SURVEY REPORT

Southern Hebrides Islands Rivers Project: Survey of Fish Populations & Habitats

2012

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For further information on this report please contact;
Argyll Fisheries Trust,
Cherry Park,
Inveraray,
Argyll, PA32 8XE

SURVEY REPORT

Summary

Southern Hebrides Islands Rivers Project: Survey of fish populations and habitats 2012.

Background

Argyll Fisheries Trust undertook surveys of fish populations at 94 sites on 35 river catchments on the Isle of Islay, Jura, Coll and Colonsay in 2012. Surveys of fish habitat were also undertaken on 56.8 km of river in ten catchments. The aims of the surveys were to identify fish species distribution, their relative abundance, and identify factors affecting the productivity of fish habitats.

Main findings

Electrofishing surveys found six native species; Atlantic salmon (*Salmo salar*), Brown trout (*Salmo trutta fario*), European eel (*Anguilla anguilla*), Flounder (*Platichthys flesus*), Three-spine stickleback (*Gasterosteus aculeatus*) and Lamprey (*Lampetra spp.*).

Juvenile Atlantic salmon were found in eight catchments on the Isle of Islay and three catchments on the Isle of Jura, while no salmon were found on the Isles of Coll or Colonsay. Juvenile brown trout were found in all catchments surveyed on Islay and Jura, but were not found in five of the 13 smaller streams surveyed on the Isle of Coll or four of the five streams surveyed on Colonsay.

Where present the relative abundance of juvenile fish varied widely between survey sites in each catchment, ranging from a relatively low to very high abundance when compared to a classification scheme for West Scotland.

Habitat surveys on Islay and Jura found over 45 ha of habitat for migratory salmonid fish in ten catchments. This habitat contained 365 significant pools with a total area of 10.5 ha which were suitable for adult migratory salmonid fish, 53 % of which was assessed as being optimal habitat. A total of 376 spawning sites were recorded containing 1.09 ha of habitat, 40 % of which was found in optimal condition. Other in-stream habitat was mostly suitable for mixed age classes of juvenile salmonid fish (68 %), while smaller proportions of habitat were deeper and suited to older parr (22 %) or shallower and suited to younger fry (10 %).

The following conclusions were reached:

The distribution of juvenile salmon found in the survey suggest that population size is related to the area of the available freshwater habitat in each catchment. Larger catchments, such as the River Laggan (Islay) and the River Lussa (Jura) appear to have relatively healthy populations of salmon, while less robust populations were found in smaller catchments such as the Claggain, Saligo and Margadale (Islay). Salmon populations in relatively moderate size catchments; Sorn, Kintour, Uisg an t-Suidhe, (Islay) and the Corran and Aoistail (Jura) appear to be widespread but abundances appear to be less than optimal at most sites.

The distribution of juvenile brown trout was more widespread in all catchments surveyed with the exception of some smaller coastal streams of Coll and Colonsay which have limited habitat availability. Some trout populations are likely to have a component of sea-run adults.

From the data collected, estimates of salmon smolt production, marine survival and adult sea returns suggest that salmon populations are not able to absorb significant exploitation of the stocks from fisheries.

The survey also identified lack of trees and other diverse vegetation on river banks as being widespread which will reduce habitat productivity and subsequently impair smolt production. Significant changes to natural river morphology were also found on the Rivers Sorn and Uisg an t-Suidhe which will impair habitat productivity. There were also numerous weir structures found on the Aoistail, Corran and Sorn rivers which may affect the upstream passage of fish and change the type of habitat available to different life-stages of fish.

Future work and management recommendations:

While there is a relatively low survival of smolt-to-adult life-stages of migratory salmonid fish at sea, operation of fisheries on a catch and release basis are likely to maximise spawning escapement and subsequently maintain recruitment of juveniles and smolt production.

Improving the productivity of freshwater habitats is key to maintaining and improving abundance of salmonid fish populations. Restoration of diverse vegetation on river banks will improve banks stability, availability of food and cover for fish. Promoting shading of the river channels with trees is also likely to future proof against future threats from climate change to cold water fishes. Introduction of large woody debris features into stream habitats will also improve habitat heterogeneity and productivity.

Restoration of natural stream morphology to the habitat on the Rivers Sorn and Uisg an t-Suidhe will increase the habitat available and improve productivity of the habitat and improve fish populations and fishery performance. A review of weir structures is required for the Aoistail, Corran and Sorn rivers to ensure that habitat remains accessible and productive for fish.

Acknowledgements

Argyll Fisheries Trust thanks the project partners for their support; Scottish Natural Heritage (SNH), Heritage Lottery Fund, Awards for All Scotland, Scottish Power Renewables and all fishery owners and land owners for permission to access survey sites.

Stage	**Name**	**Date**
Drafted by:	Alan Kettle-White	08/05/2013
Proof-read:	Daniel Brazier	25/06/2013
Authorised:	Craig MacIntyre	29/07/2013

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1 INTRODUCTION

Argyll Fisheries Trust undertook electrofishing surveys of fish population at 94 sites in 35 river catchments on the Isles of Islay, Jura, Coll and Colonsay (Figure 1.1). Fish habitat surveys were also undertaken on 56.8 km of streams in ten of the larger catchments on Islay and Jura. The aims of the surveys were to collect information on fish species distribution, their relative abundance and the status of habitats to inform a wide range of stakeholders of the status of the freshwater resource. This report summarises the findings of the surveys undertaken in 2012. Catchment specific reports that provide more detailed information on the study findings are provided separately.

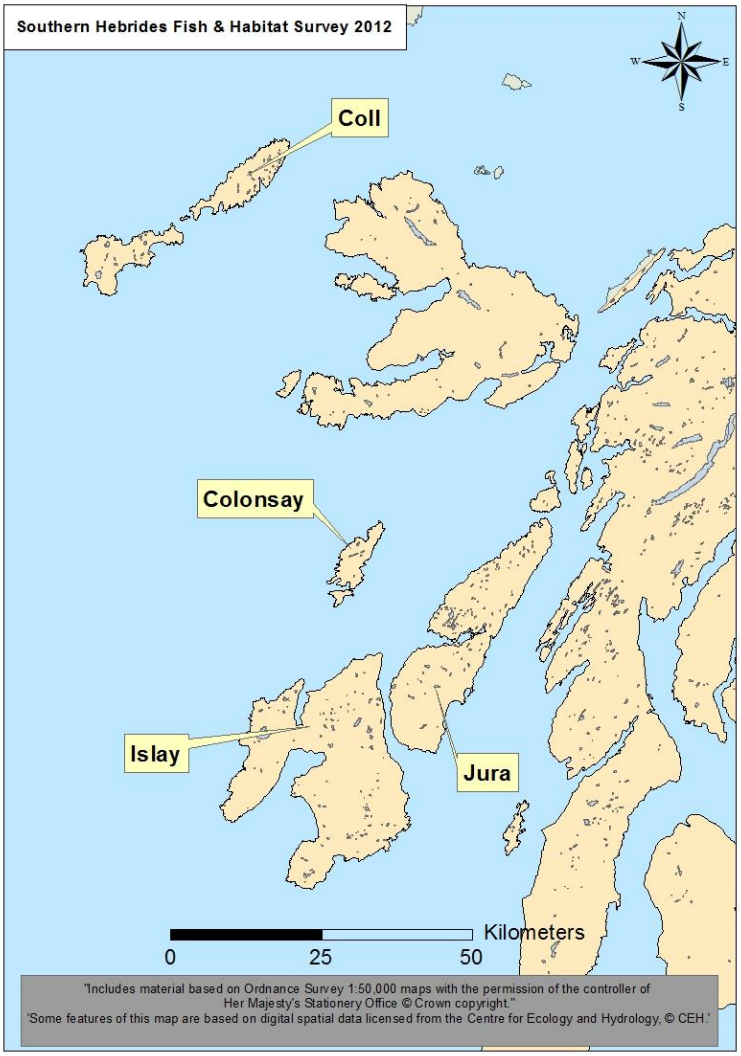

Figure 1.1 Southern Hebrides Islands surveyed in 2012

1.1 Fish populations

Most of the catchment areas of freshwater habitats on the Isles of Islay and Jura surveyed as part of this study are relatively large compared to those on the Isles of Colonsay and Coll which consist of a number of relatively small coastal streams and lochs. Subsequently the fish fauna may vary depending on the habitat provided. Native fish species mostly migrate between freshwater and marine habitats such as Atlantic salmon (*Salmo salar*) and the migratory form of brown trout; the sea trout (*Salmo trutta*). Other native fish fauna that are typically found to utilise freshwaters during their life-cycle in the west coast region of Scotland are understood to be European eel (*Anguilla anguilla*), river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*), three spine stickleback (*Gasterosteus aculeatus*) and flounder (*Platichthys flesus*). Brook lamprey (*Lampetra planeri*) and some individual brown trout may spend their whole life in freshwater. This study was mainly focused on salmonid fish, but also collected data on other species sampled at survey sites.

1.2 Salmonid fish life-cycle

Typically adult migratory salmonid fish enter freshwater in the summer months before spawning during the late autumn and early winter period. Fertilised eggs are incubated within the substrates of the river bed before emerging as fry (young of the year) in spring. Subsequently, free-swimming stages of juvenile salmonid fish inhabit freshwater rivers for a period of one (as fry), two or three years (as parr) or sometimes longer. Juveniles then migrate to sea as smolts where they complete over 90% of their growth phase before maturation and eventual return to their natal rivers. Unlike salmon, a proportion of the trout population (usually a high percentage of males) remain in fresh water as the resident form of brown trout where they may or may not interbreed with sea run morphs. This study aims to evaluate the current status of juvenile salmonid fish in their fry and parr stages prior to emigration and provide information on distribution, relative abundance and inform an initial assessment of the condition of their habitats.

1.3 Fisheries for salmon and trout

This resource supports rod & line fisheries for Atlantic salmon and sea trout in most of the catchments surveyed that are of importance to the local economy. The resource has been managed by the Laggan and Sorn District Salmon Fishery Board on the west of Islay and fishery catch data has been reported to Scottish Government by individual fisheries. There are no known stocking activities on any of the catchments surveyed during the study period.

2 METHODS

To assess the status of fish populations and the condition of their habitat, two survey methods were employed; sampling of fish by electrofishing and assessment of habitats by walk-over survey. Survey methods are summarised below and detailed in Appendix I.

2.1 Electrofishing surveys

The electrofishing technique targets juvenile stages of salmonid fish in relatively shallow water (less than 0.5 m depth), which unlike adult migratory salmonids are present all year round and represent between one and three year classes of recruitment. The method is used to temporarily stun fish in the close vicinity of the operator, allowing fish to be retained and processed prior to release. All surveys (see below) were undertaken in accordance with the Scottish Fisheries Co-ordination Centre (SFCC) protocols (SFCC, 2007).

Estimates of minimum fish density were calculated by dividing the number of fish caught by the area of stream surveyed. In order to provide a guide to the relative abundance of salmonid fish sampled during the survey, minimum density estimates were classified according to a classification scheme (Godfrey, 2005) related to geographical location and stream width.

2.1 Habitat surveys

To assess the potential use of freshwater habitat by fish, walk-over surveys were undertaken during September 2012. The survey technique was founded on the basic elements of the Scottish Fisheries Coordination Centre (SFCC) habitat survey protocols (version 2.1). Surveys of the river channels were divided into sections according to the type of habitat found. All survey section start and end points and relevant channel features were recorded on the ground during the survey (six figure grid reference by hand-held GPS).

The distribution and quality of the main in-stream and bankside habitat characteristics were recorded with the left and right banks orientation viewed downstream. The type of river channel present in each survey section was categorized in relation to the fluvial geomorphological character utilising guidance from Scottish Environment Protection Agency (SEPA, 2009, working draft) for applications on supporting information requirements for hydropower applications.

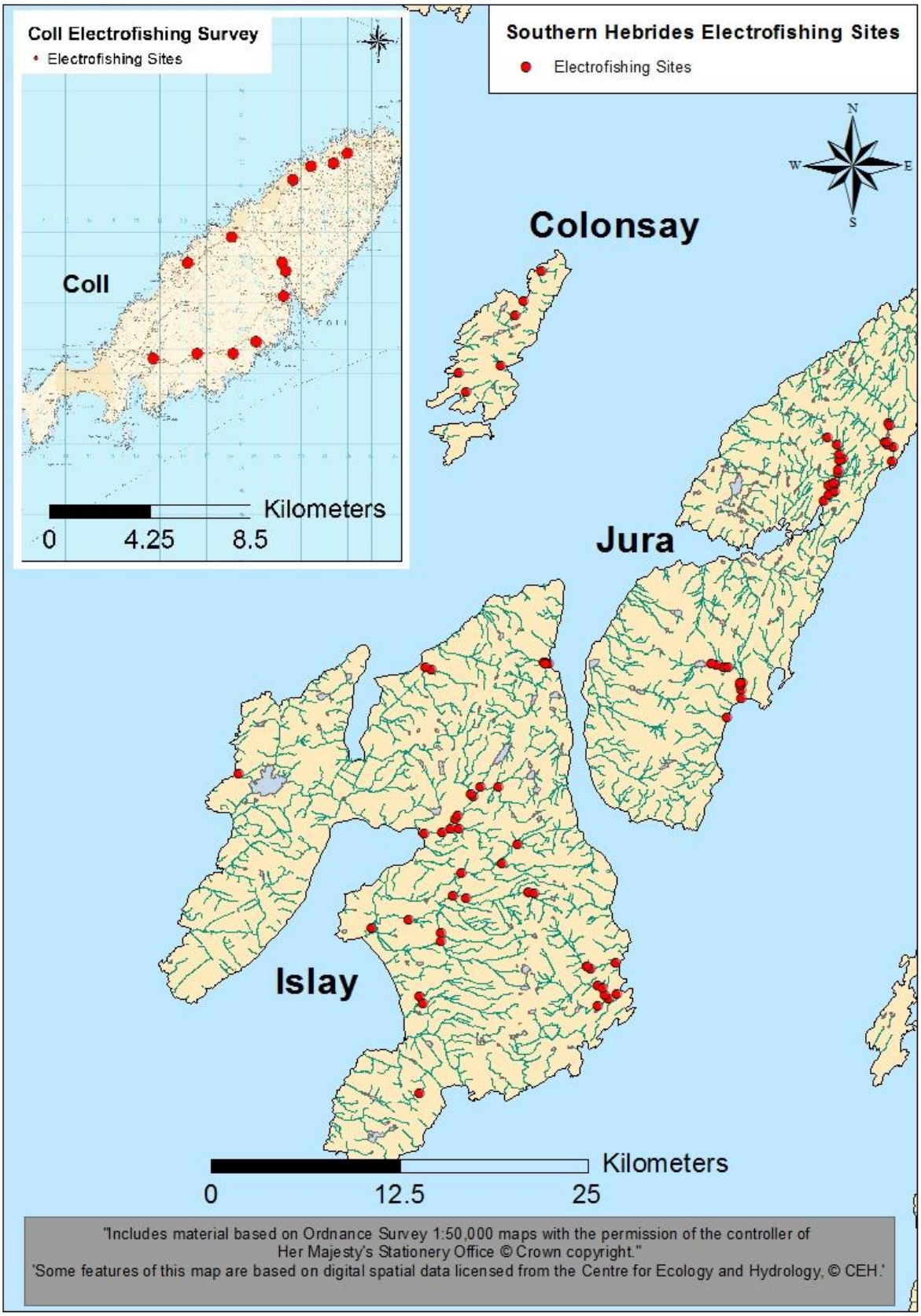

Figure 2.1 Electrofishing survey sites 2012

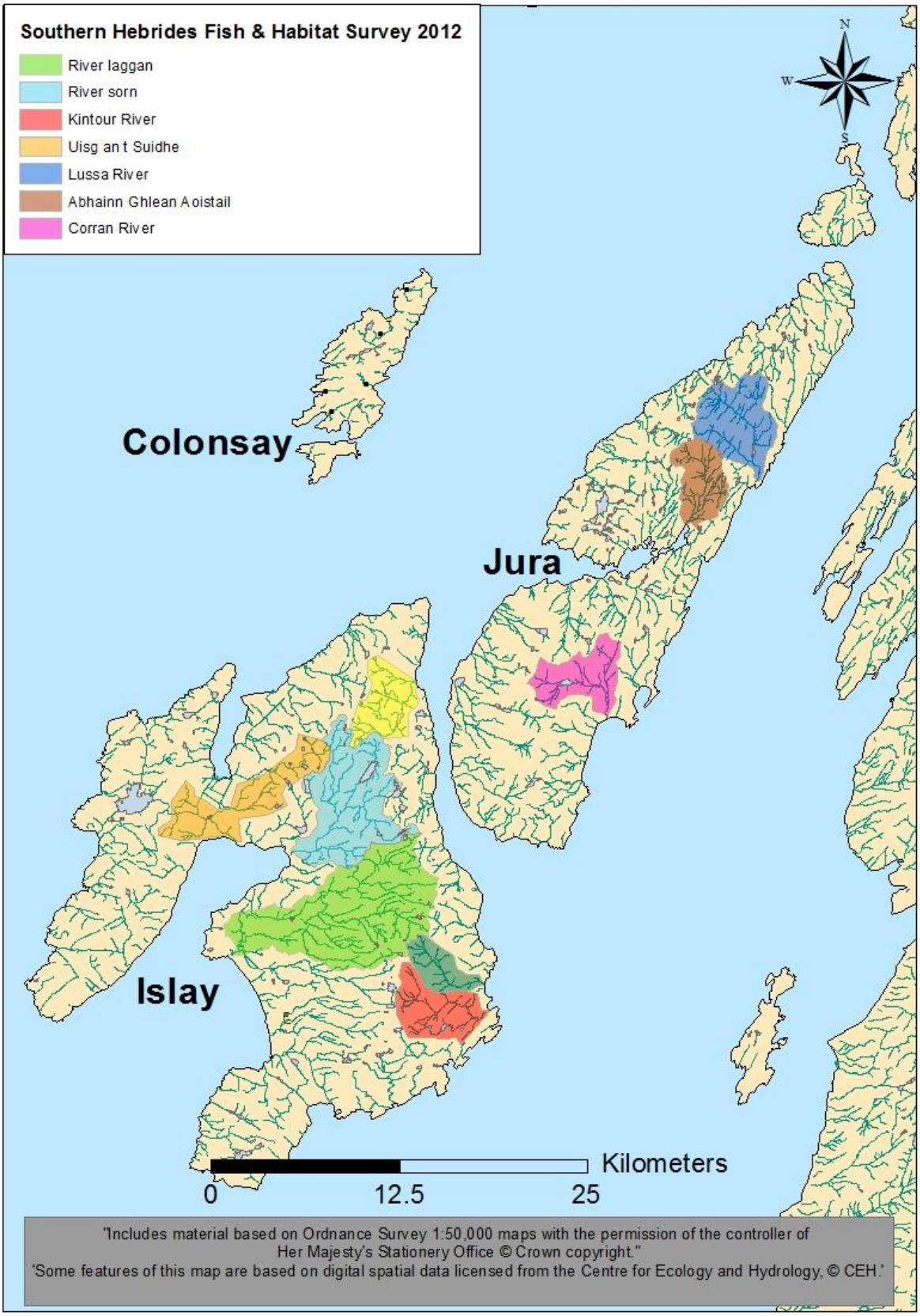

Figure 2.2 Habitat Survey catchments 2012

The quality of habitat which is associated with juvenile salmonid fish was assessed and allocated a score based on that described by Hendry & Cragg-Hine (1996) according to habitat preferences of different age classes of juvenile salmonids. A scale of 1 (poor) to 5 (excellent) was assigned to each survey section and juvenile habitats were downgraded where sub-optimal in-stream substrate, bank-side vegetation and potential effects of water and land use were identified.

The situation, quantity and quality of key habitat features associated with adult holding pools, spawning sites and obstacles to fish passage were recorded separately to allow mapping on Geographic Information System software (Arc GIS version 10.1). During the course of the survey photographs were taken of the general characteristics of the watercourse, including significant features to record a spatial view of the catchment in a systematic manner.

3 RESULTS

3.1 Electrofishing survey

Juvenile salmonids were found widely across all four islands (Table 3.1) with the exception of nine relatively small catchments surveyed on the Isles of Coll and Colonsay.

Table 3.1 Distribution of juvenile salmonid fish (no. of sites), 2012

Island	Survey No.		Salmon		Trout	
	Rivers	Sites	Fry	Parr	Fry	Parr
Islay	14	45	25	22	40	38
Jura	4	30	15	15	28	21
Coll	12	13	0	0	7	5
Colonsay	5	6	0	0	2	1
Total No.	**35**	**94**	**40**	**37**	**77**	**65**
%			43	39	82	69

Salmon fry were found at 43 % of sites and salmon parr were found at 39 % of sites. Trout fry were found at 82 % of sites, while trout parr were found at 69 % of sites surveyed in 2012.

3.1.1 Classification of salmonid fish abundance 2012

The classification of relative abundance of juvenile salmon and trout sampled in relation to stream width for the west region of Scotland are given below for four regions of Islay, Jura, Coll and Colonsay;

South-east Islay

At ten sites surveyed in three catchments in the south-east of Islay in 2012 (Table 3.2) the abundance varied; grade F represents an absence of fish and classes D and E represent low to very low abundance respectively. Classes C and B represent moderate to high abundance respectively and class A represents very high abundance.

A single survey undertaken in the Ardilistry Burn found a relatively high abundance of trout fry (class A) and a low abundance of trout parr (class D). Salmon fry and parr were found at low abundance (Classes E and D respectively) in the lower part of the Claggain River, while trout fry and parr were more widespread at varying abundance. Salmon fry were found at four sites in the Kintour River where abundance ranged from low (class D) at two sites, moderate at another (class C) along-side low abundance of parr. A high abundance of fry and parr (class B) were found at the lower-most site surveyed. Trout fry and parr were found

at all sites surveyed with mostly high abundance in the upper three sites (classes A and B) and low-to-moderate abundance at the lower three sites (Classes E, D and C).

Table 3.2 Classification of salmonid fish abundance in south-east Islay 2012

Catchment	Site	Salmon		Trout	
		Fry	Parr	Fry	Parr
Ardilistry	1	F	F	A	D
Claggain	1	E	D	E	B
	2	F	F	B	B
	3	F	F	C	D
Kintour	1	B	B	E	D
	2	C	E	C	E
	3	D	F	E	E
	4	F	F	B	B
	5	F	F	A	B
	6	D	F	B	E
South-east	**Total**	**5**	**3**	**10**	**10**

South-west Islay

Fourteen sites in three river catchments were surveyed on the south-west of the Isle of Islay including a relatively small (Cornabus), a moderate (Machrie) and the largest catchment on the island (Laggan) (Table 3.3).

Table 3.3 Classification of salmonid fish abundance in south-west Islay 2012

Catchment	Site	Salmon		Trout	
		Fry	Parr	Fry	Parr
Cornabus	1	F	F	D	D
Machrie	1	D	D	C	A
	2	E	B	C	C
Laggan	0	C	E	F	F
	1	B	B	F	F
	2	D	D	E	E
	3	A	B	D	E
	4	B	E	F	F
	5	B	C	E	C
	6	D	E	E	E
	7	B	E	E	B
	8	F	F	D	A
	9	F	F	D	B
	10	B	D	F	F
South-west	**Total**	**11**	**11**	**10**	**10**

While no juvenile salmon were found in the one site surveyed on the Cornabus, trout fry and parr were found at relatively low abundance. Salmon fry were found at low abundance (classes D and E) at two sites surveyed on the Machrie as were parr at more variable classifications (classes D and B). Trout fry were also found at both sites at moderate abundance (class C) as were parr at moderate and high classification (classes C and A). Salmon fry were found at high abundance (classes A and B) at six of the nine sites surveyed on the River Lussa, while salmon parr abundance was comparatively more variable and were commonly of relatively low abundance (Classes E and D at six sites). Where found at seven sites, trout fry abundance in the Lussa was generally low (classes D and E) while trout parr abundance was more varied between the lower main river (classes C and E) and the upper main river and tributaries (classes A and B).

North-east Islay

Seven sites in three relatively small river catchments were surveyed on the North-east of the Isle of Islay including allt a' Ghil, Gortantoid River and the Margadale River (Table 3.4).

Table 3.4 Classification of salmonid fish abundance in north-east Islay 2012

Catchment	Site	Salmon		Trout	
		Fry	Parr	Fry	Parr
Allt a Ghil	1	F	F	D	B
Gortantaoid	1	F	F	D	A
	2	F	F	E	E
Margadale	1	E	F	E	F
	2	F	F	F	F
	3	F	F	F	F
	4	F	F	E	E
North-east	**Total**	**1**	**0**	**5**	**4**

While no juvenile salmon were found in the Allt a' Ghil or the Gortantaoid River, salmon fry were found at very low abundance (class E) at the lower-most site surveyed on the Margadale River. Trout fry were found in all three catchments, but at relatively low abundance (Classes D and E), while trout parr abundance was more variable, including low abundance (class E) at one site in the Gortantaoid and one in the Margadale and high abundance at another in the Gortantaoid and Allt a' Ghil (classes A and B respectively).

North-west Islay

Fourteen sites in six river catchments were surveyed on the North-west of the Isle of Islay including one relatively large catchment (River Sorn), one moderate (Uisg an t-Suidhe) and three smaller catchments (Carrabus, Port Charlotte and Saligo Burns) (Table 3.5).

Table 3.5 Classification of salmonid fish abundance in north-west Islay 2012

Catchment	Site	Salmon		Trout	
		Fry	Parr	Fry	Parr
Sorn	3	C	E	E	C
	6	C	F	A	C
	7	C	D	B	C
	8	D	E	E	E
	9	F	F	C	A
Carrabus	1	F	F	E	E
Uisg an t-Suidhe	1	D	D	C	E
	2	F	F	C	F
	3	F	E	C	E
	4	D	D	A	A
	5	C	B	D	E
	6	F	F	B	A
Port Charlotte	1	F	F	D	A
Saligo Burn	1	D	B	E	C
North-west	**Total**	**8**	**8**	**15**	**14**

While no juvenile salmon were found in the Carrabus or the Port Charlotte Burns, salmon fry were found at low and moderate abundance (classes D and C) at four sites in the River Sorn, three sites in the Uisg an t-Suidhe and one site in the Saligo Burn. Salmon parr abundance was more variable, but mostly of low abundance (Classes E and D) at three sites in the River Sorn three sites in the Uisg an t-Suidhe alongside higher abundance (Class B) found at another site in this catchment and in the one site surveyed in the Saligo Burn.

Juvenile trout were more widespread than salmon as fry were found at all sites at varying abundance including low numbers (classes D and E) at six sites, moderate (class C) at four others and higher abundance (classes A and B) at four more sites. Similarly trout parr abundance also varied between low (five sites), moderate (four sites) and high abundance (four sites).

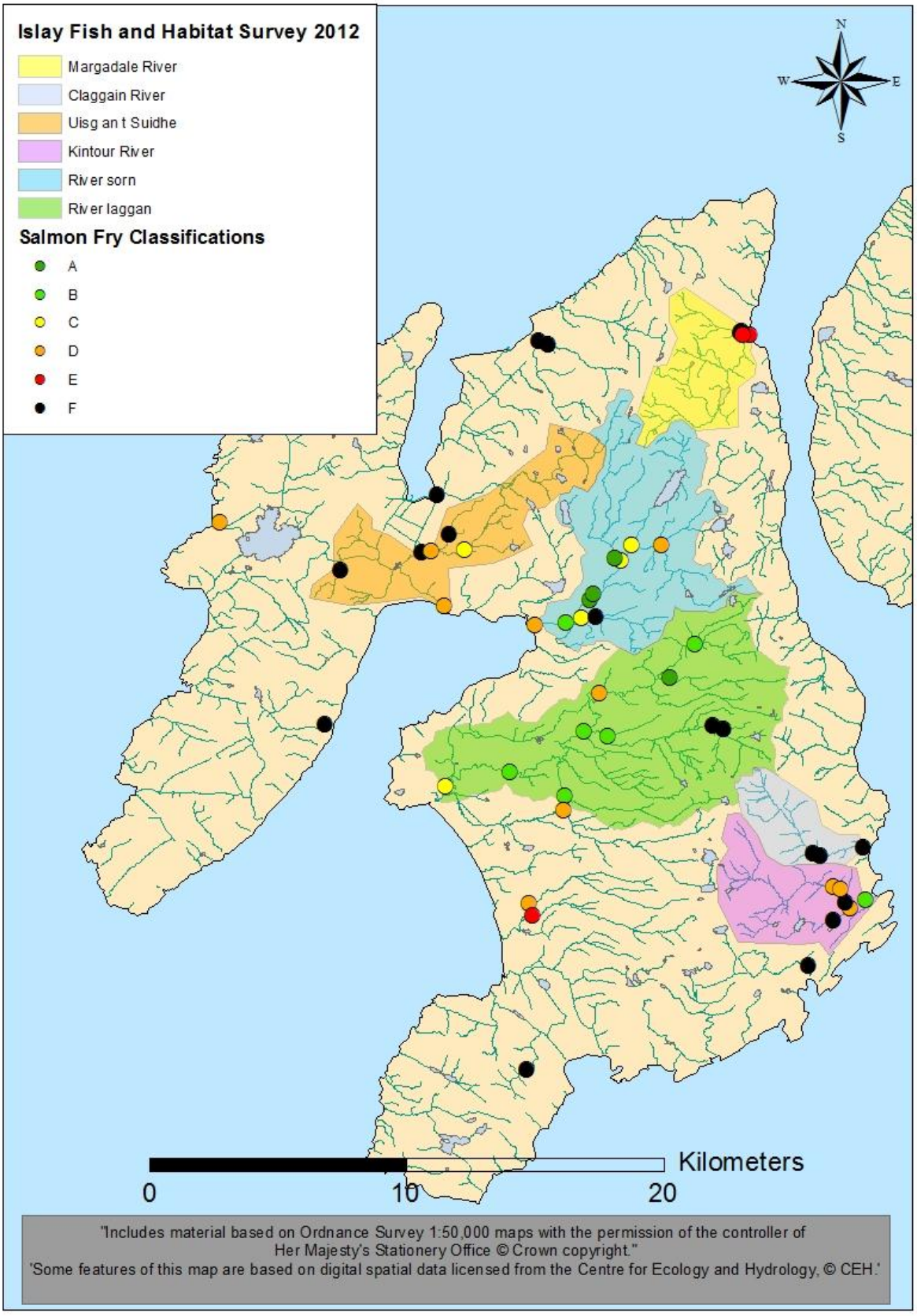

Figure 3.1 Salmon fry distribution and relative abundance at Isle of Islay survey sites

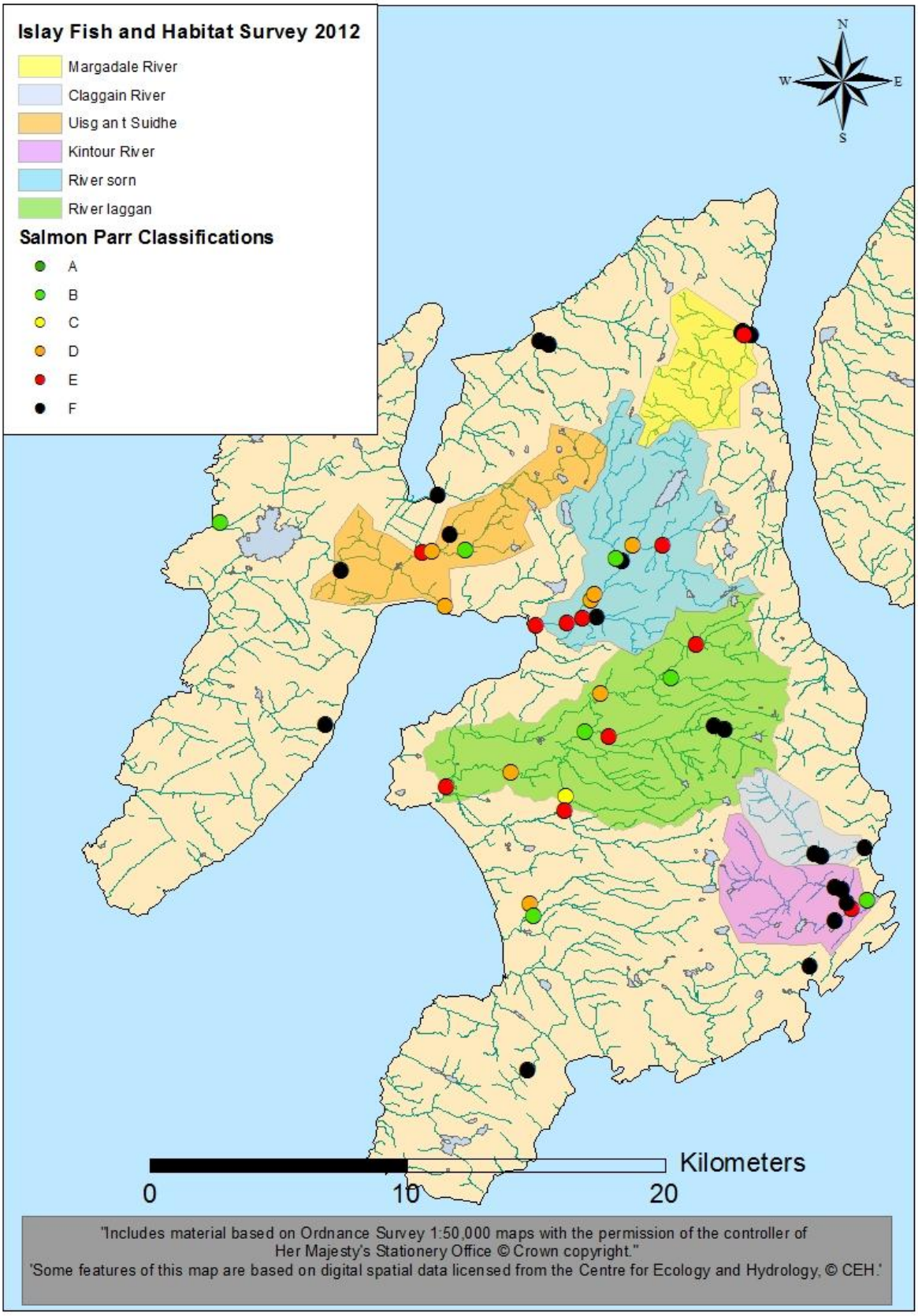

Figure 3.2 Salmon parr distribution and relative abundance at Isle of Islay survey sites

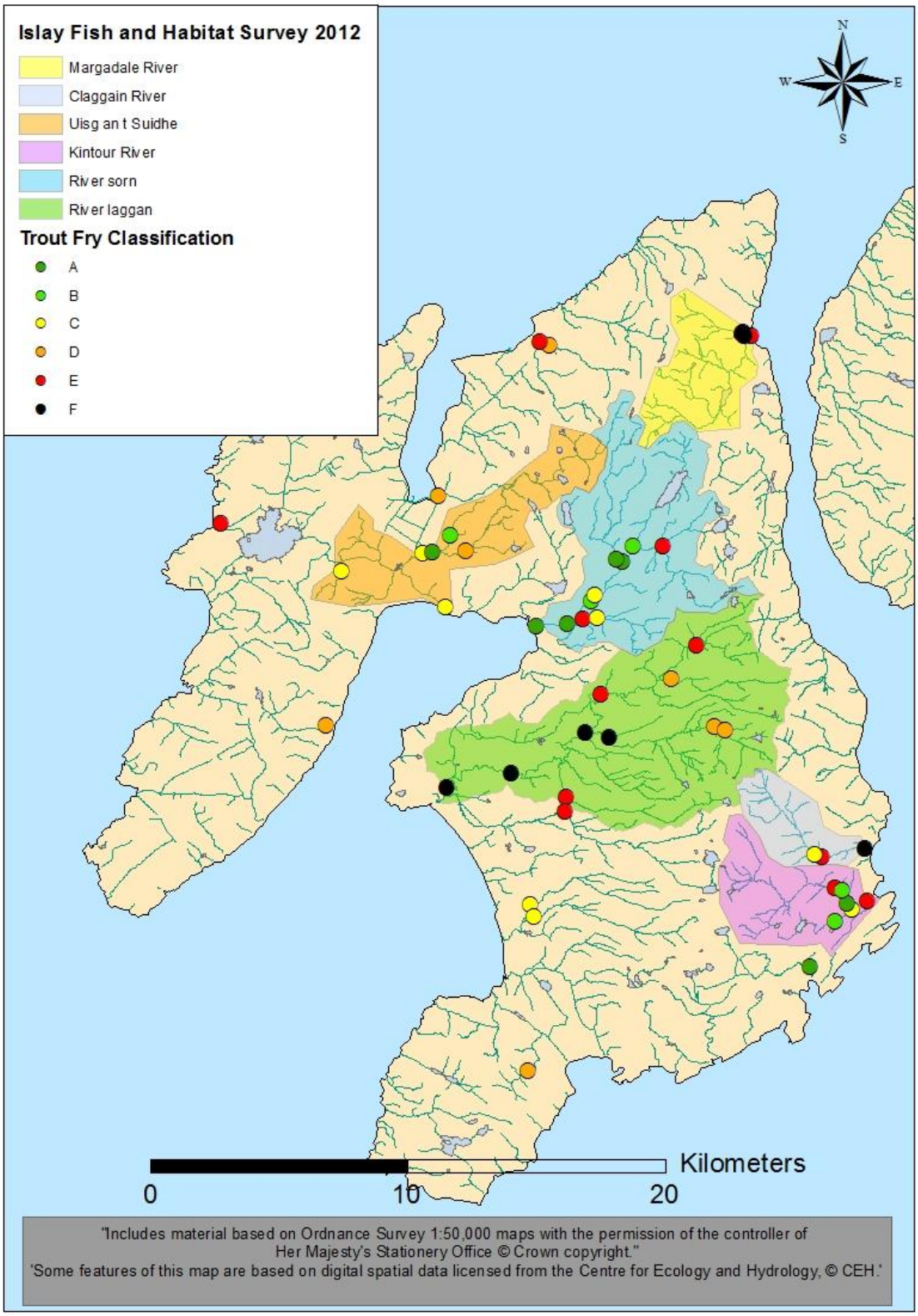

Figure 3.3 Trout fry distribution and relative abundance at Isle of Islay survey sites

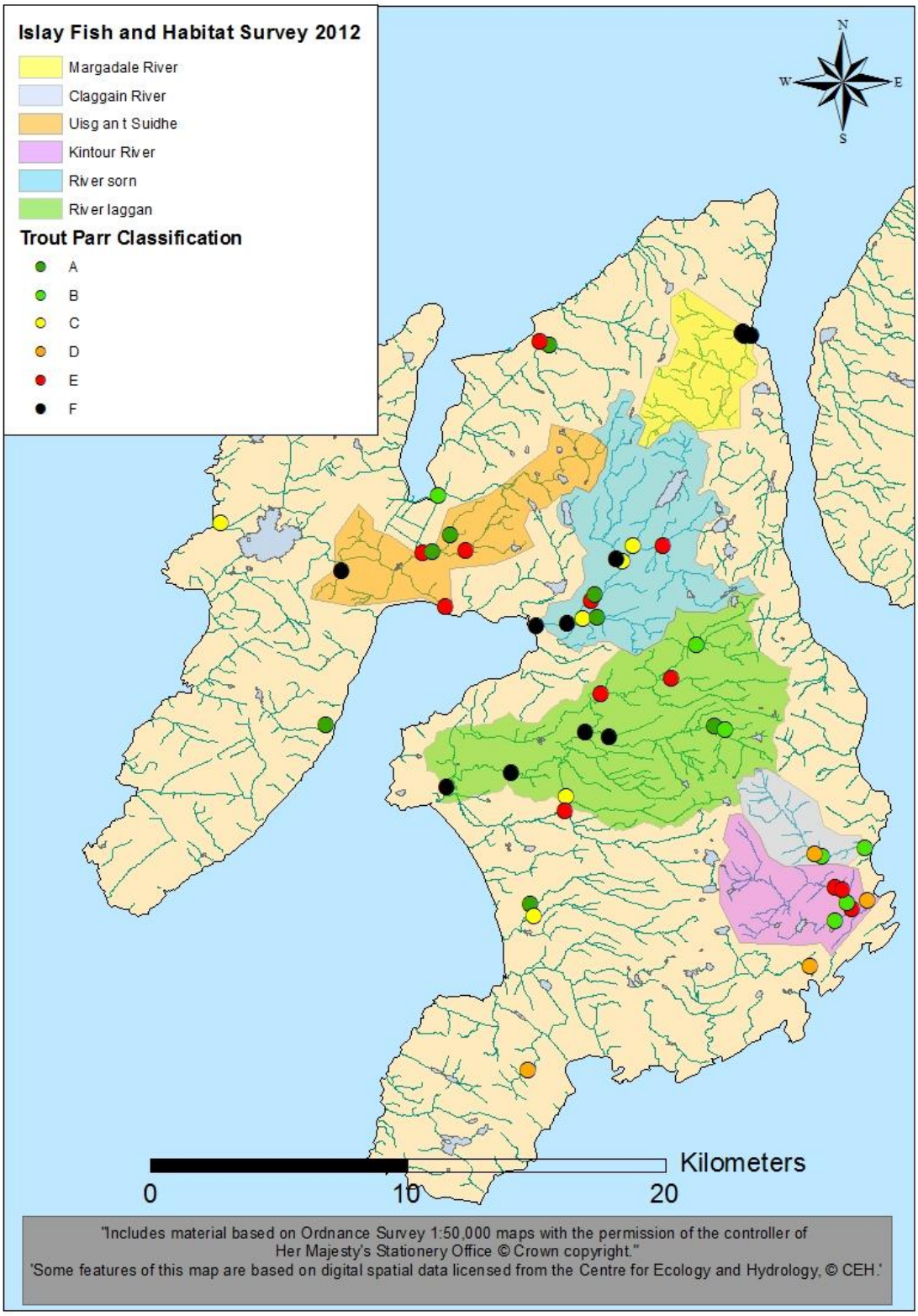

Figure 3.4 Trout parr distribution and relative abundance at Isle of Islay survey sites

Isle of Jura

Thirty sites were surveyed in four river catchments on the Isle of Jura including the relatively large catchments of the Abhainn Ghleann Aoistail, the Corran River and the Lussa River as well as one relatively small Burn at the Jura Forest Estate (Table 3.6).

Table 3.6 Classification of salmonid fish abundance on the Isle of Jura 2012

Catchment	Site	Salmon		Trout	
		Fry	Parr	Fry	Parr
Aoistail	**1**	D	E	A	E
	2	C	E	D	D
	3	F	F	C	F
	4	F	C	C	F
	5	D	D	D	F
	6	D	F	E	E
	7	D	E	A	E
	8	E	F	B	C
	9	F	F	D	B
	10	F	E	C	A
	11	F	F	D	B
	12	F	F	F	F
	13	F	F	F	F
Corran	**1**	F	E	D	A
	2	F	E	B	E
	3	E	F	A	C
	4	F	F	D	A
	5	E	F	A	A
	6	F	F	D	B
	7	F	F	A	A
	8	F	F	C	A
	9	F	F	A	A
Jura Forest Burn	**1**	F	F	E	F
Lussa	**1**	D	D	E	F
	2	C	A	C	C
	3	D	C	D	F
	4	D	E	B	E
	5	D	C	A	F
	8	B	A	C	E
	8a	C	C	D	B
Total	**30**	**15**	**15**	**28**	**21**

While no juvenile salmon were found in the Jura Forest Estate Burn, salmon fry were mostly found at low abundance (classes E and D) in five sites in the Aoistail, two sites in the Corran and five sites in the Lussa River. More moderate abundance (class C) was found at one site in the Aoistail and two sites in the Lussa as was a relatively high abundance at one other site

(class B). Similarly parr abundance was mostly low (classes E and D) at eight sites, moderate (class C) at four sites and high (class A) at two others in the Lussa River.

Juvenile trout were more widespread than salmon as fry were found at all but two sites at varying abundance including low numbers (classes D and E) at 12 sites, moderate (class C) at six others and higher abundance (classes A and B) at ten more sites. Similarly trout parr abundance also varied between low (four sites), moderate (three sites) and high abundance (eleven sites).

Isle of Coll

Thirteen sites were surveyed in twelve relatively small river catchments on the Isle of Coll (Table 3.7).

Table 3.7 Classification of salmonid fish abundance on the Isle of Coll 2012

Catchment	Site	Salmon		Trout	
		Fry	Parr	Fry	Parr
Allt Mor (Cornaig bay)	**1**	F	F	A	F
Clabhach Burn	**2**	F	F	E	B
Cliad Burn	**3**	F	F	F	F
Loch na cloich Burn	**4**	F	F	F	F
Torastan Burn	**5**	F	F	E	D
Allt an inbhive	**6**	F	F	C	D
Allt a mhuillin	**7**	F	F	C	F
Allt loch na romaird	**8**	F	F	C	F
Arnagour mainstem upper	**9**	F	F	E	A
Arnagour mainstem lower	**9a**	F	F	F	E
Allt Mor (South end)	**10**	F	F	F	F
Lodge Burn	**11**	F	F	F	F
Hyne Burn	**12**	F	F	F	F
Total		**0**	**0**	**7**	**5**

While no juvenile salmon were found on the Isle of Coll, juvenile trout were found at eight sites in seven catchments at varying abundance. Low numbers of fry (class E) were found at three sites, moderate (class C) at three others and higher abundance (class A) at one other. Similarly trout parr abundance also varied between low (three sites) and high abundance (two sites).

Isle of Colonsay

Six sites were surveyed in five relatively small river catchments on the Isle of Colonsay (Table 3.8).

Table 3.8 Classification of salmonid fish abundance on the Isle of Colonsay 2012

Catchment	Site	Salmon		Trout	
		Fry	Parr	Fry	Parr
Allt an Ghlinne	1	F	F	F	F
Airport burn	2	F	F	F	F
Allt Staosnaig	3	F	F	F	F
Abhainn a Mhuilinn	4	F	F	C	F
Abhainn a Mhuilinn	5	F	F	D	C
Sruthan na h-ulaidhe	6	F	F	F	F
Total		**0**	**0**	**2**	**1**

While no juvenile salmon were found on the Isle of Colonsay, juvenile trout were found at two sites in Abhain a Mhuilinn catchment. Low and moderate numbers of fry (classes D and C) were found at the two sites and a moderate abundance (class C) of parr at the upper site.

3.1.2 Non-salmonid fish

The electrofishing surveys found European eels in 44 sites (47 % of sites) distributed over all four islands in 2012 (Table 3.9). Stickleback were found at 19 sites (20 % of sites) on three islands, but were not found at survey sites on Jura. Flounder were found at 8 survey sites (9 % of sites) on the Isles of Islay and Coll, while lamprey ammocoetes were also found at two sites in the River Laggan on Islay.

Table 3.9 Distribution of non-salmonid fish (no. of sites) 2012

Island	Survey No.		Other Species			
	Rivers	Sites	Eel	Stickleback	Lamprey	Flounder
Islay	14	45	17	10	2	3
Jura	4	30	11	0	0	0
Coll	12	13	11	5	0	5
Colonsay	5	6	5	4	0	0
Total No.	**35**	**94**	44	19	2	8
%			47	20	2	9

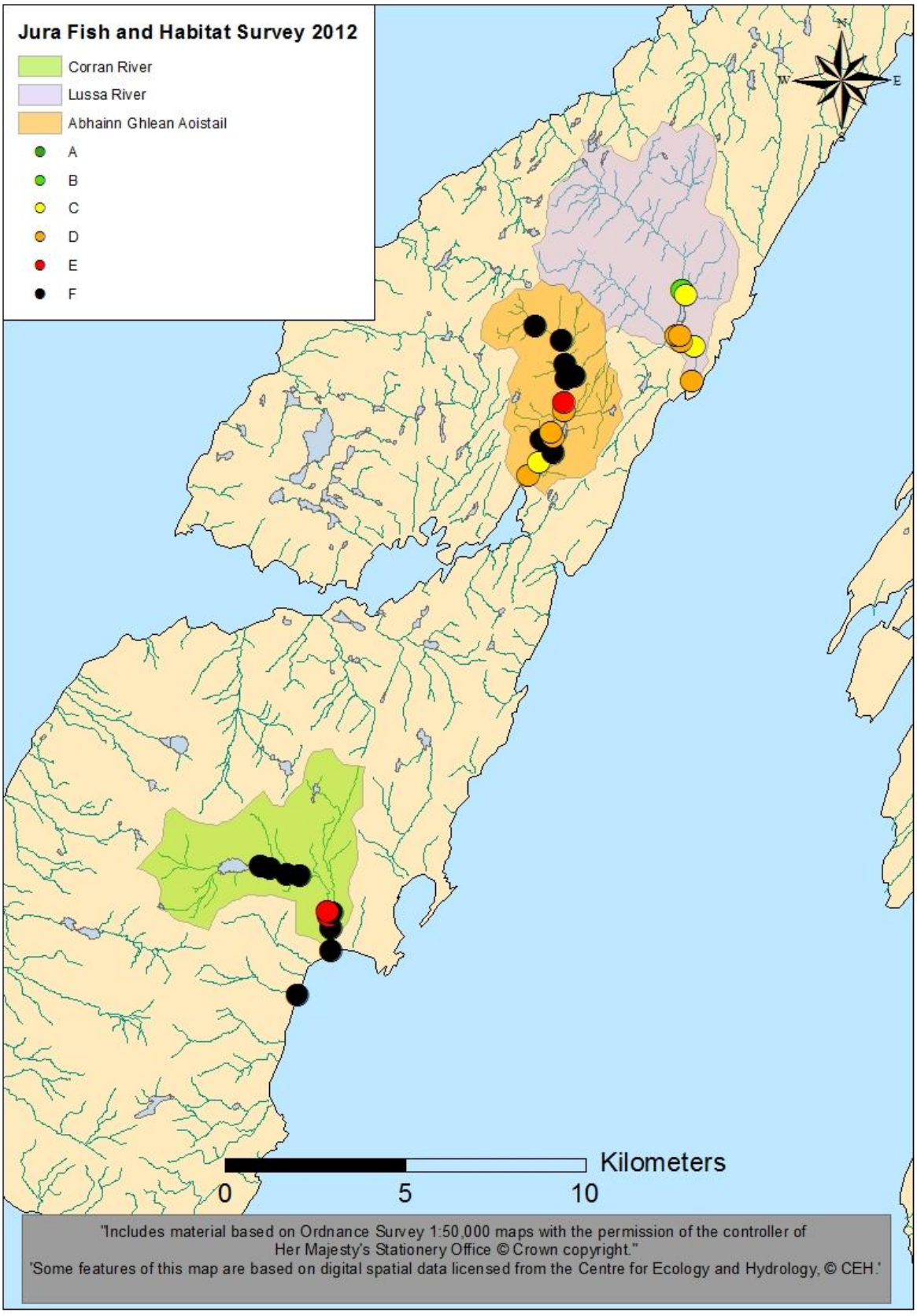

Figure 3.5 Salmon fry distribution and relative abundance at Isle of Jura survey sites

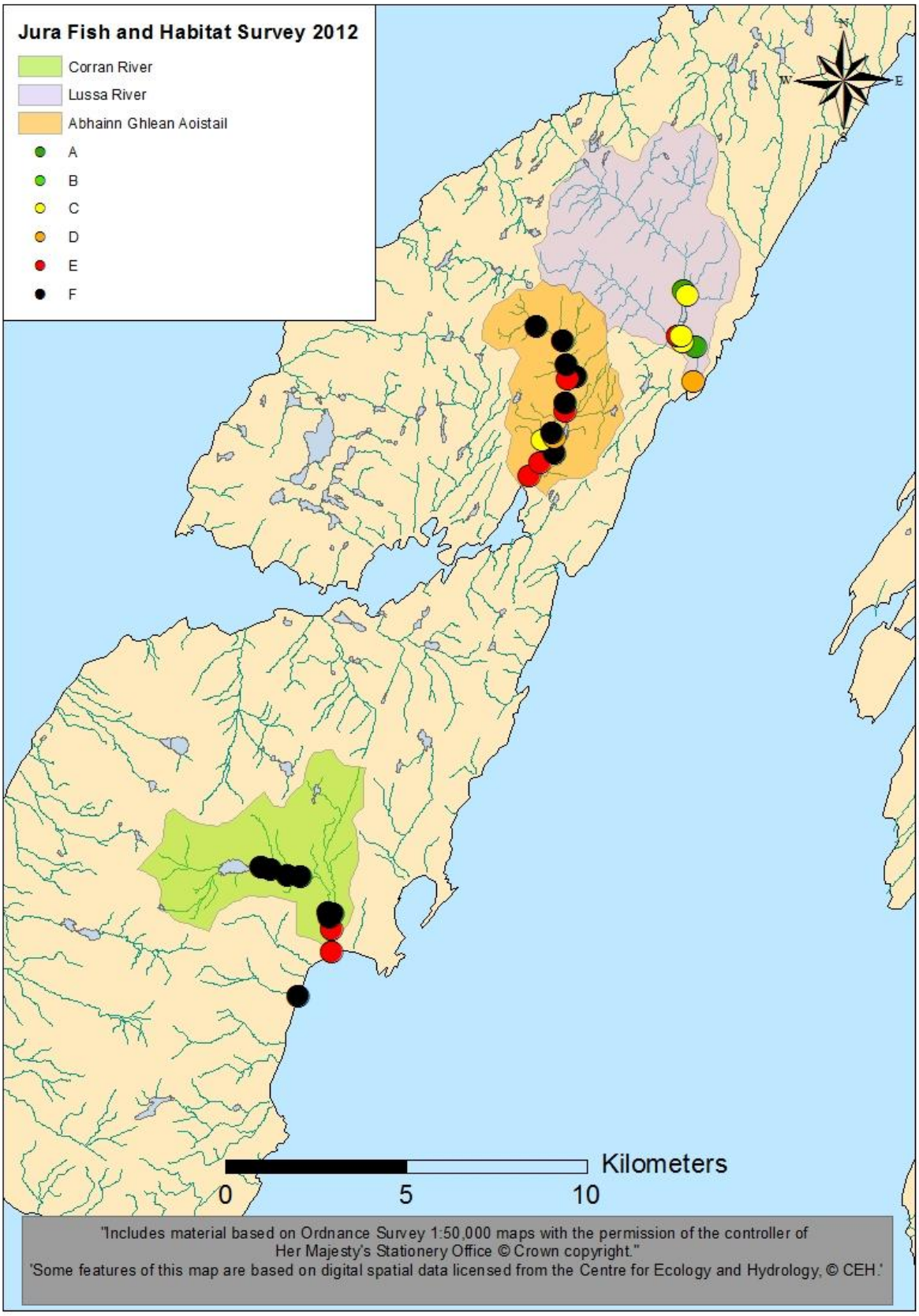

Figure 3.6 Salmon parr distribution and relative abundance at Isle of Jura survey sites

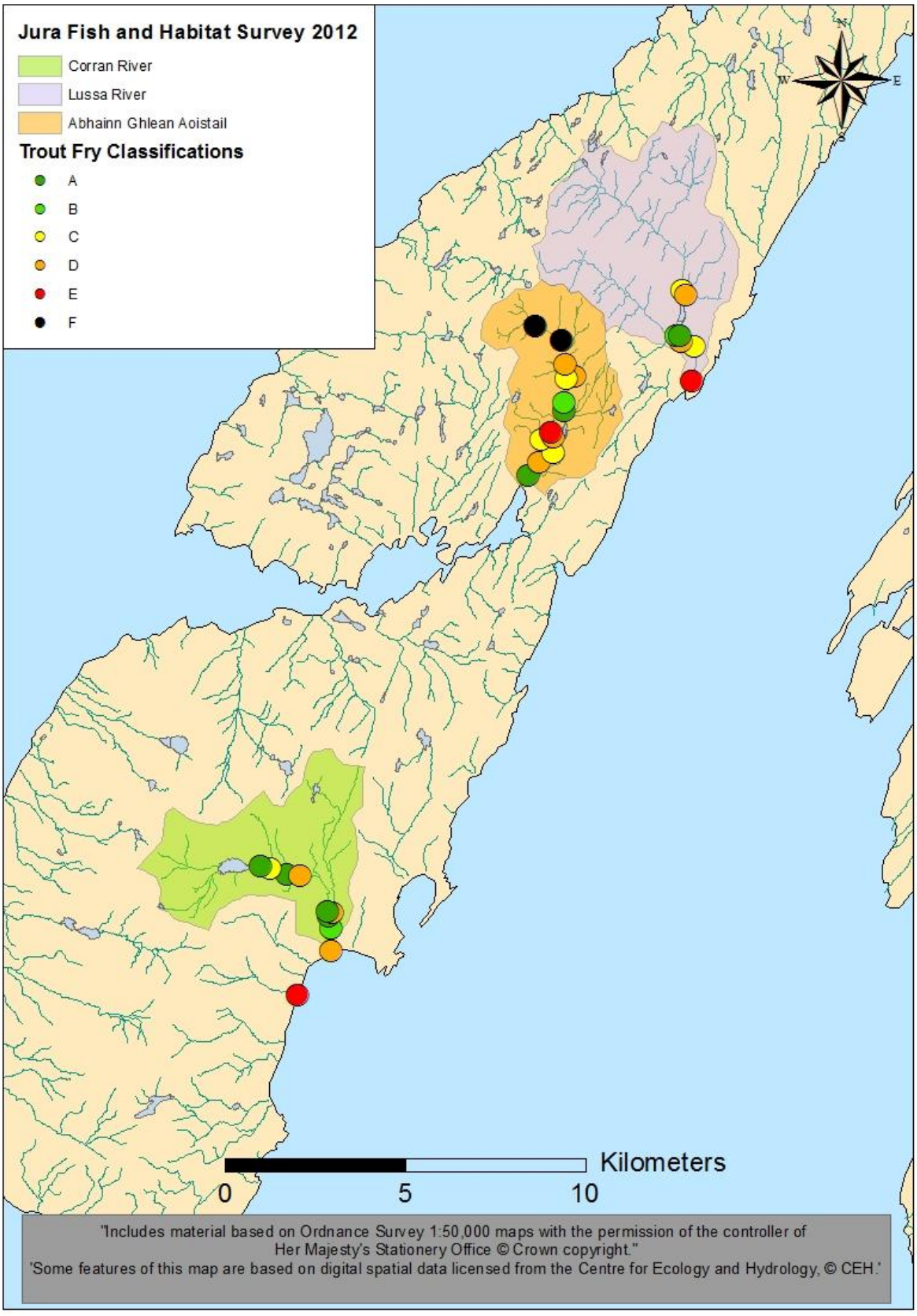

Figure 3.7 Trout fry distribution and relative abundance at Isle of Jura survey sites

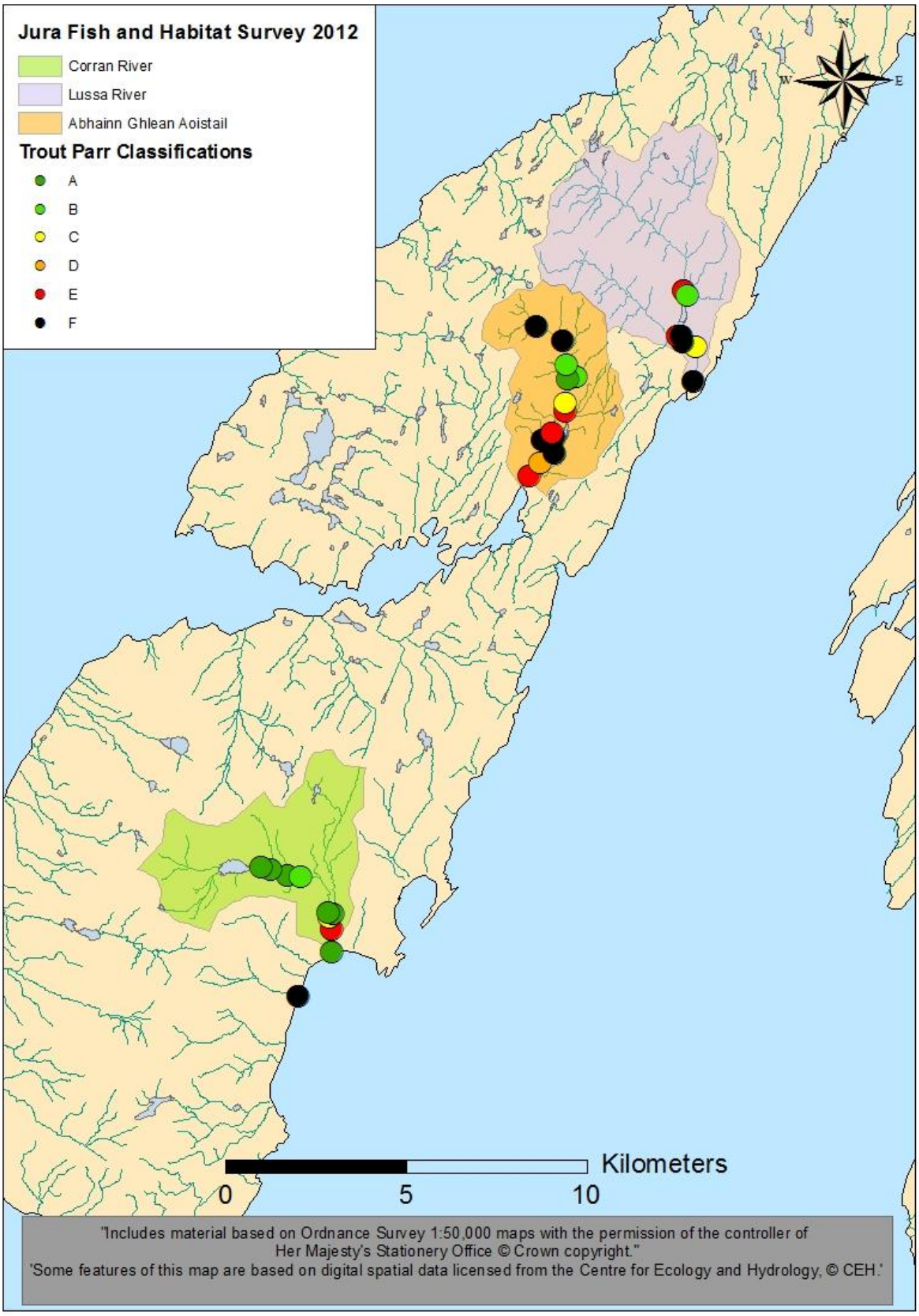

Figure 3.8 Trout parr distribution and relative abundance at Isle of Jura survey sites

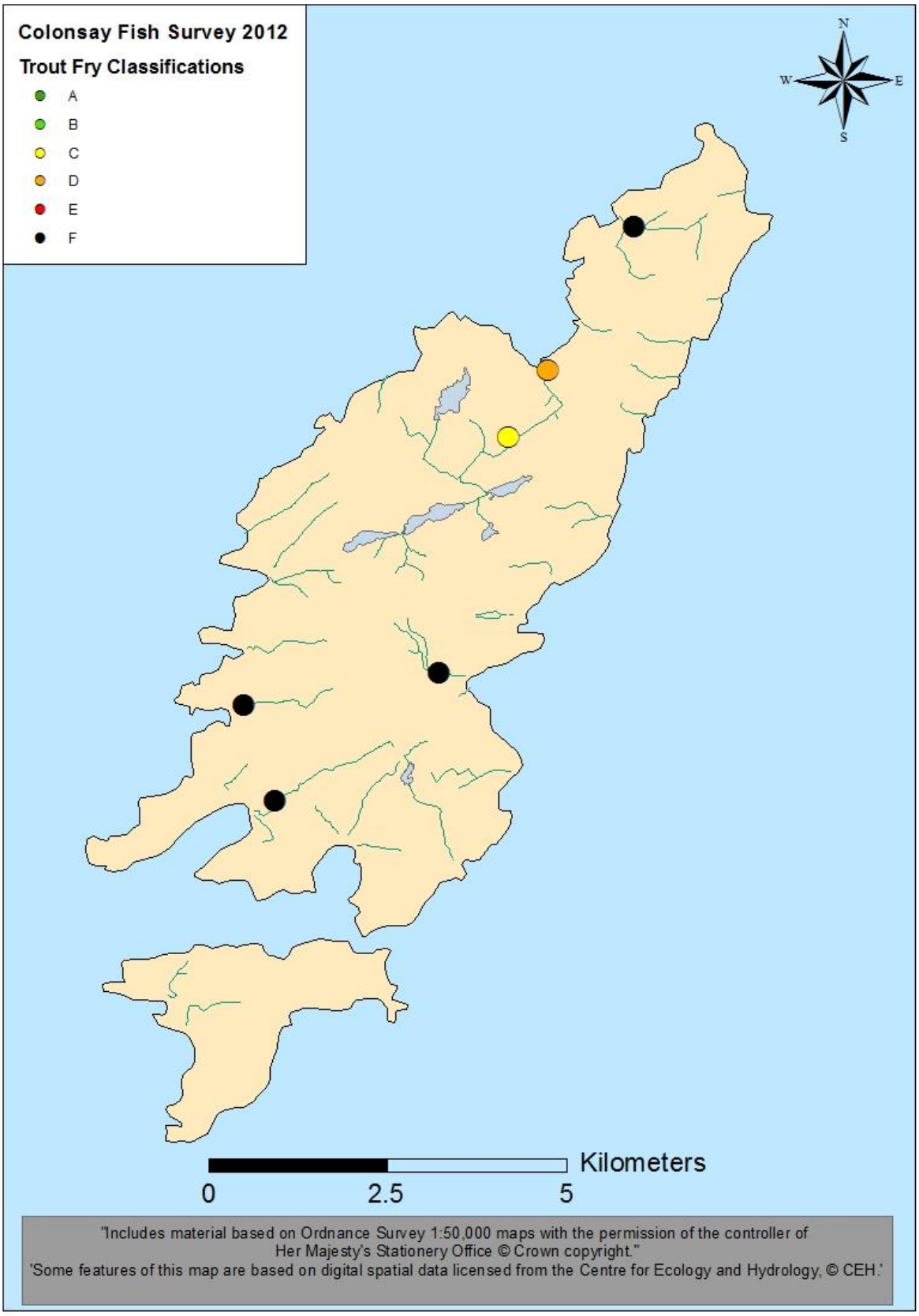

Figure 3.9 Trout fry distribution and relative abundance at Isle of Colonsay survey sites

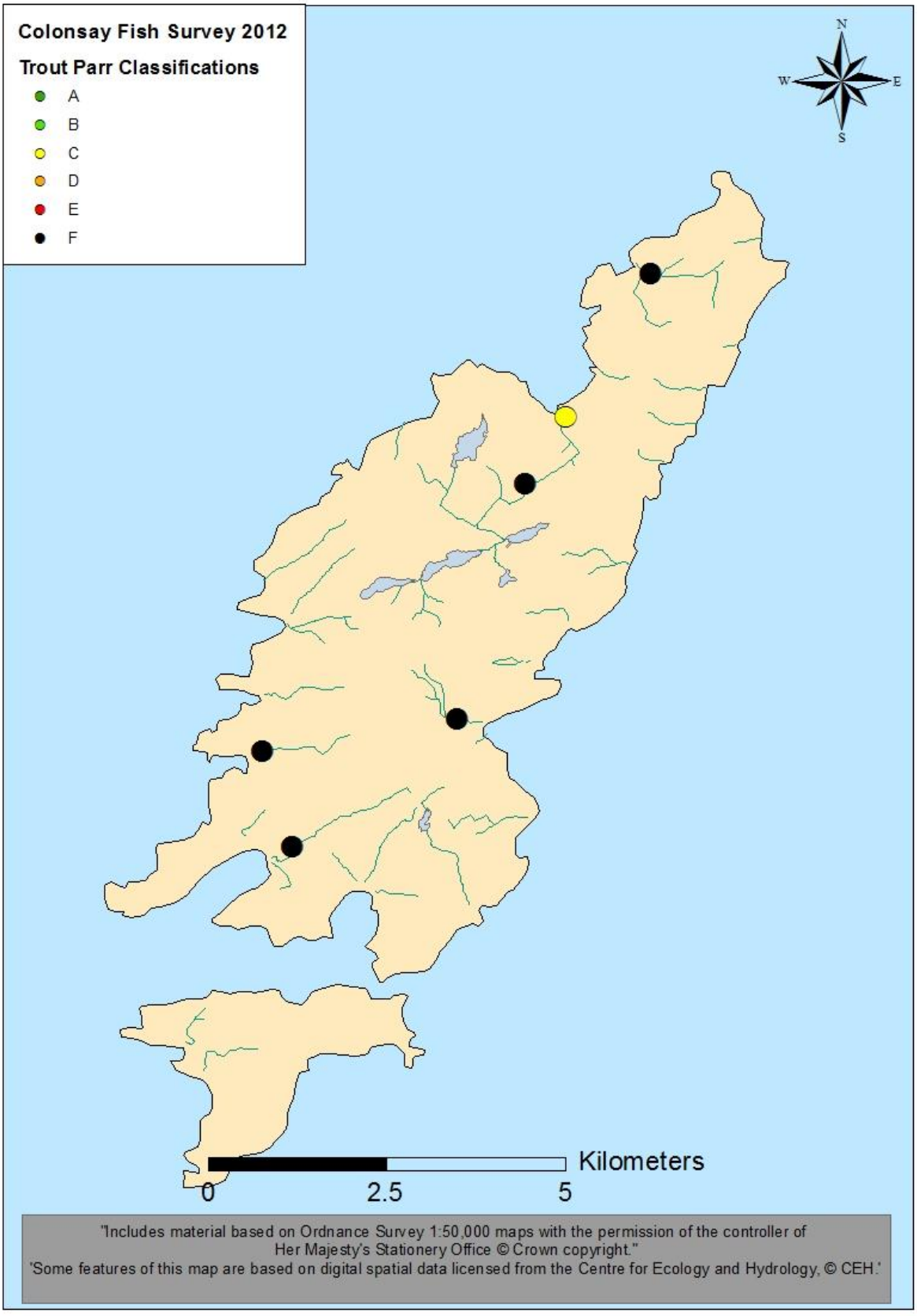

Figure 3.10 Trout parr distribution and relative abundance at Isle of Colonsay survey sites

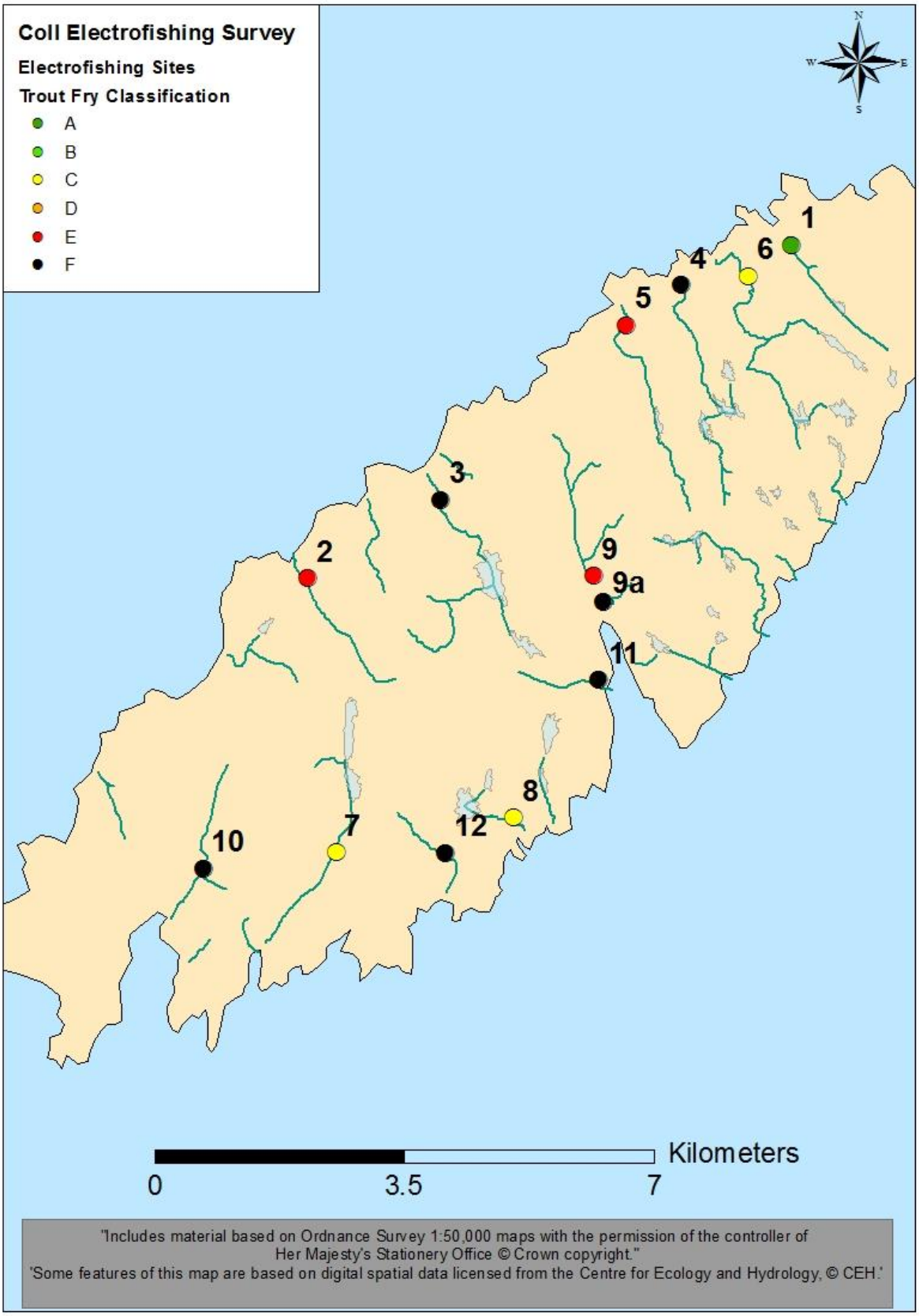

Figure 3.11 Trout fry distribution and relative abundance at Isle of Coll survey sites

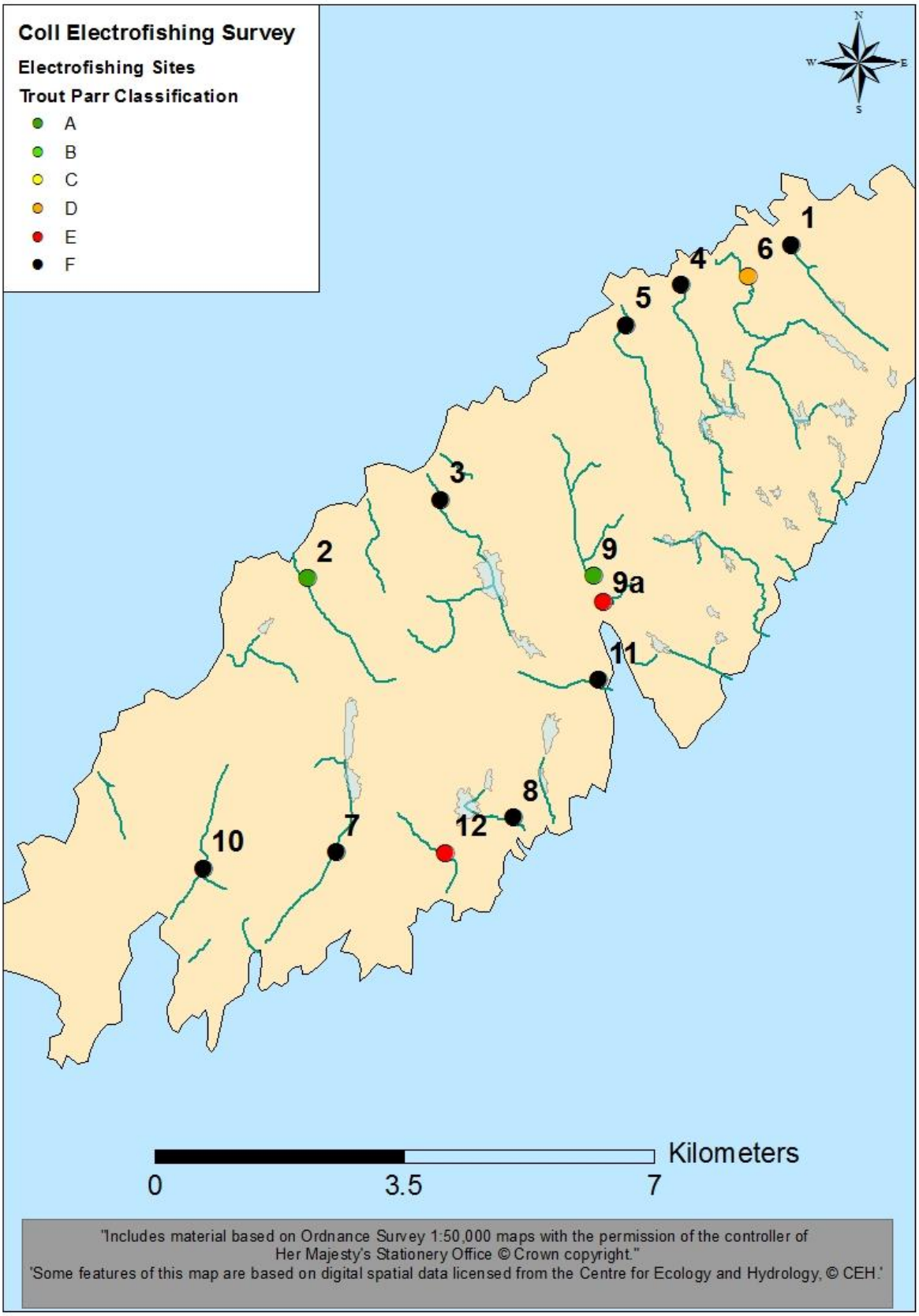

Figure 3.12 Trout parr distribution and relative abundance at Isle of Coll Survey sites

3.1.3 Classification of fish abundance in 2012 compared to previous surveys

The results of the 2012 survey may be compared to previous surveys undertaken on the Rivers Laggan and Sorn on the Isle of Islay in 2001 and the River Lussa on the Isle of Jura in 2004.

River Laggan

The distribution of salmon fry found in 2012 on the River Laggan appear similar to that found in 2001 (Table 3.10) with the exception of site seven (River Torra tributary) which was dominated by trout fry in 2001 but was dominated by salmon fry in 2012. One notable change in abundance of salmon fry was found at site two (middle mainstem) where fry abundance was low (class D) in 2012 compared to high abundance (class A) found in 2001. Salmon parr numbers however were relatively low or moderate at sites four and five (R. Cattadale and R. Kilennan) where parr abundance was high in the 2001 survey.

Table 3.10 Comparison of classification of fish abundance on the River Laggan (2001-2012)

Site	Salmon Fry		Salmon Parr		Trout Fry		Trout Parr	
	2001	2012	2001	2012	2001	2012	2001	2012
1	A	B	A	B	F	F	F	F
2	A	D	D	D	E	E	F	E
3	A	A	D	B	C	D	F	E
4	B	B	E	E	E	F	F	F
5	A	B	F	C	F	E	F	C
6	E	D	D	E	C	E	F	E
7	F	B	F	E	A	E	F	B
8	F	F	F	F	D	D	E	A
9	F	F	F	F	D	D	A	B

Trout fry distribution was broadly similar to that found in 2001, but changes were found in three sites where salmon were more abundant in one (site seven) and fry were not found where they had previously been found at one other (site four) and vice versa (site five). Trout fry abundance was low at all sites in 2012 where they had been moderate at two sites (three and six) and high at one other (site seven) in 2001. Trout parr, however were found at more sites in 2012 (seven sites) compared to 2001 (two sites). Where found, abundance was generally higher (Classes A and B) in the upper river sites compared to the low and moderate abundance (classes E and C) found further downstream where none were found in 2001.

River Sorn

The distribution of juvenile salmonids was compared in 2012 at five sites first sampled in 2001 (Table 3.11). Salmon fry were found at three sites in 2001 at high (sites three and six) and moderate (site seven) abundance. The 2012 survey found fry at moderate abundance at all three of these sites and also found fry and parr at low abundance (classes D and E) at another site (site eight; Drumnaski) where none were found in 2001. Parr were found at the same sites as the fry in 2012 at low abundance with the exception of site six (Esknish Dairy) where no parr were found.

Table 3.11 Comparison of classification of fish abundance on the River Sorn (2001-2012)

Site	Salmon Fry		Salmon Parr		Trout Fry		Salmon Parr	
	2001	2012	2001	2012	2001	2012	2001	2012
3	A	C	E	E	E	E	F	C
6	A	C	D	F	C	A	E	C
7	C	C	E	D	C	B	F	C
8	F	D	F	E	D	E	E	E
9	F	F	F	F	B	C	B	A

Trout fry were found at all sites in 2012 where they had been found in 2001, while abundance was similarly low (classes D and E) at sites three and eight in both surveys, fry abundance was higher in 2012 at two sites (sites six and seven) compared to 2001 when moderate abundance was found. Fry numbers were moderate in 2012 at site nine compared to the high numbers found in 2012. Where found at three sites in 2001, trout parr were found at all five comparable sites in 2012. Abundance was relatively moderate (class C) at the lower three sites in 2012 compared to the low abundance (class E) found at one of the sites in 2001. Similarly low abundance (class E) was found in both surveys at site eight and similarly high abundance at site nine.

River Lussa

The distribution of juvenile salmonids was compared in 2012 at five sites first sampled in 2006 (Table 3.12). Salmon fry were found at all five sites in both surveys but abundance was low at three sites in 2012 (class D) compared to two sites in 2006. Parr were also found at the same sites as the fry in 2012 where abundance was similar at two sites (site one and eight) comparatively lower at two others (high down to moderate at sites three and five) and higher in one other (site two) where moderate abundance of parr had been found in 2006.

Table 3.12 Comparison of classification of fish abundance on the River Lussa (2006-2012)

Site	Salmon Fry		Salmon Parr		Trout Fry		Trout Parr	
	2006	2012	2006	2012	2006	2012	2006	2012
1	E	D	D	D	E	E	E	F
2	B	C	C	A	A	C	E	C
3	A	D	B	C	A	D	D	F
5	D	D	B	C	B	A	F	F
8	A	B	B	A	F	C	F	E

Trout fry were found at all five sites in 2012 compared to the four sites where they had been found in 2006. Fry abundance was similarly low (class E) at site one and high (class A) at site five in each of the surveys. Comparatively lower abundance was found at sites two and three in 2012 compared with high abundance in 2006. Where found at three sites in 2006, trout parr were found at two sites in 2012, only one of which (site two) held parr in both surveys. Abundance was relatively low (classes D and E) in the lower river sites in 2006 and moderate (class C) in the lower river and low (class E) in the upper river in 2012.

3.2 Habitat survey

A total of 56.8 km of stream habitat thought to be accessible by migratory salmonid fish was surveyed in ten catchments (Table 3.13).

Table 3.13 Habitat survey coverage

Islay	Length (km)	Avg. Width (m)	Area (ha)	Avg. Gradient %	Primary habitat type
Claggain	2.26	4.5	0.96	2.7	Plane bed
Kintour	4.87	5.6	2.71	1.3	Active meander
Laggan	21.22	9.0	22.34	0.4	Active meander
Sorn	7.44	9.2	6.55	0.7	Modified passive meander
Uisg an t-Suidhe	5.86	3.8	3.15	1.3	Modified passive meander
Margadale	0.72	5.0	0.36	3.0	Plane bed
Islay Total	**42.37**		**36.07**		
Jura					
Aoistail	4.47	4.6	2.45	1.8	Plane riffle / Active meander
Corran	3.1	6.3	1.90	3.3	Plane bed / Step-pool
Lussa	6.54	7.0	4.50	1.2	Plane riffle / Active meander
Jura Forest	0.28	4.0	0.11	9.3	Bedrock / Step-pool
Jura Total	14.39		8.95		
Habitat Total	**56.8**		**45.02**		

The average width of the rivers surveyed ranged from 3.8m on the Uisg an t-Suidhe and 9.2 m on the River Sorn, while the area of habitat available to fish ranged between 0.11 and 22.34 hectares (ha).

Where average gradient of the habitat was relatively low (less than 2 %), the primary type of habitat found was mainly active meandering channels (Kintour and Laggan) and plane riffle (Aoistail and Lussa). Two catchments were low gradient (Sorn and Uisg an t-Suidhe), but channel morphology had been significantly changed (straightened) so that the channel was passive (i.e. not able to move across the flood plain). Plane bed and step-pool habitats were more common in moderate gradient habitats (2 to 4 %) found in the rivers Claggain, Margadale and Corran. Bedrock and step-pool habitats were more common in the relatively high gradient habitat (9.3 %) in the Jura Forest Burn.

3.2.1 Distribution and status of key habitats

The location and status of adult fish holding pools and spawning sites recorded in the surveys are described below.

Adult holding pools

A total of 365 significant adult fish holding pools were recorded during the surveys (Table 3.6) with a total area of 105,186 m² of habitat. The frequency of pool habitats found, ranged between an average of 2.0 (River Sorn) and 18.2 (Jura Forest Burn) per km of stream length. Optimal habitat for migratory salmonid fish was found in all catchments with the exception of the Margadale River and Jura Forest Burn. Where present, optimal pool habitat averaged 55 % of pool habitat on Islay rivers and 51 % of Jura pool habitat (Figure 3.17).

Table 3.14 Adult holding pools results

Islay	**No.**	**Area (m²)**	**Freq. (no. per km)**	**% Opt.**
Claggain	6	995	3.0	72
Kintour	53	4145	11.1	57
Laggan	137	64490	6.5	89
Sorn	13	6890	2.0	96
Uisg an t-Suidhe	11	499	6.2	18
Margadale	3	460	4.1	0
Islay total Avg.	**223**	**77479**	**5.5**	**55.3**
Jura				
Aoistail	65	9143	13.2	92
Corran	44	3777	14.2	56
Lussa	28	14690	4.3	56
Jura Forest	5	97	18.2	0
Jura total / Avg.	**142**	**27707**	**12.5**	**51.0**
Total / Avg.	**365**	**105186**	**9.0**	**53.2**

Spawning sites

A total of 376 significant salmonid fish spawning sites were recorded during the surveys (Table 3.15) with a total area of 10,896 m². Where recorded, the frequency of sites recorded in each catchment range from 1.2 per km in the Lussa River to 18.2 per km in the Jura Forest catchment and averaged 8.3 per km. An average of 40.3 % of spawning habitat area was identified as being optimal for salmonid fish.

Table 3.15 Spawning habitat survey results

Islay	No.	Area (m²)	Freq. (no. per km)	% Opt.
Claggain	7	79	3.3	22
Kintour	51	771	10.1	89
Laggan	150	7885	7.1	52
Sorn	7	440	2.7	66
Uisg an t-Suidhe	34	400	10.4	34
Margadale	0	0	0	0
Islay total Avg.	**249**	**9575**	**5.6**	**43.8**
Jura				
Aoistail	82	792	15.8	62
Corran	32	315	8.6	33
Lussa	8	211	1.2	52
Jura Forest	5	3	18.2	0
Jura total / Avg.	**127**	**1321**	**11.0**	**36.8**
Total / Avg.	**376**	**10896**	**8.3**	**40.3**

Habitat features associated with spawning sites were mostly morphological features of the river channel including glides at the outflow of pools and other features such as braided channels and islands.

3.2.2 Habitat condition

The relative suitability of the habitat for juvenile salmonid fish and factors potentially affecting productivity that were identified during the survey are described below.

Habitat suitability for juvenile salmonid fish

The juvenile salmonid fish habitat recorded (Table 3.16) consisted of shallow, mixed and deep habitats. Significant areas of shallow fry habitat were found in all catchments with the exception of the Rivers Sorn, Margadale and Jura Forest and averaged 9.6 % of all juvenile

habitat. Mixed juvenile habitats (which include smaller areas of fry and deep juvenile habitat) were most abundant; averaging 66.9 % of all juvenile habitats surveyed.

Table 3.16 Juvenile habitat availability (%) and suitability scores (1 – 5)

Islay	Fry	Mixed	Deep	Avg. score
Claggain	5	90	5	3.3
Kintour	7	76	17	3.2
Laggan	18	46	36	3.0
Sorn	0	70	30	2.5
Uisg an t-Suidhe	20	40	40	2.2
Margadale	0	60	40	2.9
Aoistail	10	70	20	3.1
Corran	14	65	21	3.0
Lussa	22	52	25	2.5
Jura Forest	0	100	0	2.0

Deep juvenile habitats were found in all surveys with the exception of the Jura Forest Burn and averaged 23.4 % of all juvenile habitat. Average scores for juvenile habitat suitability ranged from relatively low scores in the Jura Forest Burn (2.0) and the Uisg an t-Suidhe (2.2) and high scores in the Claggain and Kintour Rivers (3.2 and 3.3 respectively) and averaged 2.8 for all habitat surveyed.

3.2.3 Factors affecting productivity

The main characteristics of habitats potentially affecting productivity of juvenile salmonid fish recruitment consisted of a mixture of in-stream and bank-side features, some of which were natural but mostly derived from human influence (Table 3.17).

Natural features affecting productivity

The most common natural feature of the habitat found that is likely to reduce potential for fish habitat was related to relatively moderate-to-high gradient habitats where bedrock substrates provide no or little cover for fish from high energy or torrential flows. The percentage of accessible habitat that was identified as being sub-optimal cover for fish varied between 1 (Suidhe) and 100 % (Jura Forest). The frequency of obstacles to migration may also impair access and use of potential spawning and nursery habitat, which varied from low numbers (0.1 per km) in the River Laggan to high numbers (28.6 per km) in the Jura Forest Burn.

Table 3.17 Downgrades of in-stream habitat condition

	Natural		Human Derived				
River	**Obs. per km (No.)**	**Bedrock / torrent (% Area)**	**Mod. (% Area)**	**Weirs per km (No.)**	**Poor veg. (% Area)**	**No shade (% Area)**	**Fine sediment (% Area)**
Claggain	1.8	53	0	0	25	25	0
Kintour	1.2	25	35	0.2	35	35	0
Laggan	0.1	4	0	0.3	96	42	33
Sorn	1.9	24	100	1.6	36	36	100
Suidhe	0.3	1	82	0	95	95	82
Margadale	5.6	49	0	0	0	0	0
Aoistail	4.5	17	0	8.7	90	90	0
Corran	6.5	28	0	12.6	54	54	0
Lussa	1.8	16	23	6.0	84	84	0
Jura Forest	28.6	100	0	0	0	0	0

Human-derived channel features affecting productivity

The influences of land use for farming, forestry and infrastructure development have affected significant areas of lower gradient river habitat. Channel straightening (mod) of significant stretches of the Rivers Sorn (100 %) and Uisg an t-Suidhe (82 %) and smaller stretches of the Lussa (23 %) and the Kintour (35 %) has reduced habitat area and heterogeneity (loss of pools and riffles). The frequency of weir structures was relatively high on some rivers of Jura; the Corran (12.6 per km), Aoistail (8.7 per km) and Lussa (6.0 per km) Rivers, but was found to be lower on the Sorn (1.6), Laggan (0.3) and Kintour (0.2) on Islay.

Human-derived land use features affecting productivity

Loss of trees and other diverse vegetation from river bank-sides was found on most of the habitat surveyed which has a number of long-term effects on fish habitat and smolt recruitment. Lack of shade, bank cover and leaf litter and terrestrially derived food items were found to affect more than half of the habitat area on the Laggan, Uisg an t-Suidhe, Aoistail, Corran and Lussa Rivers. Significant fine sediment was also found within the bed substrate matrix in the lower reach of the River Laggan, most of the River Sorn and the lower Uisg an t-Suidhe.

Invasive Non-Native Species (INNS)

Invasive non-native plant species were recorded in four catchments during habitat surveys. While Japanese knotweed was found only on the Kintour River, no Himalayan balsam was found during the surveys. *Rhododendron ponticum* was more widespread; the Laggan, Sorn

and Kintour on Islay and the Jura Forest and Lussa catchments on Jura.

3.3 Smolt production and population abundance

Estimates of salmon smolt production in the North Atlantic region have been reported between 1 and 10 per 100 m² of available freshwater habitat depending on habitat productivity. Electrofishing survey data suggest that the current salmon smolt production of the Southern Hebrides Islands is widespread in eight of the nine catchments where both fish and habitat surveys were carried out (Table 3.18). While no salmon were found in the Margadale, other catchments are also known to host salmon, such as the Machrie and Duich rivers on Islay, but no habitat data were collected to assess production area.

Table 3.18 Estimated salmon smolt production at different levels of productivity (no. smolt produced per 100 m² of habitat)

Catchment	Habitat Area (ha)	Min. (1-2)	Low (3-4)	Mod. (5-6)	High (7-8)	Max. (9-10)	Avg. no. parr / 100 m² (2012)	Est. Smolt Output
Claggain	0.96	144	335	526	718	957	0.5	36
Kintour	2.57	385	899	1,413	1,926	2,569	2.4	684
Laggan	22.34	3,350	7,818	12,285	16,752	22,336	2.7	4,061
Sorn	6.55	984	2,296	3,608	4,920	6,560	1.7	945
Suidhe	3.15	473	1,104	1,734	2,365	3,153	4.7	642
Margadale	0.36	53	124	195	266	355	0.0	0
Aostail	1.99	298	695	1,093	1,490	1,987	1.3	188
Corran	3.03	285	664	1,044	1,424	1,898	0.9	154
Lussa	4.50	589	1,374	2,159	2,944	3,925	3.3	1,705
Total	**45.44**	**6,561**	**15,309**	**24,057**	**32,805**	**43,740**		**8,415**

Where present, average salmon parr densities found in fish surveys varied between less than one per 100 m² in the Claggain and Corran Rivers (0.5 and 0.9 parr per 100 m² respectively) and more moderate numbers in the Laggan (2.7), Lussa (3.3) and Uisg an t-Suidhe (4.7). However, not all one-year-old parr are likely to smolt in the following spring and further mortalities (estimated at 10 %) may be expected over-winter. Therefore, the current level of smolt production is estimated to range widely depending on the habitat available for recruitment and average parr numbers found (range 36 to 4,061 smolts). A total estimate for the catchments surveyed was 8,415 smolts.

Subsequent marine survival of smolts through to returning adult is known to vary between years but has been relatively low in recent times (estimated to be between 1 and 6%).

Marine survival will vary depending on a number of factors. Local studies indicate that marine survival of smolts was in the region of 4 % to the adult return stage of the life-cycle. If for example, this is sustained over a six year period (one generation of multi sea-winter salmon and two generations of one sea-winter grilse); an estimated 335 adults are estimated to return from the sea at current smolt production levels (Table 3.19).

Table 3.19 Estimated no. of adult sea-returns at different levels of smolt production and sea survival to adult (4 %)

Catchment	Min. (1-2)	Low (3-4)	Mod. (5-6)	High (7-8)	Max. (9-10)	Current
Claggain	6	13	21	29	38	1
Kintour	11	26	40	55	73	27
Laggan	134	313	491	670	893	162
Sorn	39	92	144	197	262	38
Uisg an t-Suidhe	19	44	69	95	126	26
Margadale	2	5	8	11	14	0
Aostail	11	27	42	57	76	6
Corran	11	27	42	57	76	6
Lussa	24	55	86	118	157	68
Total	**257**	**601**	**944**	**1,287**	**1,716**	**335**

The estimated number of adult spawning stock returning to each catchment appears to vary widely, being relatively healthy in the larger catchments; Laggan (162) and Lussa (68) compared to the moderate and smaller catchments. However, salmon fry and to a lesser extent, parr numbers are known to vary considerably year-to-year and longer-term datasets will be required to provide a higher degree of confidence in this type of estimate.

The subsequent performance of fisheries (given the estimated 4 % marine survival of smolts and 20% exploitation of returning adults by anglers) may currently be expected to yield an estimated 67 salmon, but improvement in the smolt production to moderate-to-high levels could produce higher catches (Table 3.20).

Table 3.20 Estimated rod catch (20 %) at different levels of smolt production and sea survival to adult

Catchment	Min. (1-2)	Low (3-4)	Mod. (5-6)	High (7-8)	Max. (9-10)	Current
Claggain	1	3	4	6	8	0
Kintour	2	5	8	11	15	5
Laggan	27	63	98	134	179	32
Sorn	8	18	29	39	52	8
Uisg an t-Suidhe	4	9	14	19	25	5
Margadale	0	1	2	2	3	0
Aostail	2	5	8	11	15	1
Corran	2	5	8	11	15	1
Lussa	5	11	17	24	31	14
Total	**52**	**120**	**189**	**257**	**343**	**67**

Estimates of smolt production of sea trout are less well defined in research literature, but may be expected to produce from all catchments, including those with relatively small areas of available habitat.

4 DISCUSSION

The findings of the fish and habitat surveys are discussed below in relation to the status of fish populations, factors potentially affecting their productivity and other influences on the results of the survey.

4.1 Fish distribution

The fish data collected indicate that salmon populations were widespread within the larger catchments surveyed and similarly, trout were found throughout most habitats including relatively small coastal streams. The exceptions however were found on the Isles of Coll and Colonsay where no salmonid fish were found in a significant proportion of the sites surveyed. The relatively small size of these catchments and regional variation in rainfall suggest they may be sub-optimal for salmonid fish, but habitat data collected at electrofishing sites indicate that straightening of the stream channels and extensive drainage systems may also reduce habitat availability and heterogeneity.

Although four non-salmonid fish species were recorded, the actual distribution of non-salmonids is likely to be wider than that found by this survey. All four species, including lamprey, were found on the Isle of Islay while European eel were only found on Jura. Three-spine stickleback waerefound to be widespread on both the Isles of Coll and Colonsay, utilising habitats where no salmonids were found. Flounder were found on both Islay and Coll, but their distribution is likely to be limited to the lower reaches in most catchments by obstacles to migration and therefore may not have been sampled in surveys at sites upstream of suitable habitat near estuaries. Younger life-stages of lamprey (ammocoetes) require habitat in organic silt deposits, which are relatively rare in higher gradient habitat compared to the higher proportion of low gradient habitat found in the River Lussa. It is also likely that the distribution of most of the non-salmonid fish (with the exception of eels) may be limited by man-made obstacles, such as weirs, due to their inability to leap over obstacles such as that found at the foot of the River Sorn.

4.2 Salmonid fish abundance and habitat condition

Although the abundance of juvenile salmon varied considerably between sites within each catchment, numbers were generally highest in the main channels of the larger catchments (i.e. River Laggan) or where there was relatively low-to-moderate gradient habitat in smaller rivers (i.e. Kintour River). Lower gradient habitat generally had abundant adult pools and

spawning sites which are important to the early stages of recruitment where adult salmon are able to access and utilise spawning sites from refuge habitat (pools). The exceptions were in the middle and upper reaches of the River Sorn and the lower reach of the Uisg an t-Suidhe where few pools were found, due the morphological alterations (straightening) which reduce habitat heterogeneity, particularly pools which tend to form on the outside of bends or downstream of constriction points that create scour of the river bed. Some pool habitat in the River Sorn has been provided by weir structures which have increased water depth upstream. Some moderate gradient habitat may have fewer or less deep pools than is optimal but have significant resources for spawning and juvenile fish. Here, the pool habitat has sometimes been increased by the construction of weirs (Aoistail, Corran and Lussa Rivers). This however may be at the expense of juvenile and spawning habitat in some cases, but are also likely to impair fish passage up and downstream with consequences for distribution of spawning (adults) and smolt escapement (predation).

The condition of some in-stream habitats were less than optimal in the lower Laggan and much of the River Sorn due to the amount of fine sediment retained in the river bed substrates which fill the voids between larger substrates that are important to both fish and invertebrates for cover from floods and predators. Likely sources of fine sediment are from excessive erosion of river banks and field or forestry drainage networks.

Most of the habitat surveyed was suitable for salmonid fish, but grazing of livestock (or access by deer) on river banks was widespread and vegetation was mostly uniform grasses which are less than optimal for protecting bank structure and providing cover and food items for fish. The lack of shading of the river channel in most reaches surveyed also has consequences with warmer water temperatures, which may not benefit cold water fish if predicted climate change occurs in the future.

Similar surveys in other rivers in Argyll indicate that juvenile salmon are generally more widespread and relatively more abundant in the main river channel in contrast to trout that are generally more widely distributed and more abundant in smaller tributary streams. Losses in salmon fry distribution were mostly from sites in tributary or smaller main river sites (less than 3m wet width) indicates that recruitment may be infrequent in these sites where access of mature adults may vary year-to-year due to flow conditions at the time of spawning. Alternately, the changes in salmon fry distribution found in tributary streams may also be an artefact of lower than optimal spawner numbers in the previous autumn.

The productivity of freshwater habitats may also influence juvenile numbers, particularly

where natural base-poor geology may be more prevalent on the Isle of Jura compared to that found on Islay.

4.3 Marine habitats

The wider marine survival of post-smolt salmon is possibly associated with the affects of climate change on the marine environment, but are less well understood compared to that of local marine factors known to affect migratory salmonids. A growing number of studies have indicated that the productivity of ocean habitats may have declined over time with a recorded reduction in sea age of multi sea-winter salmon and reductions in growth of one-sea winter salmon (grilse).

There is also potential that aquaculture related factors such as sea lice burdens affecting survival and growth of post-smolts and interaction with farmed escapee salmon may have an influence on the current status of migratory salmonid fish. However, at the time of survey there were no fish farms in operation close to these islands and therefore any influence from sites further afield is likely to be limited.

4.4 Factors affecting survey results and interpretation of data

There are a number of factors that may affect the results of the survey related to environmental conditions at the time of survey, survey technique and design, the use of habitats by fish and management intervention by fishery operators.

The design of the survey was mainly aimed at establishing an understanding of the broader distribution and abundance of salmonid fish, but due to the limited resources available the number of sites surveyed in each catchment was limited to main river habitats. Single-run surveys do not usually catch all the fish present in the survey site so it is likely that the actual abundance of fish found in the surveys were likely to be somewhat higher than recorded. However, the classification scheme used to assess juvenile salmonid fish abundance is established for one-run fishing and estimates of minimum abundance are therefore comparable.

The environmental conditions at the time of survey were relatively favourable for efficient sampling, although the relatively low conductivity of the water in some catchments; the Corran, Aoistail and Lussa, may reduce efficiency and fish capture. The relatively low number of smaller tributary streams sampled is likely to have meant that there is comparatively less information on the status of juvenile trout compared to salmon that are

usually more abundant in main river habitats.

The survey technique used is designed to sample relatively shallow water in streams and hence less is known of the relatively deeper areas of habitat including lochs, which are likely to be favoured habitats of trout parr and other non-salmonid fish. As a result, the actual abundance of these species maybe somewhat higher in these habitats.

Estimates of smolt production, adult sea returns and potential fishery catches are based on one relatively stable factor; habitat availability and one more variable factor; abundance of parr. The natural year-to-year variation of parr numbers at any one site and the variation between sites provide a high level of error for the current estimates of smolt production. However, the figures provided for the different ranges of smolt production is a relatively useful figure in that they provide a comparison with potential influence on the population abundance.

5 IMPLICATIONS FOR MANAGEMENT

The data on fish and their habitats collected in the survey provide an indication of the implications for the management of fish populations on the Islands surveyed.

5.1 Fishery management

The fish species sampled in the survey; Atlantic salmon, brown trout, European eel and flounder have value as part of local biodiversity, however migratory salmonids also have potential to support fisheries that are important to local recreation and economy. The data on juvenile salmon and trout indicate that there is significant potential for sustainable fisheries in the two largest catchments surveyed; Rivers Laggan and Lussa. However, it is important to maximise spawning escapement of adult fish by effective control of such fisheries to ensure that sufficient spawning escapement and recruitment of smolts is improved over time. This is important where the current status of salmon populations is less than optimal and particularly in the relatively small catchments where few salmon are found. Most rivers do not appear to be in a condition to be able to support exploitative fisheries at this time and further exploitation of fragile stocks is likely to decrease potential for future restoration and increase the potential for local extinctions.

5.1.1 Maximise spawning escapement

The apparent relatively low numbers of sea returns of salmon and consequent less than optimal status of juvenile populations indicate that it is essential to maximise the spawning escapement from the fishery. Operating fisheries on conservation-minded principles through effective catch and release angling techniques and protecting adult fish from poaching or excessive predation will be essential to maximise recruitment.

5.1.2 Stocking

Current efforts to restore fishery performance through stocking activities may have potential to stimulate recovery, but the stocking strategies employed will need to be focused on the specific requirements of each individual population if they are to be effective. Supporting information on wild spawning activity, genetic structuring of populations and survival of stocked fish will be required to inform biological and ecological aspects of stocking programmes. It will also be important to assess stocking records to provide further

interpretation of the survey data given here. Undertaking stocking, even with natal fish, without up-to-date robust information on the freshwater bottlenecks of smolt production is not likely to be effective and can potentially undermine recovery of small populations through loss of broodstock, inappropriate stocking at high densities or unsuitable stocking sites. Therefore, it is important to provide guidance to local fishery managers in relation to stocking initiatives.

5.2 Habitat management

Longer term aspects of promoting recovery and maintenance of fish populations will be to deliver improvement in the status of freshwater habitats. A number of factors affecting the productivity of freshwater habitats have been identified in this survey and during the River Basin Planning process as part of the Water Framework Directive. Future phases of this directive are likely to develop the catchment planning process which will seek to retain and improve the status of freshwater habitats by improving the use of land and water resources. The general binding rules of the controlled activities regulation administered by the Scottish Environment Protection Agency are also likely to reduce potential for inappropriate development that will be detrimental to the status of fish habitats. It will be important to engage local land and water resource users into the management of freshwater habitats to maximise the potential benefits to the productivity of fish populations and the performance of fisheries.

6 CONCLUSIONS

Interpretation of the data collected by fish and habitat surveys on the Isles of Islay, Jura, Coll and Colonsay in 2012 provides a number of conclusions.

6.1 Fish distribution

Fish surveys undertaken sampled five native fish species; Atlantic salmon, brown trout, European eel, three-spine stickleback and flounder. The distribution of juvenile salmon was relatively widespread in the main river channels of larger catchments, while juvenile trout were more widespread including relatively small streams. The distribution of trout was limited to the larger streams on the Isles of Coll and Colonsay.

6.2 Juvenile salmonid fish abundance

Where present the abundance of juvenile salmon was highly variable indicating that population status are less than optimal, particularly for salmon in marginal habitats. Juvenile trout abundance was also variable but generally moderate-to-high where habitat was suitable.

6.3 Factors affecting productivity

The principle factors affecting productivity of migratory salmonid fish are likely to occur in the marine phase of their life-cycle at this time. However, the habitat survey identified a number of factors affecting the productivity of freshwater habitats that are likely to be a consequence of natural geomorphology, some modification of channel features (straightening) and land use.

6.4 Fishery management

The data collected indicate that these salmon populations are not likely to support an exploitative fishery at this time. Operating fisheries on conservation-minded principles through catch and release angling techniques and protecting adult fish from exploitation will be essential to maximise spawning escapement and stimulate recruitment. Fisheries for sea trout appear to have more potential at this time, but similar to salmon, their exploitation requires effective controls if their status is to be maintained and improved.

7 APPRAISAL OF METHODOLOGY AND FUTURE PROGRAMME OF WORK

The two methodologies utilised in the survey; electrofishing and walkover spawning habitat surveys are appraised and their suitability discussed.

7.1. Electrofishing surveys

The results of the electrofishing survey provided adequate data to identify the general distribution of fish species and relative abundance of juvenile salmonid fish. However, the survey data collected for non-salmonid fish to SFCC protocols was of a lower resolution, which will require development to improve the standard of data available for other species.

7.2. Habitat surveys

The data collected in the habitat survey successfully identified the distribution of habitats that are essential to the recruitment of salmonid fish. This information also provided supporting information for the interpretation of electrofishing data and may have further use in establishing an improved network of fish sampling sites and further develop an understanding of factors limiting potential productivity. This information may also be used to develop the catchment management phase of the River Basin Planning process and fishery management plans for individual fisheries. The habitat survey also indicate a relatively limited potential for juvenile lamprey habitat in many catchments, but lamprey specific protocol may be required to improve survey effectiveness.

7.3. Future work

Establishing baseline information is an important first step to assess the current status of the fishery resource and inform management of the resource. Repeat electrofishing data collected over a number of generations (3-5 years per generation) will be essential to assess changes in juvenile abundance over time, particularly for salmon. Consultation with centres of expertise will provide information to further assess the data and implications for restoration of fisheries. Additional information on adult fish numbers (snorkel surveys), wild spawning (redd counts) and stocking activity will be essential to interpret the findings of this study and the stocking of hatchery reared fish. Genetic data will also be required to inform management and stocking activities in the future if genetic diversity is to be maintained.

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APPENDIX I –Survey Methods

Electrofishing surveys

The electrofishing technique is used to temporarily stun fish in the close vicinity of the operator, allowing fish to be retained and processed prior to release. All surveys (see below) were undertaken in accordance with the Scottish Fisheries Co-ordination Centre (SFCC) protocols (SFCC, 2007).

Salmonid fish

The surveys are designed to investigate relatively shallow areas of flowing water (< 1m depth) in which juvenile salmonid fish frequently inhabit. Juvenile life stages of salmonid fish are targeted by such surveys as, unlike adult fish, they are generally present throughout the year and provide a history of which species have spawned in the vicinity of the survey site in recent years.

Fish surveys were conducted during low-to-medium flow conditions with backpack electric fishing equipment, using smooth direct current between 200 and 350 volts. The voltage was varied depending on the conductivity, depth and flow of the water at each site. All surveys (see below) were undertaken in accordance with the Scottish Fisheries Co-ordination Centre (SFCC) protocols (SFCC, 2007). An assessment of the in-stream and riparian habitat characteristics were undertaken at each site. Digital photographs were taken of each site to aid identification during future surveys.

It is preferable to undertake fully-quantitative sampling (i.e. each site fished three times over a known area) to provide accurate estimates of fish abundance with known confidence limits. However, the broad requirement of the survey and limited resources available dictated that a lower resolution of information was collected at a higher frequency of sampling sites. Therefore, semi-quantitative sampling (i.e. each site fished once over a known area) were utilised to estimate the minimum density of fish present within the site at the time of the survey. Captured fish were anaesthetised prior to being identified to species level and measured for length. Scale samples were removed from a number of salmonid fish at each site to provide age information to allow estimates of fry (< 1 year old) and parr (> 1 year old) abundance to be calculated. Genetic samples were also taken from a number of salmon parr for later analysis.

Other fish

The technique is also effective for non-salmonid species, but the shallow water habitats sampled may not reflect their preferences, that may change on a seasonal basis. Therefore data may be less representative for non-salmonid species. The fish sampled were recorded for number only.

Classification of salmonid fish abundance

Densities of fish were calculated separately for fry (young of the year) and parr (juveniles that have spent at least one winter in freshwater but have not yet been to sea) for salmon and trout. Estimates of minimum density were calculated by dividing the number of fish caught by the area of stream surveyed. In order to provide a guide to the relative abundance of salmonid fish sampled during the survey, minimum density estimates were classified according to a classification scheme (Godfrey, 2005).

Quintile ranges for juvenile salmonid fish density (West region)

	Stream width Class				
Min. Percentile	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
Salmon fry (0+)					
0th	1.3	1.6	0.8	0.6	E
20th	2.4	3.5	1.6	2.7	D
40th	5.3	6.0	10.4	8.1	C
60th	10.7	14.0	14.0	15.9	B
80th	17.2	35.5	21.1	45.1	A
100th	60.0	27.3	44.7	29.4	
Salmon parr (1++)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
0th	1.4	0.8	0.5	0.5	E
20th	2.3	2.0	1.9	1.7	D
40th	3.3	5.0	4.4	3.2	C
60th	6.9	6.6	5.9	4.2	B
80th	12.2	10.8	10.9	6.6	A
100th	30.9	40.4	22.0	24.0	
Trout fry (0+)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
0th	1.4	0.7	0.5	0.2	E
20th	9.9	3.0	1.1	0.8	D
40th	28.5	5.0	1.8	1.5	C
60th	44.7	12.4	2.7	2.6	B
80th	74.4	19.0	5.3	4.0	A
100th	181.3	103.5	94.6	9.8	
Trout parr (1++)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
0th	0.9	0.9	0.8	0.5	E
20th	3.9	2.3	1.5	0.7	D
40th	5.6	3.3	2.1	0.9	C
60th	7.6	5.4	3.2	1.5	B
80th	12.1	8.4	4.9	1.8	A
100th	66.7	30.3	10.8	6.0	

This classification system compares minimum fish abundance sampled at 156 sites in the

west coast region of Scotland and placed abundance into six quintile ranges according to stream width at the survey site. Classes A through to E are given for abundance within each quintile range and class F represents an absence of fish. The 100th percentile represents the highest density found at any one of the 156 sites compared.

Survey sites

A total of 94 fish survey sites covering an area of 8,951 m² of habitat were sampled in 35 catchments. The wet width of survey sites ranged from 0.5m to 18.4 m and the conductivity of water ranged between 22 and 620 (μs^{-1}). Water temperatures during the survey ranged from 9.1 to 18.2 °C and survey conditions were clear or stained with either low or medium height of flow. Survey sites were chosen to represent the likely distribution of migratory fish in each catchment and typical habitat condition.

Electrofishing survey sites on Islay

Catchment	Site	Location	Easting	Northing	Width (m)	Area (m²)
Ardilistry	1	30m U/s of road bridge	143967	749110	5.2	83
Claggain	1	d/s of gorge section	146117	653697	5.4	97
	2	Bend below high bank	144453	653365	3.8	99
	3	U/s of sharp LH bend	144750	653502	4.8	110
Kintour	1	Lower Mainstem	146215	651650	3.0	94
	2	Middle Mainstem	145618	651327	8.0	216
	3	Upper Mainstem	144962	652194	3.8	91
	4	Tributary	144954	650861	1.2	36
	5	upper mainstem	145428	651555	9.0	180
	6	upper mainstem	145220	652089	6.2	174
Cornabus	1	Lower Cragabus	133077	645073		160
Laggan	0+	Lower mainstem	129913	656064	11.3	186
	1	Middle Mainstem	135300	758200	10.7	64
	2	Upper Mainstem	135900	759700	6.8	211
	3	River Cattadale	138600	760300	4.4	68
	4	Kilennan River	136200	658000	8.9	205
	5	Abhainn Bhogie	134530	755716	2.4	60
	6	River Torra	134500	755142	5.7	177
	7	Barr River	139600	761600	3.0	90
	8	Kilennan River	140286	658438	3.7	89
	9	Kilennan River	140700	758300	2.3	92
	10	Laggan - mainstem	132399	756609	18.4	313
Sorn	3	Lower Mainstem	135200	662600	10.8	216
	6	Upper Mainstem	136700	664800	8.1	130
	8	Upper Mainstem	138300	665400	3.7	107
	9	Dail Burn	135800	662700	2.98	86
	7	Ballymartin Burn	137114	665409	2.74	77
Suidhe	1	Lower Mainstem	129839	663059	5.2	166
	2	Allt Eibhrionn	125823	664472	1.4	49
	3	Abhainn Ghlas	128989	665131	8.5	145
	4	Abhainn Ghlas	129338	665201	6.3	139
	5	Abhainn Ghlas	130627	665236	3.5	66
	6	Sruthan Ath an Fhiona	130031	665835	2.04	61
	1	Middle Mainstem	133128	651539	4.3	116
	2	Middle Mainstem	133303	651066	4.9	88
P. Charlotte	1	Abhainn Gearach	125227	658489	6	156
Saligo	1	Lower Mainstem	121135	666304	2	44
Carrabus	1	Mainstem	131414	663151	15	165
Gortantaoid	1	Lower Mainstem	133880	673220	2	48
	2	LH Trib.	133533	673329	2	78
Margadale	1	Lower Mainstem	141706	673575	5	135
	2	Middle Mainstem	141381	673670	3	90
	3	Middle Mainstem	141337	673653	3	90
	4	RB Trib.	141459	673583	4	74

Electrofishing survey sites on Jura

Catchment	Site	Location	Easting	Northing	Width (m)	Area (m²)
Aoistail	1	Lower Mainstem	159968	684368	7	210
	2	Lower Mainstem	160228	684749	3	75
	3	Lower trib.	160647	685011	1	20
	4	Lower trib.	160279	685409	1	20
	5	Lower Mainstem	160610	685454	5	100
	6	Lower Mainstem	160550	685595	3.5	98
	7	Middle Mainstem	160922	686197	6.5	221
	8	Middle Mainstem	160943	686425	4.4	136
	9	Middle trib.	161231	687146	1	20
	10	Middle Mainstem	161003	687084	5.8	180
	11	Upper Mainstem	160964	687486	3.3	124
	12	Upper Mainstem	160839	688130	3	60
	13	Upper Mainstem	160130	688543	1.5	30
Corran	1	Lower Mainstem	154462	671244	5.5	121
	2	Lower Mainstem	154481	671852	5.6	101
	3	Lower Mainstem	154406	672184	8	176
	4	Abhainn bheag	154509	672294	1.8	40
	5	Middle Mainstem	154374	672340	6.4	122
	6	Upper Mainstem	153612	673334	3.6	69
	7	Upper Mainstem	153240	673355	6.2	136
	8	Upper Mainstem	152790	673525	5.7	94
	9	Upper Mainstem	152507	671244	4	24
Lussa	1	Lower Mainstem	164452	687035	10.9	164
	2	Lower Mainstem	164533	687964	9.8	98
	3	Lower Mainstem	164159	688123	7.8	125
	4	Allt Grundale	164016	688280	6.1	145
	5	Lower Mainstem	164138	688285	6.2	65
	6	Middle Mainstem	164201	689525	4.1	51
	7	LB trib @ head of loch	164287	689408	1.26	38

Electrofishing survey sites on the Isle of Coll

Catchment	Site No.	Location	Easting	Northing	Width (m)	Area (m²)
Allt Mor	**1**	Cornaig bay	124994	763380	1.7	37
Clabhach	**2**	Clabhach	181220	758	1.8	38
Cliad	**3**	Cliad	120077	759809	1.8	40
Loch na cloich burn	**4**	Loch na cloich burn	123455	762820	1.85	33
Torastan	**5**	Torastan	122674	762262	1	20
Allt an inbhive	**6**	Allt an Inbhive	122400	763250	1.8	41
Allt a mhuillin	**7**	Allt a Mhuillin	118611	754869	1.2	37
Allt loch na Romaird	**8**	Allt loch na Romaird	121126	755859	1.1	34
Arnagour	**9**	Mainstem upper	122217	758742	1.55	39
Arnagour	**9a**	Mainstem lower	122363	758385	2.1	107
Allt Mor	**10**	South end	116802	754662	1.5	75
Lodge burn	**11**	Lodge burn	122288	757288	1.2	42
Hyne burn	**12**	Hyne burn	120144	754856	0.7	35

Electrofishing survey sites on the Isle of Colonsay

Catchment	Site No.	Location	Easting	Northing	Width (m)	Area (m²)
Allt an Ghlinne	**1**	200m u/s of tide	136178	691566	0.8	24
Airport burn	**2**	u/s of track	135753	692910	0.7	35
Allt Staosnaig	**3**	d/s of road	138485	693368	1.5	45
Abhain a Mhuilinn	**4**	100m d/s of pond	139447	696673	3.7	56
Abhainn a Mhuilinn	**5**	150m u/s of tide	140011	697604	3.78	121
Sruthan na h-ulaidhe	**6**	u/s of fence line	141207	699623	0.5	28

Habitat surveys

A walkover habitat survey was undertaken on main channels of ten catchments with the aim of quantifying and evaluating the condition of freshwater habitats utilised for recruitment by salmonid fish. Additionally, the habitat data collected at electrofishing sites was also assessed to provide information of a higher resolution.

The survey technique was founded on the basic elements of the SFCC habitat survey protocols (SFCC, 2007) and undertaken by walking upstream during low and clear flow conditions. The survey was divided up into 500m sections and location of survey start and end points were recorded using a six figure grid reference by hand-held GPS. During the course of the survey photographs were taken of the general characteristics of the watercourse, including significant features to provide a spatial view of the catchment in a systematic manner. Information on habitat characteristics which are associated with salmonid fish was recorded for survey sections that were potentially accessible to migratory fish. The distribution and quality of the main in-stream and bankside habitat characteristics were recorded with the left and right banks orientation viewed downstream.

River channel characteristics

The type of river channel present in each survey section was categorized in relation to the fluvial geomorphological character as described by Rosgen (1996), summarised in the table below.

River channel types and associated characteristics (after Rosgen, 1996)

Type	Channel	Bed	Flow	Fish habitat
A	High gradient Straight Constrained	Bedrock, boulder & cobbles	Shallow cascade & plunge pool	Limited. Resident brown trout in lower gradient sections.
B	Moderate gradient Straight Constrained	Boulder, cobble and pebble	Shallow contiguous riffle/pool sequences	Important spawning and nursery habitats for salmonids.
C	Low gradient Meandering channel. Braided in places	Cobble, pebble and gravels	Sinuous line of defined deep water within the bed Riffle and glide flow sequences	Important habitat for all salmonid life stages and other fish species

Classification of habitat type

Classification of habitat types were undertaken using methods adapted from Hendry and Cragg-Hine (1996), that distinguishes habitat type according to their use by salmonid fish.

Juvenile fish habitat type (adapted from Hendry and Cragg-Hine 1996)

Habitat Type	Classification
Fry habitat	Shallow (< 20cm) and fast flowing water with surface turbulence and a substrate dominated by pebbles and cobbles
Mixed juvenile habitat	Generally deeper water than fry habitat (20-40cm) with a pebble, cobble and boulder substrate. Water may be more turbulent than fry habitat. Stream edges often more suited to fry than parr.
Deep juvenile habitat	Water over 40cm deep with pebble, cobble and boulder substrate (generally in main-stem rivers).
Pools (adult habitat)	Optimal; No perceptible flow and usually greater than 1metre deep with cover from canopy or undercut banks Sub optimal; smooth flow with little surface turbulence and generally greater than 30cm deep. Small substrates dominated by cobbles and fine materials.
Bedrock and gorge	Habitat dominated by sheets of bare rock. Depth usually <50cm. Little or no cover and unsuited to juvenile fish. May include different flow types including pools (although larger pools recorded separately).
Spawning	Optimal; stable & not compacted. Mean substrate size up to 80mm. Not silted. Sub optimal; As above with fine sediments (sand & fine gravel <2mm) more than 20%.

Indices were used to indicate the quality of juvenile habitat using a scale of 1 (poor) to 5 (excellent). Scores were attributed depending on the presence of habitat features likely to promote or reduce the productivity for juvenile salmonid fish (Table 2.5).

Downgrades for fry and older juvenile salmonid habitat

Habitat characteristic	Downgrade features
Substrate	**Presence of;** Bedrock, fine substrates (silt & sand) & substrate size variation
In-stream cover for fish	**Presence of** ; fine substrates (silt & sand), compacted substrate matrix **Lack of;** Broken flow type (Run & riffle), depth variation
Bank cover for fish	**Lack of;** Draped vegetation, tree roots & bank undercut
Habitat instability	**Presence of;** Unstable channel & substrates, overly-wide and shallow wetted area
Gradient of fall	**Presence of;** High % of turbulent flow (torrent) or glide or pool flow
Shading of channel	**Lack of;** Canopy cover & riparian trees **Presence of;** Tunnelling, Livestock grazing, conifer plantation, invasive non-native plants
Morphological alteration	**Presence of;** Channel straightening, bank protection, fords, culverts, weirs & bridge aprons

Distribution and status of key habitats

The location of obstacles and key habitats for salmonid fish were recorded (six figure grid reference by hand-held GPS) and given site specific identification codes. An assessment of the relative size of the site and its condition was also undertaken to designate the site as optimal or sub-optimal. To assess the distribution of habitats for connectivity and usefulness to fish, key habitats were mapped using Geographic Information System (GIS) software (Arc GIS version 10.1).

Obstacles

The location, type and approximate size of significant obstacles to fish migration of was recorded and assessed in relation for potential passage of salmonid fish.

Obstacle assessment

Assessment	Selected options
Type of obstacle	**Natural;** Waterfall (WF), Flood debris (FD), Fallen tree (FT), Gravel cone (GC) **Man-made;** Dam (DA), Weir (WE), Culvert (CU), Bridge apron (BR), Fish counter (FC), Water gate (WG)
Passable?	No (Upstream & Downstream), No (Upstream), Yes (Species/flow specific), Yes or Unsure
Vertical?	Yes / No / Not applicable
E-fish requirement?	Yes / No (if unsure of fish passage)
Notes	Other information such as the height of the barrier or the presence of pools below waterfalls

Adult holding pools

The location of potential pool habitats for adult salmonid fish was recorded and approximate dimensions assessed. The status of the habitat was assessed in relation to site features that provide cover for fish as optimal or sub-optimal. Optimal habitats are likely to be long-term holding habitats for adult fish providing a high level of cover. Sub-optimal habitats are likely to be short-term habitats for adult fish during migration or spawning activities.

Adult pool habitat assessment

Assessment	Selected options
Area (m²)	Approximate estimate of length and width
Cover type	Depth / Canopy cover / Bank cover / Other
Status	**Optimal;** Large size (>50m²), deep (>2m), In-stream boulders, overhanging vegetation **Sub-optimal;** Small size (<50m²), shallow (<2m), Lower availability of in-stream and bank cover
Notes	Other information such as features creating or sustaining the pool habitat

Spawning sites

The location of potential spawning habitats for salmonid fish was recorded and approximate dimensions assessed. The status of the habitat was assessed in relation to site features that affect the potential productivity of the site.

Spawning site assessment

Assessment	Selected options
Area (m²)	Approximate estimate of length and width
Status	**Optimal;** Protected stable substrate, suitable substrates, Low % fine substrates, adult fish cover nearby, **Sub-optimal;** Exposed or unstable substrate, Large or fine substrates in sites, no or low available cover
Suitability	Trout (gravel / pebble) / Salmon (pebble / cobble) or both (mix)
Situation	Left bank (LB) / Central (C) / Right bank (RB)
Downgrades	Stability, Substrates; fines or boulder, accessibility, de-watering or other
Site features	Pool / braid / Island / Ford / Large woody debris (LWD) or other
Notes	Other information such as accessibility of the habitat

Channel and bank modifications

The location of modifications to the bank and channel was recorded and length of channel affected was assessed. Notes on potential effects likely to impair the productivity of fish habitat were also recorded.

Habitat modifications

Assessment	Selected options
Area (m)	Approximate estimate of length (and width if applicable)
Location	Left bank / central / right bank
Type	Gabions (GA), Concrete wall (CW), Fishing pool (FP), Croys (CR), Current deflectors (CD), Revetments (RE), Rip rap (RR) or Under construction (UC) or other or none
Notes	Other information the effects on fish habitat

Riparian habitats

The relative cover for fish, percentage shading and riparian habitat features were estimated for left and right bank (observed downstream). Predominant land use 50m from the channel and the presence of invasive non-native plants (INNS) were also recorded.