	1) Evaluate migration timing and pathways in the Penobscot Estuary and Bay 2) Estimate survival of migrating smolts and post-smolts
Brief description of research project	Telemetry data was first collected on hatchery-reared out-migrating Atlantic salmon smolts in the Penobscot River, Maine, in 2005, and this research effort is continuing. Atlantic salmon smolts are surgically implanted with acoustic tags. Acoustic telemetry receivers are deployed throughout the estuary and near-shore marine arrays in Penobscot Bay. The array identifies the migration pathways of smolts as they exit the system between release groups. Since 2005 between 50 and 200 smolts have been tagged and release (no smolts were released in 2007) of differing origins (hatchery, fall parr stocked, naturally reared and wild).
Dates during which research will take place	2013 - 2019
Area in which research will take place	Penobscot Estuary Penobscot Bay
Estimated number and weight of salmon to be retained	It is anticipated that no Atlantic salmon will be retained during this project.
Resources	
Estimated cost of the research project	Approximately £10,000 per annum (public funding)
Number of participating scientists	~5
Name and e-mail address of coordinating scientist in charge of project	James Hawkes James.Hawkes@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	Equipment deployed from small research boats and leased commercial vessels. Vessel use is subject to change annually.
Type and amount of gear and other equipment to be used	Amirix Vemco Acoustic Telemetry Tags (~150-250 annually) and Acoustic Telemetry Receivers (100-150 annually)
Details of any collaborating countries	Acoustic Telemetry Receiver arrays deployed by Canadian investigators were capable of detecting and recording tagged fish. Acoustic Telemetry Receiver arrays deployed for this study were capable of detecting and recording Canadian tagged fish.

Summary of Progress:

Field activities for this project have concluded and analysis is ongoing. Detailed analysis and development of a peer reviewed manuscript are underway (Expected completion 2019). Annual summary narratives can be found in the 2015-2016 Annual US Atlantic Salmon Assessment Committee reports (http://www.nefsc.noaa.gov/USASAC/Reports/).

Project No. U5 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Comprehensive evaluation of marine survival of hatchery-stocked smolts: Migration behaviour and success of Dennys River smolts**
Objective of research project	1) Evaluate migration speed and behaviour from lower river release sites through estuarine habitat 2) Estimate survival of migrating smolts and identify areas where mortality may be occurring
Brief description of research project	An experimental evaluation of river-specific Atlantic salmon smolt stocking in the Dennys River was developed. The program was scheduled to run for a minimum of five years (2001-2006), but acoulstic telemetry efforts on the Dennys were discontinued in 2005. Acoustic telemetry investigations were used to evaluate the migration success, nearshore marine mortality and nearshore migration routes of these stocked smolts. Approximately 50,000 smolts are released annually and, of these, approximately 70-150 fish were released with surgically implanted acoustic transmitters.
Dates during which research will take place	2001 - 2017 2001 – 2005 Data collection. 2005 – 2017 Data Analysis of publication
Area in which research will take place	Dennys River, Cobscook Bay, Gulf of Maine
Estimated number and weight of salmon to be retained	It is anticipated that no Atlantic salmon will be retained during this project.
Resources	
Estimated cost of the research project	Approximately £10,000 per annum (public funding)
Number of participating scientists	~3
Name and e-mail address of coordinating scientist in charge of project	James Hawkes James.Hawkes@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	Equipment deployed from small research boats and leased commercial vessels. Vessel use is subject to change annually.
Type and amount of gear and other equipment to be used	Acoustic Telemetry Tags (70-200 annually) Acoustic Telemetry Receivers (20-40 annually)
Details of any collaborating countries	Acoustic Telemetry Receiver arrays deployed by Canadian investigators were capable to detecting and recording tagged fish. Acoustic Telemetry Receiver arrays deployed for this study were capable to detecting and recording Canadian tagged fish.

Summary of Progress:

Complete

Citation:

Hawkes, J.P., T.F. Sheehan, and D.S. Stich. 2017. Assessment of Early Migration Dynamics of River-Specific Hatchery Atlantic Salmon Smolts. Transactions of the American Fisheries Society 146:6, 1279-1290.

Abstract

Many Atlantic Salmon *Salmo salar* populations within the southern extent of the species' range are at critically low abundances, while others have been extirpated. The focus of many ongoing recovery efforts is on maximizing the number of smolts that reach the ocean, where marine survival is low, primarily through hatchery supplementation and improvement of in-river hydropower system management. However, estuaries also are known to be sites of high mortality, although in many cases the correlates of this mortality are poorly characterized. We acoustically tagged hatchery smolts (n = 666) during 2001–2005 to evaluate migration performance through freshwater, estuarine, and bay reaches of the small but tidally dynamic Dennys River, Maine, USA, to investigate potential drivers contributing to low returns within the system. Migration behaviours (e.g., migration timing and tidal use) were typical for Atlantic Salmon smolts, but reversals during migration were observed upon entry into the estuary environment more frequently in this system than in regional rivers. We used Cormack–Jolly–Seber mark–recap-ture models to estimate apparent survival within the study environment during this period. We found two distinct periods of survival, with much lower survival in 2003–2005 than in 2001 and 2002 (more than a 40% decrease). Among the variables considered, temperature and migratory behaviour had the largest effects on survival. We found that survival increased by about 28% across the range of temperatures observed during these years; additionally, survival increased by about 15% for fish that reversed direction during migration compared to fish that did not. These results indicate that extreme environmental changes during the transition through this coastal system constitute a significant obstacle to Atlantic Salmon restoration stocking efforts.

Project No. U6 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Comprehensive evaluation of marine survival of hatchery-stocked smolts: Dennys River smolt stocking assessment**
Objective of research project	1) evaluate smolt-to-adult survival rates of Atlantic salmon smolts based on temporal and spatial patterns of release 2) determine optimal stocking levels to achieve stock rebuilding objectives
Brief description of research project	The Maine Atlantic Salmon Technical Advisory Committee (TAC) developed, and fishery managers supported, the experimental evaluation of river-specific Atlantic salmon smolts in the Dennys River for a minimum of five years (2001-2006). Stocking rates were developed based on retrospective analysis of Penobscot River stocking and adult return data during the period from 1973 to 1995. Model results indicated that a range of 32,000 (low) to 56,000 (high) would result in a 75% probability of achieving 2SW Atlantic salmon returns of at least 67 (low) or 117 (high) adults. Approximately 50,000 smolts will be released annually. All stocked fish will receive an elastomer mark and adipose fin clip to allow quantitative evaluation of survival in relation to release location and time. Returning adults will be enumerated and identified at a weir-based adult trap.
Dates during which research will take place	May – October, 2001-2012
Area in which research will take place	Dennys River Cobscook Bay Gulf of Maine
Estimated number and weight of salmon to be retained	It is anticipated that no Atlantic salmon will be retained during this project.
Resources	
Estimated cost of the research project	Approximately £14,000 per annum (public funding)
Number of participating scientists	~3
Name and e-mail address of coordinating scientist in charge of project	Joan Trial Joan.trial@maine.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	Elastomer Marks and Marking Equipment Rotary Screw Smolt Trap Weir-Based Smolt Trap Weir-Based Adult Trap
Details of any collaborating countries	Elastomer marks may be recovered during the NASCO international cooperative sampling programme at West Greenland.

Summary of Findings:

Monitoring of hatchery-origin smolts on the Dennys River was performed from 2001 to 2005. Stocking groups of Visual Implant Elastomer marked smolts were released at different times and from different stocking sites. An adult weir trap was used to monitor the contribution of each stocking group. Extremely low numbers of returning adults were documented, indicating very low marine survival levels. Survival reported to the US Atlantic Salmon Assessment Committee (http://www.nefsc.noaa.gov/USASAC/Reports/) in 2012.

Project No. U7 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Evaluation of estuary and nearshore marine distributions of Atlantic salmon post-smolts in Penobscot Bay and the Gulf of Maine**
Objective of research project	1) evaluate nearshore distribution and migration pathways of smolts and post-smolts 2) estimate the relative contribution of stocked hatchery smolts to overall post-smolt populations 3) evaluate the relative contribution of spatially and temporally distinct smolt releases on post-smolt populations 4) evaluate the physiological condition of post-smolts in marine environments
Brief description of research project	Synchronous declines in the survival of Atlantic salmon smolts throughout North America indicate a sharp decline in marine survival. Many investigators hypothesize that this decline occurs early in the marine phase, as Atlantic salmon smolts transition from freshwater to marine environments. A surface pelagic trawl survey was initiated in 2001 in the Penobscot Bay estuary and nearshore waters of the Gulf of Maine to sample hatchery- and naturally reared Atlantic salmon smolts in the marine environment. A Norwegian-designed pelagic net with a modified aquarium cod end is towed through the surface waters enabling live capture and release. Biological data including size, scale samples, genetic samples, physiology samples, and diet composition are collected from a subsample of fish.
Dates during which research will take place	Data collection from May, 2001-2005. Data analysis from 2005 - 2011.
Area in which research will take place	Penobscot Bay Gulf of Maine
Estimated number and weight of salmon to be retained	Although project objectives and methodology strive to minimize mortality of Atlantic salmon, immediate trawl and or sampling induced mortality is estimated to be approximately 5%.
Resources	
Estimated cost of the research project	Approximately £20,000 per annum (public funding)
Number of participating scientists	2
Name of coordinating scientist in charge of project	Timothy Sheehan Tim.Sheehan@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	F/V Nobska and F/V Morue 30-m commercial trawler
Type and amount of gear and other equipment to be used	Post-smolt trawl Standard oceanographic instruments

Details of any collaborating countries	No direct collaboration

Summary of Findings:

Two manuscripts summarizing the findings of this project have recently been published

Sheehan, T. F., Renkawitz, M. D., and Brown, R. W. 2011. Surface trawl survey for U.S. origin Atlantic salmon *Salmo salar*. Journal of Fish Biology. 79: 374-398.

Poor marine survival of Atlantic salmon *Salmo salar* populations across the North Atlantic is a key factor limiting spawning escapement. Nearshore mortality is higher than previously assumed and imparts a large influence on overall marine survival. A Surface Trawl Survey (2001-2005) in Penobscot Bay, Maine USA and the nearshore Gulf of Maine waters was conducted to investigate early marine dynamics of a hatchery dependant Atlantic salmon population from a severely modified river system. Data generated were used to evaluate the effect of stocking location and time on migration success and to describe the early marine migratory pathways and environment that postsmolts traverse. Significant differences in early migration success were detected among different stocking groups, but subsequent marine survival was independent of stocking group. While the postsmolt population was primarily comprised of hatchery origin smolt stocked fish, other life stage stocking strategies (i.e., parr stocking) represented a higher proportion of the population than previously assumed. Catch distribution suggests evidence of an initial marine migratory pathway out of the dynamic Penobscot Bay environment. The hypothesized benefits of a predator refuge based on the co-occurring species complex is considered minimal for emigrating postsmolts given a mismatch in the size overlap among species and low abundance of other co-occurring diadromous populations. These data can be used to modify current management actions to optimize salmon recovery and inform future research agendas.

Renkawitz, M. D. and Sheehan, T. F. 2011. Feeding ecology of early marine phase Atlantic salmon *Salmo salar* post-smolts. Journal of Fish Biology. 79: 356-373

Dietary analyses of Atlantic salmon *Salmo salar* post-smolt stomachs collected from 2001 to 2005 in Penobscot Bay, Maine, U.S.A., have yielded insights into the feeding ecology of early marine phase post-smolts from different rearing origins. Most stomachs contained only one or two prey types, suggesting active prey selection. Post-smolts that lived in the river longer (i.e. from naturally reared and parr-stocked origins) were smaller and consumed more fishes than invertebrates compared to larger post-smolts that emigrated immediately post-stocking (i.e. from smolt-stocked origins). Naturally reared *S. salar* consumed c. 84% fishes and 16% crustaceans and parr-stocked S. salar consumed 64% fishes and 34% crustaceans. Stocked smolts consumed 48% fishes and 40% crustaceans. Differences in the type and quantity of consumed prey may be indicative of behavioural differences among rearing origins that influence post-smolt survival.

Project No. U8 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Cormorant harassment in the Narraguagus River/Narraguagus Bay**
Objective of research project	To reduce predation on migrating Atlantic salmon smolts by excluding double-crested cormorants from the lower Narraguagus River and Narraguagus Bay, and to assess the efficacy of non-lethal predator exclusion as a means of reducing predation on migrating Atlantic salmon smolts.
Brief description of research project	US Department of Agriculture (USDA) Wildlife Services professionals will use non-lethal methods to exclude cormorants from the lower Narraguagus River and Narraguagus Bay. These professionals will use fire-cracker shells, "screamers", and other non-lethal methods to displace foraging cormorants anywhere they are encountered within the study area. Effort will be focused within areas in which substantial amount of smolt mortality occurs. Observational data on the frequency and occurrence of cormorants in Narraguagus Bay during the smolt migration will also be collected. These data will be useful for comparing smolt movements with the occurrence of cormorants before, during, and after cormorant exclusion. USDA personnel will fill out a data sheet each day they are in the field. Additionally, cormorant abundance will be documented using two automated digital cameras. Telemetry arrays, already in place in the Narraguagus system, will allow us to assess the efficacy of the cormorant harassment by providing mortality data at each telemetry array.
Dates during which research will take place	May-June 2005. This research will expand upon similar work that was done in May-June 2004. Data analysis and publication of findings in 2005-2012.
Area in which research will take place	Lower Narraguagus River, Estuary and Narraguagus Bay, Maine
Estimated number and weight of salmon to be retained	It is anticipated that no Atlantic salmon will be retained during this project.
Resources	
Estimated cost of the research project	£3,500 per annum (public funding)
Number of participating scientists	Approximately five, representing Federal and State resource management agencies
Name and e-mail address of coordinating scientist in charge of project	James Hawkes James.Hawkes@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A

Type and amount of gear and other equipment to be used	Small boat, digital cameras, shotguns with fire-cracker and screamer shells, laser.
Details of any collaborating countries	None

Summary of Findings:

Cormorant harassment activities concluded in 2005 and analysis is being performed to determine what effect was observed as a result. Ultrasonic telemetry data collected during the harassment period is used to determine success of the project. Preliminary results suggest that emigrating smolts pass through the fresh water with a high rate of success. However, once fish enter the estuary, mortality increases, specifically during daylight hours. Manuscript published in the Northeastern Naturalist.

Project No. U9 Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	**SALSEA Greenland**
Objective of research project	To advance understanding of the ecology of the Atlantic salmon West Greenland stock complex and to gain insights into the factors resulting in recent significant increases in marine mortality across the North Atlantic.
Brief description of research project	SALSEA Greenland involves purchasing fresh whole Atlantic salmon from individual fishers and performing an Enhanced Sampling Program on these fish in addition to the Baseline Sampling Program referenced in project D1 "West Greenland Salmon Fishery Sampling Programme". The enhanced sampling protocols are similar to the sampling protocols followed for SALSEA North America and SALSEA-Merge and will allow the results from these three marine sampling programs to be combined and analyzed across temporal and spatial scales.
Dates during which research will take place	Sampling, August – October 2009-2011 Data analysis and publication continue through 2018
Area in which research will take place	Ilulissat, Sisimiut, Nuuk and Qaqortoq, Greenland
Estimated number and weight of salmon to be retained	Maximum of 900 1SW non-maturing (primarily) adults annually
Resources	
Estimated cost of the research project	Approximately £15,000 per annum (public funding) Many of the sample collection costs are accounted for in project D1.
Number of participating scientists	1 additional personnel above and beyond those identified in project D1
Name and e-mail address of coordinating scientist in charge of project	Timothy Sheehan Tim.Sheehan@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	Standard sampling and laboratory equipment
Details of any collaborating countries	Collaborative project with countries/investigators outlined in project D1 and scientists from SALSEA-Merge. The work is coordinated via NASCO and is reported to ICES (Working Group on North Atlantic Salmon).

Summary of Progress:

Sampling concluded in 2012 and a total of 1200 fish were sampled from 2009-2011. The Enhanced Samples collected will be used to evaluate a wide variety of topics such as age and growth, diet, origin, lipid analysis, stable isotope analysis, parasites, diseases, sea age at maturity as well as genetic relations and SLICE® resistance in sea lice. Samples continue to be processed and analyzed. Preliminary results for some samples were presented at the 2011 Salmon Summit and work in this area continues. These data will be valuable in furthering our understanding of marine phase salmon once they are combined with the data collected under the SALSEA North America and SALSEA-Merge programs.

Numerous manuscripts summarizing some of the findings from this project have been published. Further collaborative investigations will be pursued as opportunities arise.

Dixon, H., Power, M., Dempson, J.B., Sheehan, T.F., and Chaput, G. 2012. Characterizing trophic status and shift in Atlantic salmon, *Salmo salar*, from freshwater to marine life cycle phases. ICES Journal of Marine Science. 69(9): 1646–1655.

Dixon, H.J., Dempson, J.B., Sheehan, T.F., Renkawitz, M.D. and Power, M. 2017. Assessing the diet of Atlantic salmon (*Salmo salar* L.) off the West Greenland coast using gut content and stable isotope analyses. Fisheries Oceanography. 26: 555-568.

Minke-Martin, V., Dempson, B. J., Sheehan, T. F., and Power, M. 2015. Otolith-derived estimates of marine temperature use by West Greenland Atlantic salmon (*Salmo salar*). ICES Journal of Marine Science. 72(7), 2139–2148.

Renkawitz, M.D., Sheehan, T.F., Dixon, H. J. and Nygaard, R. 2015. Changing trophic structure and energy flow in the Northwest Atlantic: implications for Atlantic salmon feeding at West Greenland. Marine Ecology Progress Series. 538: 197–211.

Project No. U10 Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	**Using Pop-up Satellite Tags (PSATs) to track adult Atlantic salmon in the Northwest Atlantic**
Objective of research project	To provide information on localized movement patterns of Atlantic salmon off the coast of West Greenland, large scale movement and migration patterns en route to natal rivers in North America and Europe, locations of overwinter residence and depths and temperatures experienced during the 2nd or 3rd winter at sea in the North Atlantic. These data will be used to evaluate if conditions experienced from September through April are favourable for survival and subsequent spawning escapement.
Brief description of research project	The tagging project at West Greenland involves purchasing live Atlantic salmon from local Greenlandic fishers. Fish are tagged and transported away from the nets for release. Tags are programmed to jettison from the fish on April 1 each year. The tags then transmit the archived data to satellites and the data are then processed and analyzed.
Dates during which research will take place	Sampling will occurred annually during the fishing season, August – October 2010-2012, and sample processing and data analysis of tagging and tracking is expected to continue into 2018.
Area in which research will take place	Coastal waters off West Greenland
Estimated number and weight of salmon to be retained	7 salmon in 2010, 17 salmon in 2011, 1 salmon in 2012.
Resources	
Estimated cost of the research project	Approximately £10,000 per annum (public funding)
Number of participating scientists	7
Name and e-mail address of coordinating scientist in charge of project	Mark Renkawitz Mark.Renkawitz@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	None
Type and amount of gear and other equipment to be used	Specialized satellite transmitters, gillnet, bag net, trolling gear, small research vessel (6 m), specialized tag attachment bracket, surgical equipment, anaesthetic, tagging tube, miscellaneous supplies.
Details of any collaborating countries	Collaborative work with investigators from US (M. Renkawitz, T. Sheehan), Norway (A. Rikardsen, C. Chittenden, R. Hedger), Greenland (R. Nygaard), United Kingdom (David Righton)

Summary of Progress:

Manuscript development is underway and submission is expected to occur in 2018.

Project No. U11 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Impact of oceanographic changes on Atlantic salmon survival in the Northwest Atlantic**
Objective of research project	Determine mechanisms controlling the ecosystem-salmon connections and hypothesize on their implications for salmon populations in the future.
Brief description of research project	The project will analyze available hydrographic and biological (plankton and fish) time series from the Gulf of Maine, Scotian Shelf, and Newfoundland regions. Data sets will be evaluated for correlations between salmon production in the USA and North America and with oceanographic conditions along their migration route and feeding areas.
Dates during which research will take place	2010-2014
Area in which research will take place	Desktop study
Estimated number and weight of salmon to be retained	Not applicable
Resources	
Estimated cost of the research project	Approximately £10,000 per annum (public funding)
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	Timothy Sheehan (Tim.Sheehan@noaa.gov)
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	USA only
Summary of Findings: Efforts focused on investigating the marine ecosystem-salmon connections driving marine survival dynamics. One manuscript has been published as a result (see below). Mills, K. E., Pershing, A., Sheehan, T. F. and Mountain, D. 2013. Climate and ecosystem linkages explain widespread declines in North American Atlantic salmon populations. Global Change Biology. 19: 3046-3061.	

Abstract:

North American Atlantic salmon (*Salmo salar*) populations experienced substantial declines in the early 1990s, and many populations have persisted at low abundances in recent years. Abundance and productivity declined in a coherent manner across major regions of North America, and this coherence points toward a potential shift in marine survivorship, rather than local, river-specific factors. The major declines in Atlantic salmon populations occurred against a backdrop of physical and biological shifts in Northwest Atlantic ecosystems. Analyses of changes in climate, physical, and lower trophic level biological factors provide substantial evidence that climate conditions directly and indirectly influence the abundance and productivity of North American Atlantic salmon populations. A major decline in salmon abundance after 1990 was preceded by a series of changes across multiple levels of the ecosystem, and a subsequent population change in 1997, primarily related to salmon productivity, followed an unusually low NAO event. Pairwise correlations further demonstrate that climate and physical conditions are associated with changes in plankton communities and prey availability, which are ultimately linked to Atlantic salmon populations. Results suggest that poor trophic conditions, likely due to climate-driven environmental factors, and warmer ocean temperatures throughout their marine habitat area are constraining the productivity and recovery of North American Atlantic salmon populations.

Project No. U12 Status: Completed

Party or relevant jurisdiction	United States of America
Title of project	**Evaluation of the importance of predator and prey fields and ocean circulation on Atlantic salmon growth and survival in the Gulf of Maine**
Objective of research project	Evaluate the consequences for Atlantic salmon post-smolt growth and survival of the match or mismatch of spawning runs of diadromous fishes, aggregations of other marine forage fishes, and thermal/circulation patterns in the Gulf of Maine (GoM) with the timing of Atlantic salmon out-migration.
Brief description of research project	Develop a spatially- and temporally-explicit potential predation risk field model for postsmolt Atlantic salmon. The model will be used to evaluate how timing and abundance of diadromous fish runs in the spring and the abundance and distribution of marine forage fishes influence the potential predation risk to and the growth rate of post-smolt Atlantic salmon. It will also evaluate the importance of the strength and timing of Gulf of Maine circulation patterns for moving post-smolts out of the Gulf.
Dates during which research will take place	2010-2014
Area in which research will take place	Desktop study
Estimated number and weight of salmon to be retained	Not applicable
Resources	
Estimated cost of the research project	Approximately £10,000 per annum (public funding)
Number of participating scientists	5
Name and e-mail address of coordinating scientist in charge of project	John Kocik (John.Kocik@noaa.gov)
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	USA only

Summary of Findings:

Project focus has emphasized the oceanography of the Gulf of Maine to identify migration windows (times) and corridors (place) as sea through modelling by postdoc collaborators. Two manuscripts published (see below).

Some follow-on research will use these models to project habitat use in fishery management zones by time and space for salmon populations from 3 Maine river systems. Model results will also be used to target investigations of fish migration through additional modelling and proposing locations for hypothesis testing using telemetry or traditional surveys to better understand salmon migration routes and factors that influence them

Byron, C. J., A. J. Pershing, J. D. Stockwell, H. Xue, and J.F. Kocik 2014. Migration model of post-smolt Atlantic salmon (*Salmo salar*) in the Gulf of Maine. Fisheries Oceanography 23(2): 172–189. link

Abstract:

Understanding how oceanographic factors independently and interactively influence fish behavior, physiology, and survival is essential to predicting the impact of climate change on fish. Such predictions are especially challenging for highly migratory species like salmon that experience a broad range of conditions. We applied a novel modelling approach that combines an individual-based particle model with a bioenergetics model to evaluate the effects of oceanographic variability on oceanic migration of post-smolt Atlantic salmon (Salmo salar). Interannual variability in the surface current velocity and sea surface temperature differentially influenced post-smolt salmon migration success, as defined by the ability of salmon to traverse the Gulf of Maine within a realistic period of time and quantified by distance travelled, elapsed travel time, and growth. The magnitude, duration and direction of the currents relative to a fish’s intended swimming direction had the strongest influence on migration success. Changes in ocean circulation led to changes in currents at a regional scale that have a similar, relative effect across multiple populations during out-migration. Results of this study suggest that the Nova Scotia Coastal Current has a strong influence on the migration pathways of migrating salmon through the Gulf of Maine. The influx of cool fresh water from the Arctic, observed in the early 1990s, changed the Nova Scotia Coastal Current and, as suggested by model results, could have dramatically influenced post-smolt salmon migration success. There was a trade-off between arriving at the destination quickly but at a small size and not arriving at the destination at all. Fish that took a long time to migrate had more opportunities to feed and encountered warmer summer waters, increasing their overall growth.

Byron, C. J., & Burke, B. J. (2014). Salmon ocean migration models suggest a variety of population-specific strategies. Reviews in Fish Biology and Fisheries, 24(3), 737-756.

Abstract:

Many species of salmon around the world migrate to open ocean environments for multiple years and then return to their natal rivers to spawn. How exactly salmon are able to execute these long distance migrations, and the impact of environmental conditions on migration behavior, is not well understood. Individual-based modelling is one tool that has been used to explore salmon migration in the ocean. Although models are usually not able to confirm whether a particular behavior is used, they can rule out some behaviors as unrealistic. An extensive review of published literature suggests that there is no universal migration behavior. Behaviors that fish use to navigate depend on where they are in the ocean relative to where they are going, as well as the ocean flows and conditions along the way. Future models of salmon migration should be flexible and at an appropriate scale to capture variable oceanographic conditions and fish responses.

Project No. U13 Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	**Migration timing of Atlantic salmon smolts from Penobscot Bay to the Scotian Shelf**
Objective of research project	Evaluate the migration timing and likely spatial extent of Gulf of Maine Atlantic salmon post-smolts along migration to the Ocean Tracking Network's Halifax Array and other distant water telemetry assets in the OTN network.
Brief description of research project	Low marine survival is limiting recovery of Gulf of Maine Atlantic salmon and a better understanding of migration ecology is key to determining limiting ocean factors. We have collected acoustic telemetry tracks of more than 1,200 wild and hatchery origin smolts since 2005 in the lower Penobscot River. These data have allowed us to document post-smolt movements from outer Penobscot Bay into the Gulf of Maine. Additional monitoring on integrated ocean observing systems, weather buoys, and other platforms has provided additional data on postsmolts in the Gulf of Maine proper. More distant detections along the coast of Nova Scotia from the Ocean Tracking Network's Halifax Line and other coastal Canadian arrays have further extended some of these tracks. We are working to present a synthesis of postsmolt migration timing from Maine to these distant locations for over 300 postsmolts from 2005 to present and this research is ongoing. We used these tracks in conjunction with oceanographic and bioenergetics models to identify probable migration routes. Together these data allow us to identify offshore areas that may be critical for Atlantic salmon post smolt growth and survival. Work related to this project involves coordination with the Ocean Tracking Network to advance field of study of salmon and other living marine resources across international boundaries and large seascapes.
Dates during which research will take place	2013-2019
Area in which research will take place	Desktop study (data from Gulf of Maine river headlands and OTN Canada Assets)
Estimated number and weight of salmon to be retained	None
Resources	
Estimated cost of the research project	Approximately £10,000 per annum (public funding) The majority of the data collection costs were covered under U4.
Number of participating scientists	6
Name and e-mail address of coordinating scientist in charge of project	John Kocik (John.Kocik@noaa.gov)

Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Amirix Vemco Ultrasonic Telemetry Tags and Automated Pinger Detection Units
Details of any collaborating countries	USA and Canada (OTN)

Summary of Progress:

Multiyear analysis ongoing with one publication in 2017, one in-review, and several presentations that integrated this work with comprehensive examinations of salmon marine ecology. Work on transit times through the Gulf of Maine and the impact on freshwater migration history, especially the impact of dam passage are ongoing.

Devers, M, J.F. Kocik, D. Hebert , J.P. Hawkes, J. Zydlewski, and.D. Stich. *In Review*. Linkage between coastal conditions, detection patterns, and migratory behavior of Atlantic Salmon postsmolts across the Scotian Shelf.

Synopsis - Atlantic salmon Salmo salar migrate over long distances in the marine environment and are threatened by changes in oceans conditions linked to climate change. To better understand their migratory behavior and the linkages with local hydrographic and current conditions, we used acoustic telemetry in conjunction with concurrent oceanographic measurements collected from underwater gliders. We released acoustically tagged Atlantic salmon smolts in the Penobscot River (Maine, USA) from 2008 to 2014 (157 - 597 annually). Over 325 of these fish were detected more than 500 km away, along an acoustic curtain of up to 256 hydrophones deployed over 180 km along the Halifax Line, across the Scotian Shelf. The arrival of postsmolts at the Halifax Line varied by more than two weeks depending on the year and was concurrent with the seasonal solar heating of the top 20 m of the water column. Detections were generally concentrated near-shore (within 40 km) but varied somewhat annually. Detections were negatively correlated to temperature and salinity, suggesting that Atlantic salmon postsmolts may be selecting colder and less saline water. The absence of a significant correlation with ocean currents indicated that local ocean circulation does not affect their spatial distribution. The migratory behavior of postsmolts at the Halifax Line was characterized by a localized detection pattern (fish detected at two or less adjacent stations), and short residence time (less than 25 min within the detectable range). The migratory heading was estimated between 50° and 120° North. These results provide the first empirical data on migratory routing of Atlantic salmon postsmolts during annual migration to ocean feeding grounds, and highlight important relationships with climate variables that are subject to change in the future.

Lennox, R.J., K. Aarestrup, S.J. Cooke, P. Cowley, Z. Daniel Deng, A.T. Fisk, R. Harcourt, M. Heupel, S. G. Hinch, K. Holland, N. Hussey, S. Iverson, S. Kessel, J. Kocik, M. C. Lucas, J. Mills Flemming, V.M. Nguyen, M. Stokesbury, S. Vagle, D. VanderZwaag, D. Webber, F.G. Whoriskey, and N. Young. 2017 Envisioning the future of aquatic animal tracking: technology, science, and application. Bioscience.67(10): 884–896 link

Abstract - Electronic tags are significantly improving our understanding of aquatic animal behavior and are emerging as key sources of information for conservation and management practices. Future aquatic integrative biology and ecology studies will increasingly rely on data from electronic tagging. Continued advances in tracking hardware and software are needed to provide the knowledge required by managers and policymakers to address the challenges posed by the world's changing aquatic ecosystems. We foresee multiplatform tracking systems for simultaneously monitoring the position, activity, and physiology of animals and the environment through which they are moving. Improved data collection will be accompanied by greater data accessibility and analytical tools for processing data, enabled by new infrastructure and cyberinfrastructure. To operationalize advances and facilitate integration into policy, there must be parallel developments in the accessibility of education and training, as well as solutions to key governance and legal issues. *Salmon highlights* – the importance of platforms of opportunity and public databases is highlighted in this paper. The ability to expand ocean monitoring hinges upon sharing resources across studies and nations.

Project No.   U14   Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	**Impact of oceanographic changes on Atlantic salmon survival in the Northwest Atlantic**
Objective of research project	Investigate the hypothesis that ecosystem changes have influenced the energy needed by and available to Atlantic salmon and thereby have affected salmon growth, survival, and productivity during their marine phase.
Brief description of research project	Atlantic salmon populations have declined throughout North America and Europe in recent decades. These declines have exhibited similar patterns over broad geographic areas, and previous studies have shown correlations between salmon declines and changing marine ecosystem conditions. These analyses have specifically identified warming ocean conditions and changes in the prey base as closely linked with Atlantic salmon population trends. The observed ecosystem changes have likely increased the energy requirements of Atlantic salmon and reduced the energy available to them through their prey. However, the mechanisms behind these relationships remain undiagnosed. Through this project, we will investigate the hypothesis that ecosystem changes have influenced the energy needed by and available to Atlantic salmon and thereby have affected salmon growth, survival, and productivity during their marine phase. Results will provide a better understanding of how marine ecosystem conditions affect Atlantic salmon populations, which is valuable information for evaluating their recovery prospects and constraints.
Dates during which research will take place	2014-2019
Area in which research will take place	Desktop study
Estimated number and weight of salmon to be retained	Not applicable
Resources	
Estimated cost of the research project	Approximately £180,000 per annum (public funding)
Number of participating scientists	3
Name and e-mail address of coordinating scientist in charge of project	Timothy Sheehan (Tim.Sheehan@noaa.gov)
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Not applicable

Details of any collaborating countries	USA only
Summary of Progress: Work continues to collect growth data from time series of scales from Atlantic salmon adult returns and marine captures. A Postdoc has been hired (January 2017) and preliminary efforts have been towards collating appropriate datasets and modelling techniques, familiarization with the Northwest Atlantic, Northwest Atlantic salmon populations, US Atlantic salmon populations and the various/miscellaneous datasets available. This position will primarily be responsible for the data processing and analysis under this project. A manuscript which describes a newly developed Dynamic Energy Budget (DEB) model for Penobscot River (USA) Atlantic salmon is expected to be submitted for publication in 2018.	

Project No. U15 Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	**Species interactions in the Penobscot Estuary**
Objective of research project	1) Merge datasets from acoustic telemetry smolt tagging studies and hydro-acoustic data collected within the Penobscot Estuary. 2) Describe overlap of timing and location (along river and within the water column) data of Atlantic salmon smolts and hydro-acoustic data targets (river herring). 3) Describe and compare these data and how it relates to survival.
Brief description of research project	Acoustic telemetry has been conducted by NOAA's NMFS in the Penobscot Estuary since 2005 (see project U4). These investigations have been used to describe migration dynamics and survival of ATS smolts within the estuary. Hydro-acoustic surveys have been conducted in the Penobscot Estuary since 2011. These surveys have allowed researchers to describe the spatial and temporal variability of the fish community during bimonthly surveys of this environment. By merging datasets from telemetry and hydro-acoustic surveys, researchers will attempt to describe interaction and function of the estuary environment during the smolt migration period. Data and results from this effort may be used to suggest management actions toward restoration efforts on the Penobscot River system.
Dates during which research will take place	Data collection 2013-2015. Data analysis and publication 2015-2019
Area in which research will take place	Penobscot Estuary, Maine
Estimated number and weight of salmon to be retained	It is anticipated that no Atlantic salmon will be retained during this project.
Resources	
Estimated cost of the research project	Approximately £50,000 per annum (public funding)
Number of participating scientists	~5
Name and e-mail address of coordinating scientist in charge of project	James Hawkes James.Hawkes@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	Equipment deployed from small research boats and leased commercial vessels. Vessel use is subject to change annually.
Type and amount of gear and other equipment to be used	Amirix Vemco Acoustic Telemetry Tags (~150 annually) and Acoustic Telemetry Receivers (100-150 annually)
Details of any collaborating countries	None

Summary of Progress:

Field activities have concluded and analysis is ongoing. The 2013 abstract of findings can be found in the 2014 Annual US Atlantic Salmon Assessment Committee report (http://www.nefsc.noaa.gov/USASAC/Reports/). Expected completion 2019.

Project No. U16 Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	**Acoustic Telemetry Evaluation of Migration Performance in the Kennebec Estuary.**
Objective of research project	1) Evaluate smolt emigration dynamics and timing in the Lower Kennebec River and Estuary and Merrymeeting Bay 2) Estimate survival of migrating smolts and post-smolts
Brief description of research project	The Maine Department of Marine Resources (DMR) has been using egg planting in the Sandy River to try to supplement and restore the population of Atlantic salmon to the Sandy River, a large tributary to the Kennebec River. Although there are several mainstem dams hindering restoration efforts, there is still a need for evaluation of these restoration fish. This evaluation is focused on the migration performance within the Lower Kennebec River and Estuary and Merrymeeting Bay. Brookfield Power Company monitors smolt emigration timing in the Sandy River using a rotary screw trap. NOAA staff acoustically tag a portion of these smolts then transport them below the lowest mainstem dam and release them into the river. A collaborative telemetry receiver array is deployed in partnership between NOAA and DMR throughout the Lower Kennebec River and Estuary and Merrymeeting Bay environments to track tagged fish. The array allows NOAA staff to be able to define pathways, timing and survival of smolts as they exit the system.
Dates during which research will take place	Data collection 2014-2015. Data analysis and publication 2015-2019
Area in which research will take place	Kennebec Estuary, Maine
Estimated number and weight of salmon to be retained	It is anticipated that no Atlantic salmon will be retained during this project.
Resources	
Estimated cost of the research project	Approximately £8,000 per annum (all public funding)
Number of participating scientists	~5
Name and e-mail address of coordinating scientist in charge of project	Graham Goulette Graham.Goulette@noaa.gov
Details of research vessels, e.g. name, registration, call sign and description of vessel	Equipment deployed from small NOAA and DMR research boats – no contracted vessels.
Type and amount of gear and other equipment to be used	Amirix Vemco Ultrasonic Telemetry Tags (50 annually) and Automated Acoustic Receivers (30 annually)
Details of any collaborating countries	None

Summary of Progress:

Field activities concluded at the end of June 2015. Data and analysis will be developed into a peer-reviewed manuscript, in the meantime, preliminary results can be found in the 2015/2016 Annual US Atlantic Salmon Assessment Committee report (http://www.nefsc.noaa.gov/USASAC/Reports/).

Project No. U17 Status: Ongoing

Party or relevant jurisdiction	United States of America
Title of project	Effects of climate-driven ecosystem change on Atlantic salmon growth and survival at sea: analyses of West Greenland salmon
Objective of research project	Understand Atlantic salmon growth as a mechanism linking ecosystem conditions to population outcomes.
Brief description of research project	Extract annual growth data from scales collected at Greenland (1969-present) to examine questions such as: • Have growth characteristics of North American Atlantic salmon changed over time? • Do distinct growth patterns emerge in the Greenland fish that may be related to 'survivors' versus 'non-survivors'? • Are variations in growth indices related to oceanographic and ecosystem conditions? • Are variations in growth related to population abundance and productivity?
Dates during which research will take place	2017 - 2019
Area in which research will take place	Desktop study
Estimated number and weight of salmon to be retained	Not applicable
Resources	
Estimated cost of the research project	Approximately £45,000 per annum (public funding) Some monetary linkages with project U14 (Impact of oceanographic changes on Atlantic salmon survival in the Northwest Atlantic)
Number of participating scientists	4
Name and e-mail address of coordinating scientist in charge of project	Timothy Sheehan (Tim.Sheehan@noaa.gov)
Details of research vessels, e.g. name, registration, call sign and description of vessel	Not applicable
Type and amount of gear and other equipment to be used	Not applicable
Details of any collaborating countries	Canada

Summary of Progress:

Growth data extraction from scales collected at West Greenland continues. Targeted sample size is 75 individual per year (1968-2016). Data collection will be finalized in early 2018 and a peer reviewed publication is planned for 2019.

FRANCE (IN RESPECT OF ST PIERRE AND MIQUELON)

Project No. F1 Status: Ongoing

Party or relevant jurisdiction	France (In respect of St Pierre and Miquelon)
Title of project	**St Pierre and Miquelon Salmon Fishery Sampling Programme**
Objective of research projects	To improve the understanding of the biological characteristics and origin of salmon harvested in the fishery at St Pierre and Miquelon.
Brief description of research project	-The Scientific Programme at St Pierre and Miquelon was introduced in 2003 under the direction of the Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER). The project was developed through cooperation with NASCO and was designed so as to include three components: - A biometric study - A genetic study - A disease and parasite study. In 2012, France and Canada (Quebec) organised a scientific workshop in Saint-Pierre and Miquelon from 10 to 14 September to improve the accuracy of ageing salmon harvested in the North-western Atlantic.
Dates during which research will take place	Annually during the fishing season (2017 : 1 May – 21 July)
Area in which research will take place	Around the islands of St Pierre and Miquelon
Estimated number and weight of salmon to be retained	Sampling of harvest : 144 salmons in 2017
Resources	
Estimated cost of the research project	-
Number of participating scientists	1
Name and e-mail address of coordinating scientist in charge of project	Herlé Goraguer herle.goraguer@ifremer.fr
Details of research vessels, e.g. name, registration, call sign and description of vessel	N/A
Type and amount of gear and other equipment to be used	Samples obtained from the fishery
Details of any collaborating countries	Canada : DFO/Newfoundland and Labrador Dr Ian Bradbury and DFO/New Brunswick Gerald Chaput

Summary of Progress:

Salmon Fishery Sampling: In 2017, the sampling program of salmon harvested at sea around St Pierre et Miquelon was continued by Ifremer. Between 14 June and 9 July, 144 salmons, harvested around both islands of Miquelon and St Pierre, were measured and weighted.

Age structure and genetic analyses : The collaboration set up in 2013 between Ifremer-St Pierre et Miquelon and DFO-Newfoundland and Labrador continued in 2017. Scales and tissue samples taken from the 144 salmons were transmitted by Ifremer to the DFO laboratory in St John’s, Newfoundland for age determination and genetic analyses. As of 1st February, results are not available yet.