SURVEY REPORT

South Argyll Rivers Project, Final Report: Survey of Fish Populations & Habitats

2008-10

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SURVEY REPORT

Summary

South Argyll Rivers Project, Phase 2 of 2: Survey of fish populations and habitats 2008/10.

Background

Argyll Fisheries Trust undertook electrofishing surveys of fish populations on 27 catchments and habitat surveys on 18 catchments on the Cowal Peninsula from 2008 until 2010. The aim of the surveys was to establish baseline information on fish species distribution, their relative abundance and the status of habitats. This work fulfils phase two of a two year project to assess fish populations and their habitats in South Argyll.

Main findings

- Electrofishing surveys were undertaken at 143 sites in 27 catchments. The surveys sampled 5 native species; Atlantic salmon (*Salmo salar*), Brown trout (*Salmo trutta fario*), European eel (*Anguilla anguilla*), river or brook lamprey ammocoetes (*Lampetra spp.*), three spine stickleback (*Gasterosteus aculeatus*) and flounder (*Platichthys flesus*).
- Juvenile Atlantic salmon were sampled in 11 of the 27 catchments sampled. Salmon fry were sampled at 36% of sites and salmon parr were sampled in 30% of sites. Where present their abundance was relatively low-to-moderate when compared to the SFCC classification scheme.
- Juvenile Brown trout were sampled in 26 out of 27 catchments sampled. Trout fry were sampled at 82% of sites and trout parr were sampled at 58% of sites. Their abundance was relatively moderate-to-good at most sites when compared to the SFCC classification scheme.
- Habitat surveys were undertaken on 90.15km of main channels in 18 catchments. The location and assessment of 163 obstacles to fish passage, 375 significant adult holding pools and 285 spawning sites was recorded. Mixed juvenile habitat category was the most abundant habitat and was mostly of poor-to-moderate status.
- The factors affecting productivity of juvenile habitats were identified for in-stream conditions (average of 7.3 downgrades per km), which were primarily a combination of bedrock and fine sediments in the substrate matrix, providing relatively poor in-stream cover for fish. Factors

affecting riparian habitats (3.3 downgrades per km) included over-shading of smaller stream channels and lack of bank cover (vegetation) on larger channels.

The following conclusions were reached:

- The patchy distribution of juvenile salmon is likely to be primarily due to population shrinkage as a consequence of low numbers of adult sea returns.
- Juvenile brown trout were sampled from a wide range of habitats including major rivers, coastal streams and habitats upstream of waterfall obstacles. Relatively high densities at some sites indicate that they are likely to be derived from the migratory form, sea trout (*Salmo trutta trutta*).
- The principal 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 mixture of natural and modified channel features and a consequence of use of land and water resources.
- The data collected indicate that salmon populations are not likely to support an exploitative fishery at this time. Operating fisheries on conservation-minded principles will be essential to maximise spawning escapement of sea run adult fish and stimulate restoration of the fishery resource.
- It is likely that catchment-scale management initiatives are required to restore productivity of freshwater habitats and improvement in local and wider marine survival of migratory salmonids to sustain improvement in biodiversity and fishery resource.

Acknowledgements

Argyll Fisheries Trust thanks the project partners for their support;

Scottish Natural Heritage (SNH), the Scottish Government, Scottish & Southern Energy Plc, Lighthouse Caledonia Ltd, Dunoon and District Angling Club, Goil Angling Club, River Ruel Protection and Improvement Association and the Argyll and Eachaig District Salmon Fishery Boards.

The project partners also thank the Forestry Commission and other land owners for permission to access survey sites. Additional thanks are given to all those that helped with the survey work.

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1 INTRODUCTION

Argyll Fisheries Trust undertook electrofishing surveys of fish populations on 27 catchments and habitat surveys on 18 catchments on the Cowal Peninsula from 2008 until 2010 (Figure 1.1). The aim of the surveys was to establish baseline information on fish species distribution, their relative abundance and the status of habitats. This work fulfils completes a two year project to assess fish populations and their habitats in South Argyll. The information on fish populations and their habitats is required to inform a wide range of stakeholders of the status of the resource. This report summarises the findings of the surveys undertaken from 2008 to 2010 and complements catchment specific reports that provide more detailed information on the study findings (see appendices 1 to 15).

1.1 Fish populations and fisheries

The freshwater habitats of South Argyll consist of a number of relatively moderately sized river catchments and a number of coastal streams. This resource supports rod & line fisheries for Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta trutta*) that is of importance to the local economy. As well as migratory salmonids, the region's freshwater habitats also support a number of other fish and lamprey species that are important elements of local biodiversity. The health of this resource relies on productive and unpolluted freshwater habitats that are essential for the recruitment of most of the fish fauna.

1.2 Salmonid fish

Typically adult migratory salmonid fish enter freshwater in summer where they provide a fishery resource 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 freshwater as the resident form of brown trout (*Salmo trutta fario*) where they may or may not interbreed with sea run morphs. This study aims to evaluate the current status of juvenile fish in their fry and parr stages prior to emigration and provide initial assessment of the condition of their habitats.

1.3 Other fish and lampreys

Other native fish fauna that are typically found to inhabit freshwaters in this region are understood to be a mixture of resident and migratory species including European eel (*Anguilla anguilla*), brook lamprey (*Lampetra planeri*), river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*), three spine stickleback (*Gasterosteus aculeatus*) and flounder (*Platichthys flesus*). This study collected data on these species sampled at salmonid fish survey sites. Additional information was also collected on lamprey targeting their larval life stage (ammocoetes) in patches of organic silt prior to metamorphosis into the adult life phase.

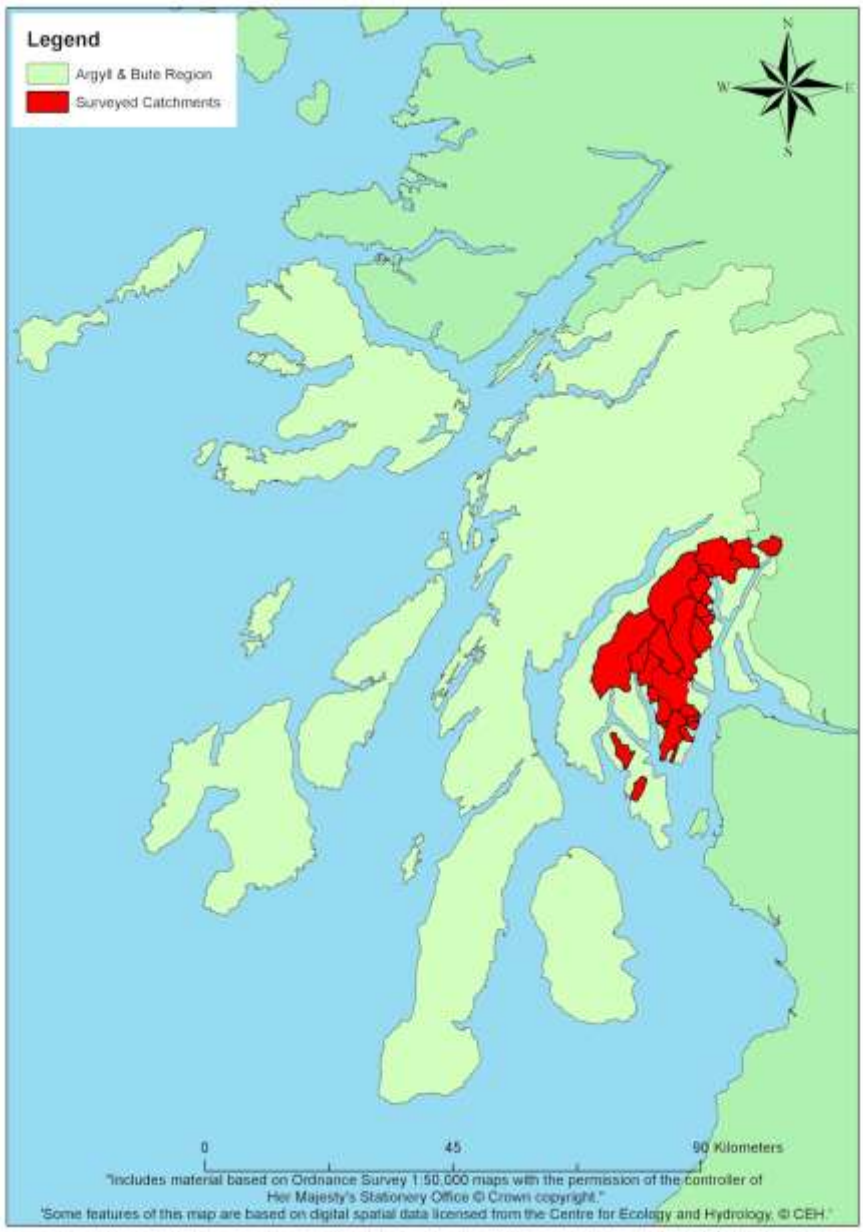

Figure 1.1 Overview of South Argyll catchments surveyed

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.

2.1 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.

2.1.1 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 was 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.

2.1.2 Other fish and lamprey

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 with the exception of lamprey. Site specific surveys were undertaken at locations where potential habitat for lamprey ammocoetes was identified. Semi-quantitative five minute surveys were used to sample such habitats and where present provide an index of catch per unit effort. This method repeated that used as part of the National Lamprey Survey (Ecological Research Associates 2004).

2.1.3 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 the SFCC classification scheme (Godfrey, 2005) (Table 2.1).

This classification system compares minimum fish abundance sampled at 151 sites in the Clyde coast region of Scotland and places 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 as described for the national classification scheme developed for England and Wales (National Rivers Authority, 1994). The 100th percentile represents the highest density found at any one of the 151 sites compared.

2.1.4 Survey sites

A total of 135 fish survey sites and 8 lamprey survey sites were sampled in 18 larger catchment and 9 smaller coastal burns in 2008 and 2009 (Table 2.2 and Figure 2.1). Survey sites were chosen to represent the likely distribution of migratory fish in each catchment and typical habitat condition. The lamprey survey was undertaken at a single site where a suitable pocket of organic silt was observed during the course of the electrofishing surveys. Where no suitable lamprey habitat was identified no sampling was undertaken.

Table 2.1 Quintile ranges for juvenile salmonid fish density (Clyde coast region)

Min. Percentile	River Width Class				
Salmon fry (0+)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
0th	0.7	0.7	1.5	0.3	E
20th	5.5	8.5	4.5	7.4	D
40th	11.2	15.6	5.5	9.7	C
60th	19.1	25.4	17.7	16.5	B
80th	53.5	50.4	41.5	30.0	A
100th	115.6	210.6	89.1	62.8	
Salmon parr (1++)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
0th	0.7	0.7	0.4	0.3	E
20th	1.6	1.6	1.6	1.1	D
40th	3.0	3.9	3.1	2.2	C
60th	4.6	5.6	6.0	4.4	B
80th	6.9	9.2	12.6	6.9	A
100th	19.3	24.0	20.5	37.0	
Trout fry (1++)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
0th	0.9	0.6	0.5	0.4	E
20th	5.0	2.8	1.8	1.4	D
40th	9.2	4.4	2.7	2.1	C
60th	15.8	6.8	4.2	2.7	B
80th	28.8	16.7	5.3	4.6	A
100th	87.4	145.5	40.0	8.6	
Trout parr (1++)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
0th	0.9	0.6	0.6	0.2	E
20th	2.5	1.4	1.5	0.8	D
40th	4.8	3.8	2.1	1.2	C
60th	6.1	5.9	3.4	2.1	B
80th	8.5	9.9	5.3	2.7	A
100th	29.7	42.9	8.6	4.1	

Table 2.2 South Argyll electrofishing survey site summary

Catchment	Catchment Size (km^2)	No. of salmonid e-fish sites	Lamprey e-fish sites
Upper Loch Long			
Loin	10	6	1
Croe	18	7	
Loch Goil			
Goil	40	16	
Lettermay	13	3	
Carrick	5	2	
Loch Goil coastal	<5	3	
Middle Loch Long			
Finart Burn	19	10	1
Eachaig Catchment			
Eachaig (inc Little Eachaig)	176	22	4
Lower Loch Long			
Balgaidh	6	5	
Coastal burns	<5	4	
Loch Striven			
Ardyne	31	8	
Balliemore	13	6	
Inverchaolain	9	4	
Invervegain	5	4	
Tarsan	13	6	
Knockdhu Burn	<5	1	
Loch Riddon			
Ruel (inc Auchenbreck)	90	19	2
Bute			
Glenmore	5	6	
Greenan	<5	3	
Total		**135**	**8**

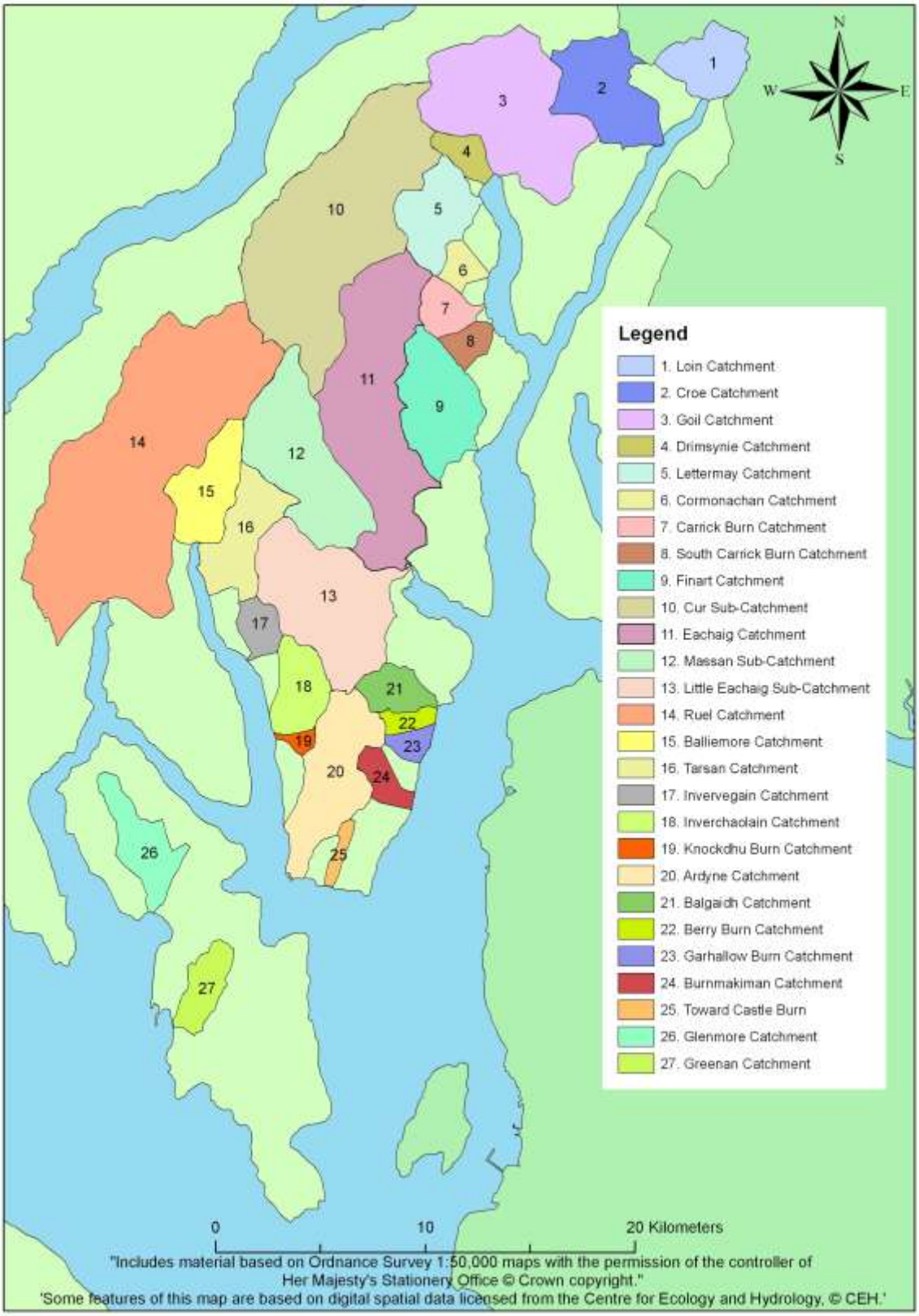

Figure 2.1 South Argyll electrofishing catchments

2.2 Habitat surveys

A walkover habitat survey was undertaken on main channels of 18 catchments. The aim of the survey was to quantify and evaluate 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 generally divided up into 250m 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.

2.2.1 River channel characteristics

The type of river channel present in each survey section was categorized in relation to the fluvial geomorphological character based on Rosgen (1996), adapted and summarised in Table 2.3.

Table 2.3 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

2.2.2 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 (Table 2.4).

Table 2.4 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).

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

2.2.3 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 9.2).

2.2.3.1 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 (Table 2.6).

Table 2.6 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

2.2.3.2 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 (Table 2.7). 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.

Table 2.7 Adult pool habitat assessment

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

2.2.3.3 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 (Table 2.8).

Table 2.8 Spawning site assessment

Assessment	Selected options
Area (m^2)	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

2.2.3.4 Channel and bank modifications

The location of modifications to the bank and channel was recorded and length of channel affected was assessed (Table 2.9). Notes on potential affects on fish habitat were also recorded.

Table 2.9 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 affects on fish habitat

2.2.4 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.

3 RESULTS

3.1 Electrofishing surveys

The results of electrofishing sampling of salmonid and other fish species are given for separately below.

3.1.1 Juvenile salmonid fish distribution

Juvenile trout were sampled in 26 out of 27 catchments surveyed, while juvenile salmon were sampled in 11 catchments (Table 3.1). Of the 135 electrofishing surveys conducted, trout fry were present at most sites (82% of sites) and trout parr were sampled at 58% of sites. Salmon fry were recorded at 36% of sites surveyed, while salmon parr were sampled from a lower number of sites (30%).

3.1.2 Classification of fish abundance

The minimum density of juvenile salmon and trout sampled in the 2008 and 2009 is compared using the SFCC classification scheme in Tables 3.3. For interpretation, when compared to 151 other sites sampled in the region, grade F represents an absence of fish and grades D and E represent low to very low abundance respectively. Grades C and B represent moderate to high abundance respectively and grade A represents very high abundance.

Minimum classes of salmon fry abundance (Table 3.2) was very low (class E) in all catchments where they were sampled, with the exception of the Eachaig catchments, where minimum abundances were D and C. Maximum classes ranged from moderate (class C) in the Eachaig and Croe catchments to high (class B) in the River Finart and River Goil, to very high in the River Ruel (class A). Minimum classes of salmon parr abundance were very low (class E) in the River Eachaig, Ruel, Goil and Finart catchments, low in the Croe (class D) and moderate in the Glenmore, Little Eachaig and Massan catchments (class C). Maximum classes of parr ranged between moderate (class C) in the Croe Water and Eachaig to very high (class A) in the Goil catchment.

Table 3.1 Distribution of juvenile salmonid fish (no. of sites where sampled) 2008-2009

Catchment	No. sites	Salmon Fry	Salmon Parr	Trout Fry	Trout Parr
Upper Loch Long					
Loin	6	0	0	6	6
Croe	7	3	2	7	6
Loch Goil					
Goil	16	7	8	12	5
Lettermay	3	0	0	3	2
Carrick	2	0	0	2	1
South Carrick Burn	1	0	0	1	0
Cormonachan Burn	1	0	0	1	1
Drimsynie Estate Burn	1	0	0	1	0
Middle Loch Long					
Finart Burn	10	6	5	9	6
Eachaig Catchment					
Eachaig	2	2	2	2	1
Little Eachaig	5	1	1	5	5
Massan	4	1	1	4	3
Cur	11	9	5	11	6
Lower Loch Long					
Balgaidh	5	0	0	3	3
Berry Burn	1	0	0	1	1
Garhallow Burn	1	0	0	1	1
Burnmakiman Burn	1	0	0	1	1
Toward Castle Burn	1	0	0	1	1
Loch Striven					
Ardyne	8	0	0	5	8
Balliemore	6	0	0	6	3
Inverchaolain	4	0	0	4	3
Invervegain	4	0	0	3	4
Tarsan	6	1	1	5	6
Knockdhu Burn	1	0	1	1	1
Loch Riddon					
Ruel	19	18	12	12	1
Bute					
Glenmore	6	0	2	4	3
Greenan	3	0	0	0	0
Totals	**135**	**48**	**40**	**111**	**78**

Table 3.2 Classification of salmonid fish abundance per catchment

Catchment	Salmon Fry		Salmon Parr		Trout Fry		Trout Parr	
	Min	Max	Min	Max	Min	Max	Min	Max
Upper Loch Long								
Loin	F		F		E	A	E	A
Croe	E	C	D	C	E	A	E	A
Loch Goil								
Goil	E	B	E	A	E	A	D	A
Lettermay	F		F		E	A	D	
Carrick	F		F		B	A	E	
South Carrick Burn	F		F		A		F	
Cormonachan Burn	F		F		A		C	
Drimsynie Estate Burn	F		F		A		F	
Middle Loch Long								
Finart Burn	E	B	E	B	E	A	E	B
Eachaig Catchment								
Eachaig	D	C	E	C	E	E	E	
Little Eachaig	C		C		D	A	E	A
Massan	C		C		B	A	E	C
Cur	E	C	E	B	E	A	E	D
Lower Loch Long								
Balgaidh	F		F		E	A	E	C
Coastal burns	F		F		E	A	B	A
Loch Striven								
Ardyne	F		F		E	A	D	A
Balliemore	F		F		E	B	E	D
Inverchaolain	F		F		D	A	C	B
Invervegain	F		F		E	A	E	B
Tarsan	E		E		E	D	E	A
Knockdhu Burn	F		D		B		A	
Loch Riddon								
Ruel (inc Auchenbreck)	E	A	E	B	E	B	A	
Bute								
Glenmore	F		C	B	E	A	D	A
Greenan	F		F		F		F	

Classification of minimum trout fry abundance was similar to that of salmon. Minimum classes were very low (class E) in most catchments with the exception of the high abundance (class B) in the Carrick Burn and very high abundance (class A) in the smaller coastal burns of Loch Goil. Maximum values for fry were generally high to very high (class A & B) in most catchments with the exception of the River Tarsasn, which was low (class D). Minimum classification of trout parr abundance was

mostly very low (class E) with the exception of low abundance in the Lettermay Burn and River Goil, moderate abundance in the Inverchaolain and in a single sample taken from the Cormonachan Burn (class C) and high abundance from the Lower Loch Long coatsal burns. Maximum values ranged from very low abundance (class E) in the River Eachaig to very high (class A) in the Little Eachaig, Croe, Loin, Goil, Ardyne, Tarsan and Glenmore catchments.

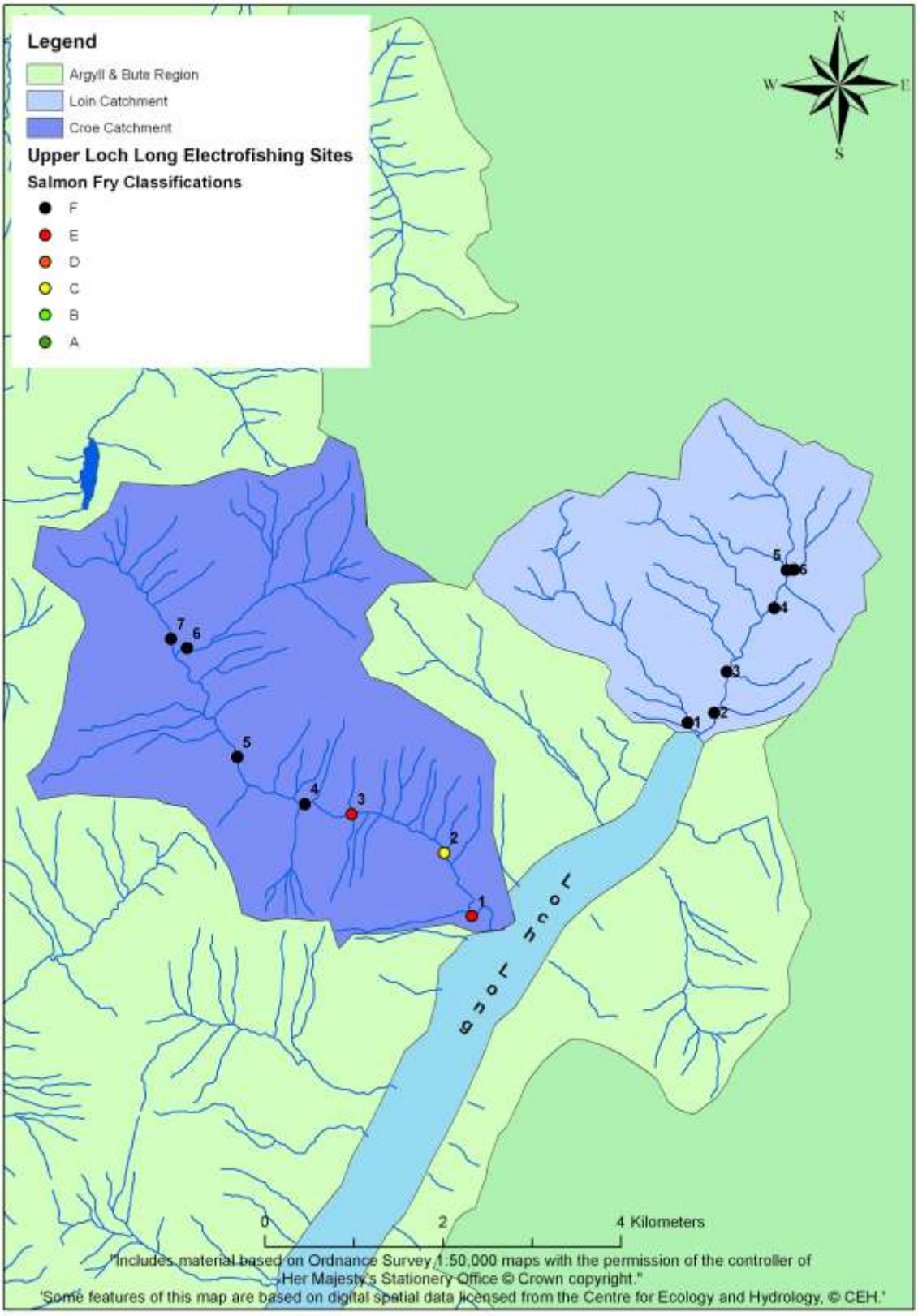

Figure 3.1 Upper Loch Long salmon fry distribution and relative abundance (SFCC classification)

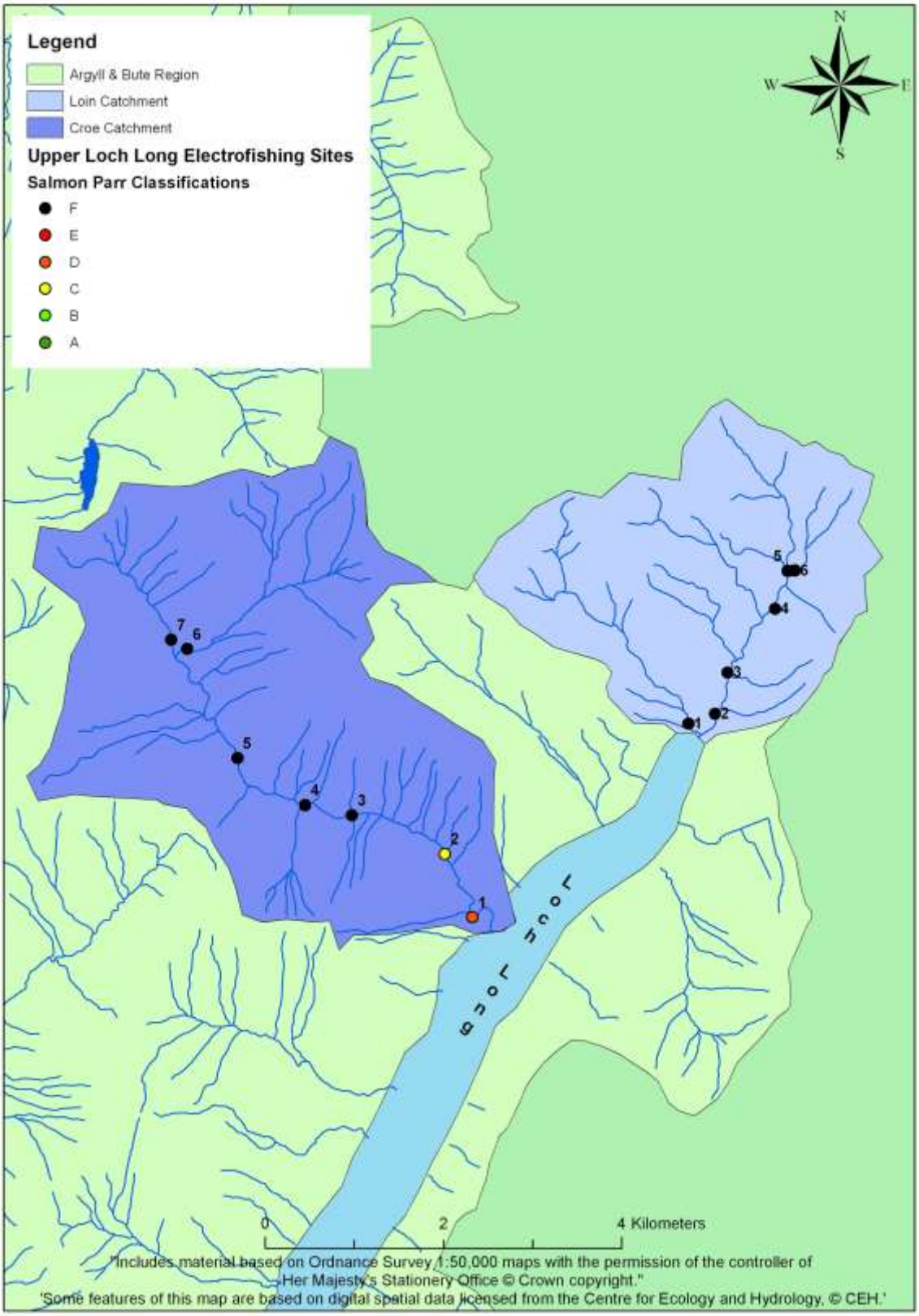

Figure 3.2 Upper Loch Long salmon parr distribution and relative abundance (SFCC classification)

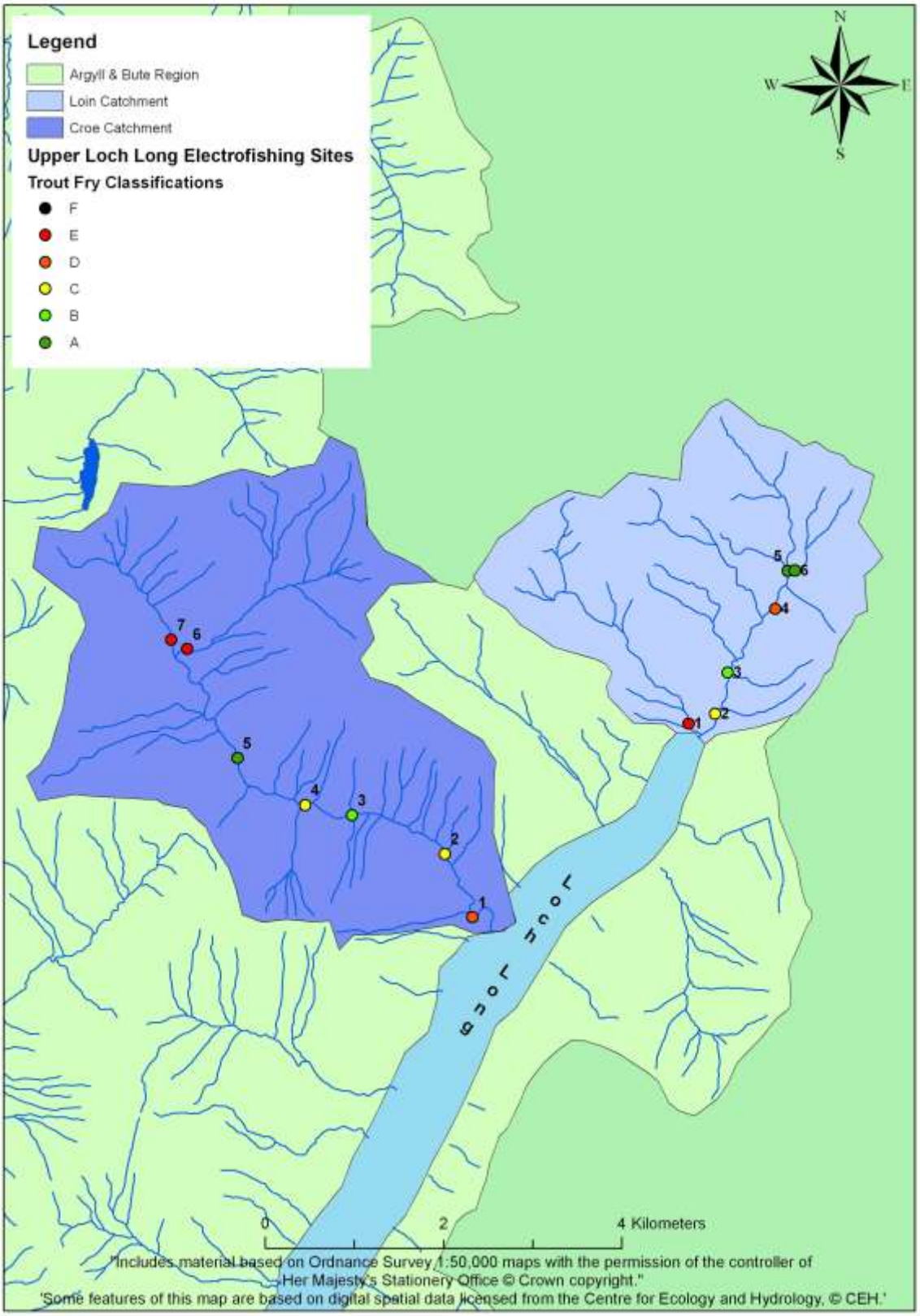

Figure 3.3Upper Loch Long trout fry distribution and relative abundance (SFCC classification)

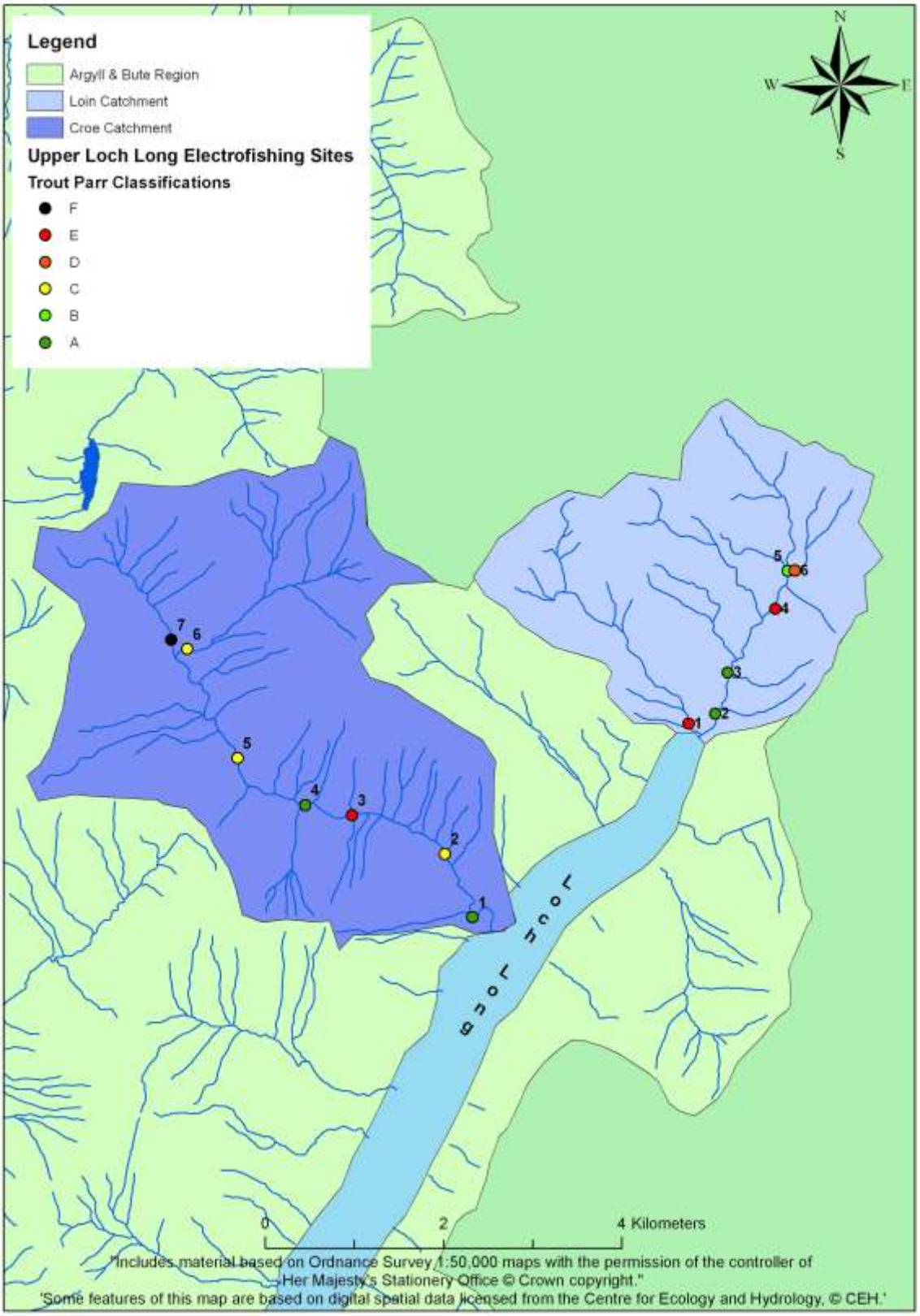

Figure 3.4 Upper Loch Long trout parr distribution and relative abundance (SFCC classification)

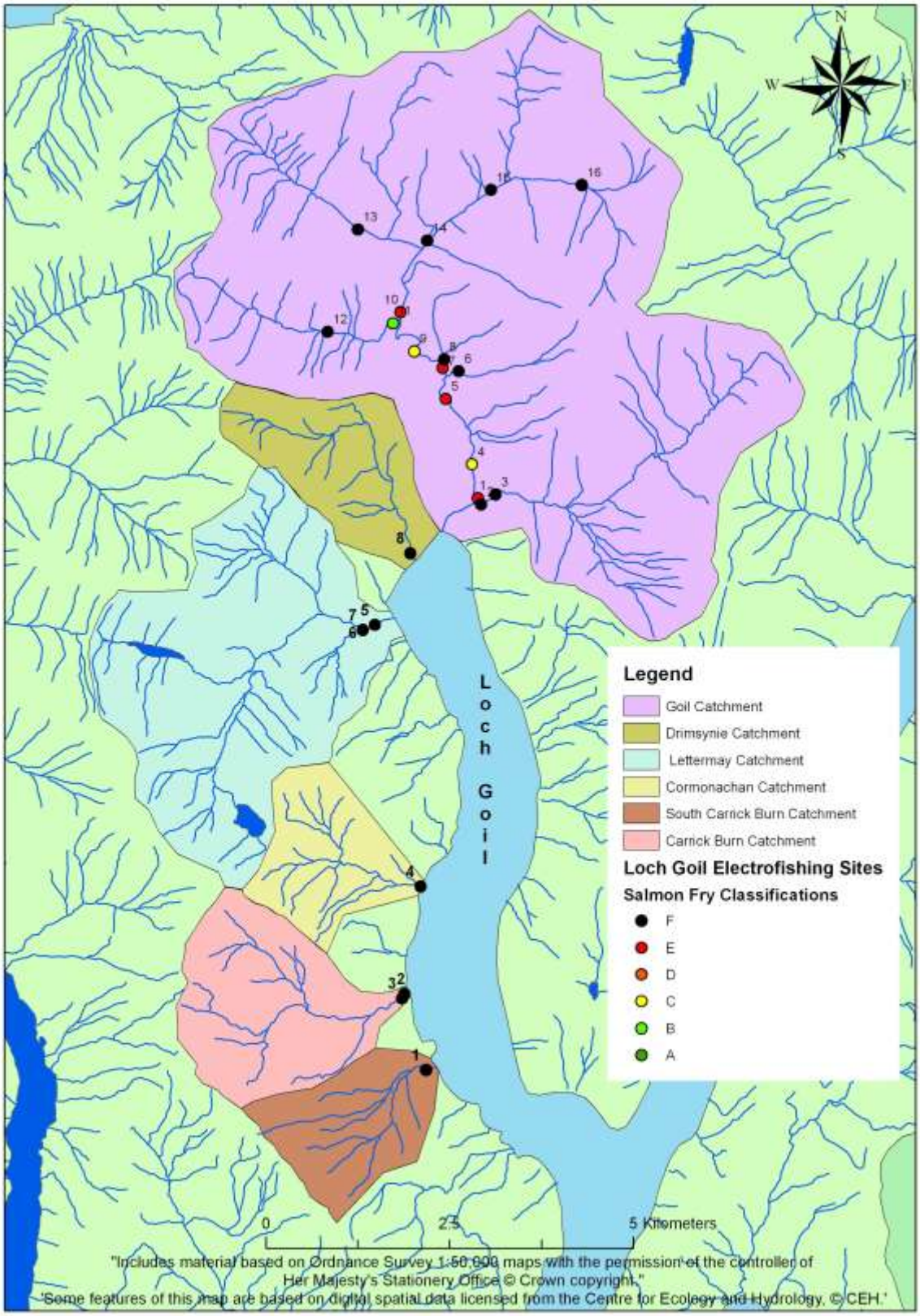

Figure 3.5 Loch Goil salmon fry distribution and relative abundance (SFCC classification)

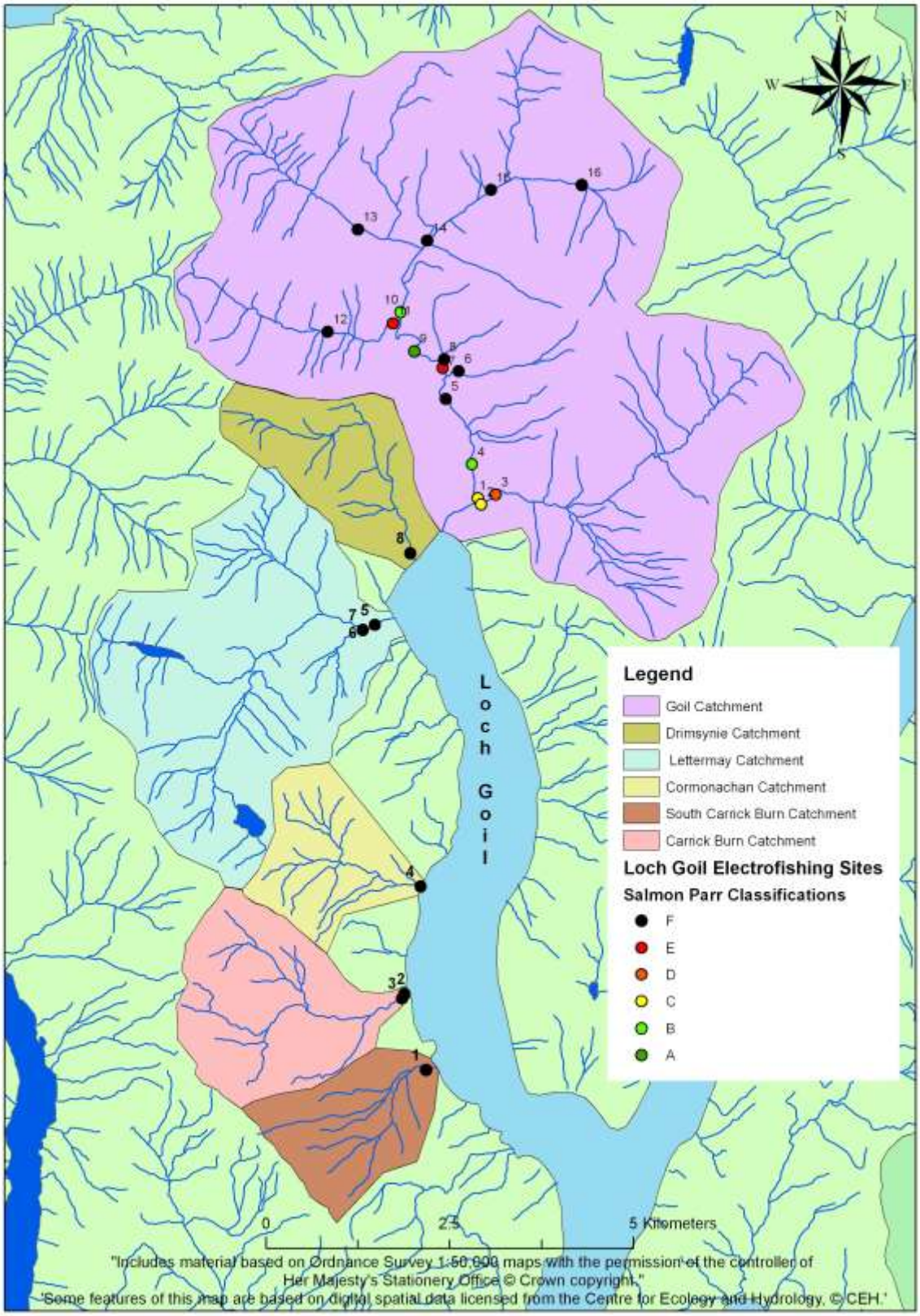

Figure 3.6 Loch Goil salmon parr distribution and relative abundance (SFCC classification)

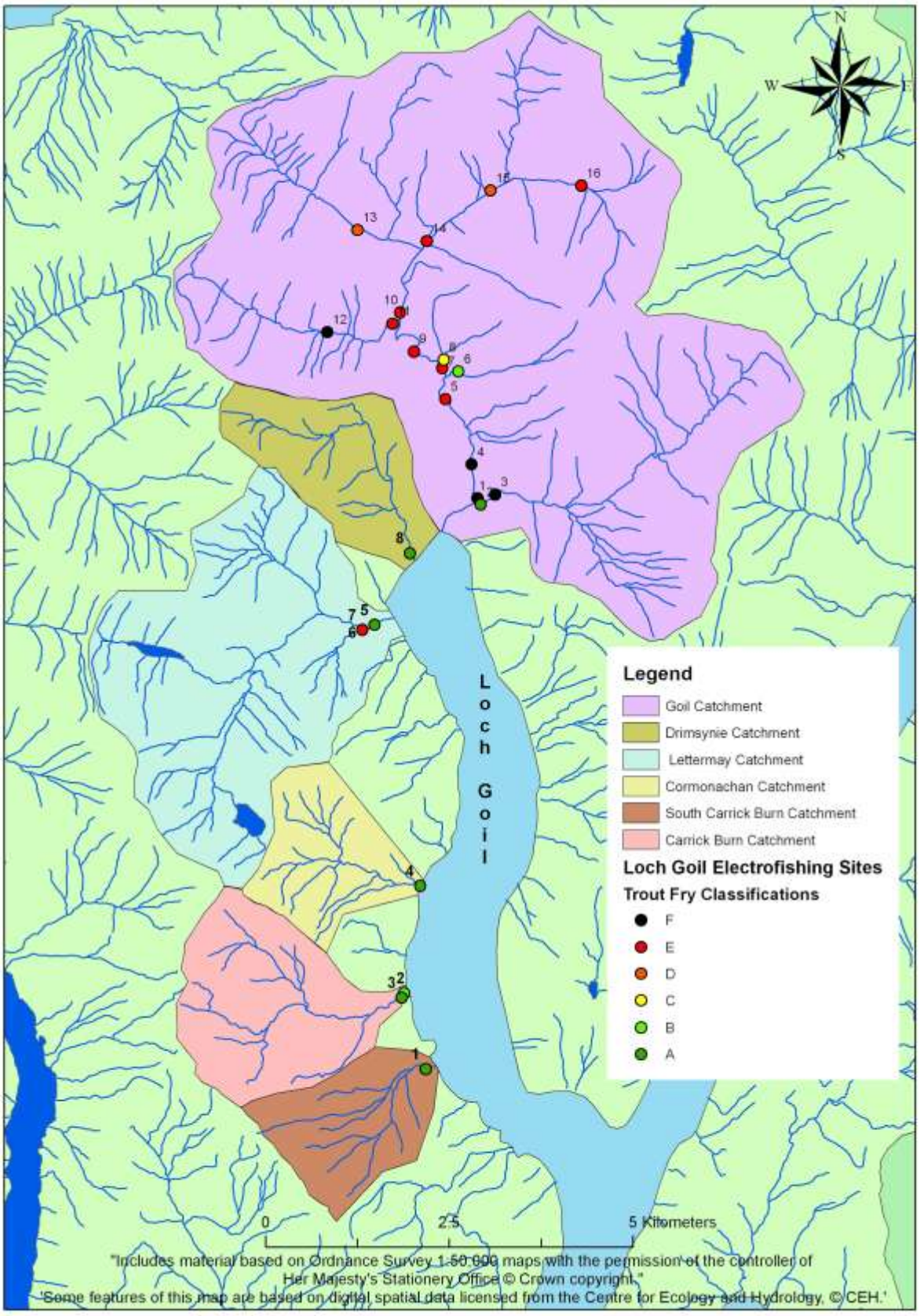

Figure 3.7 Loch Goil trout fry distribution and relative abundance (SFCC classification)

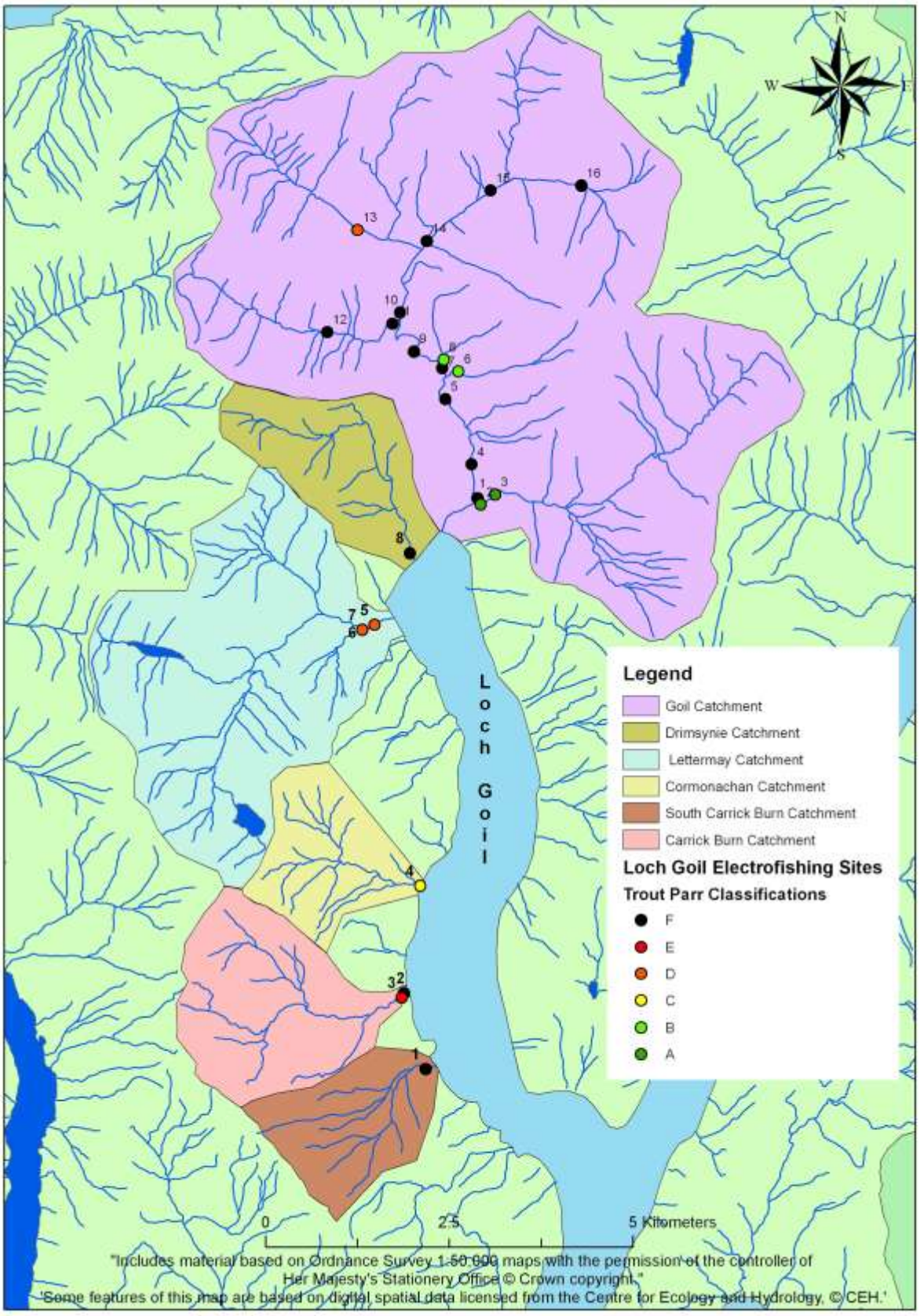

Figure 3.8 Loch Goil trout parr distribution and relative abundance (SFCC classification)

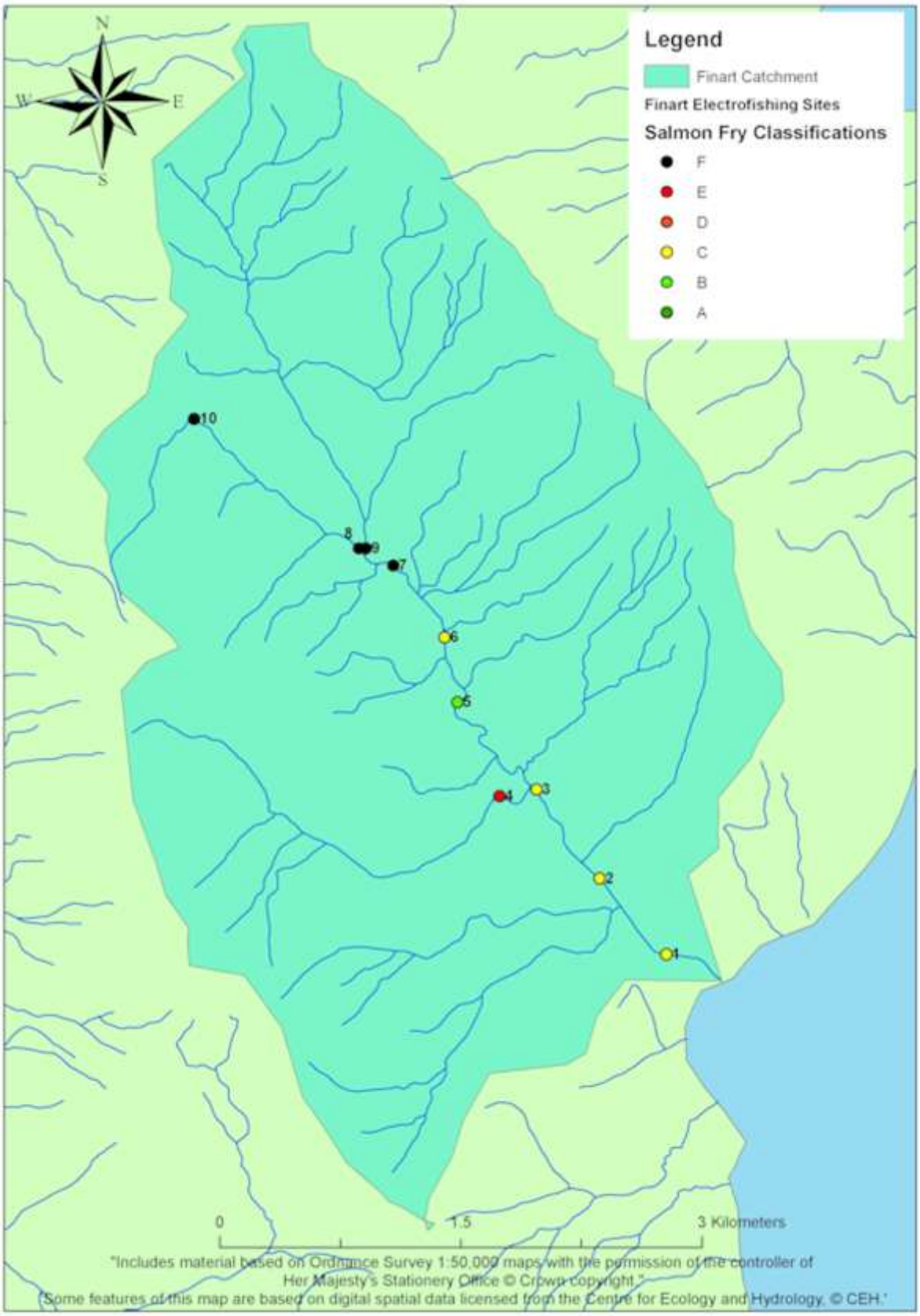

Figure 3.9 Middle Loch Long salmon fry distribution and relative abundance (SFCC classification)

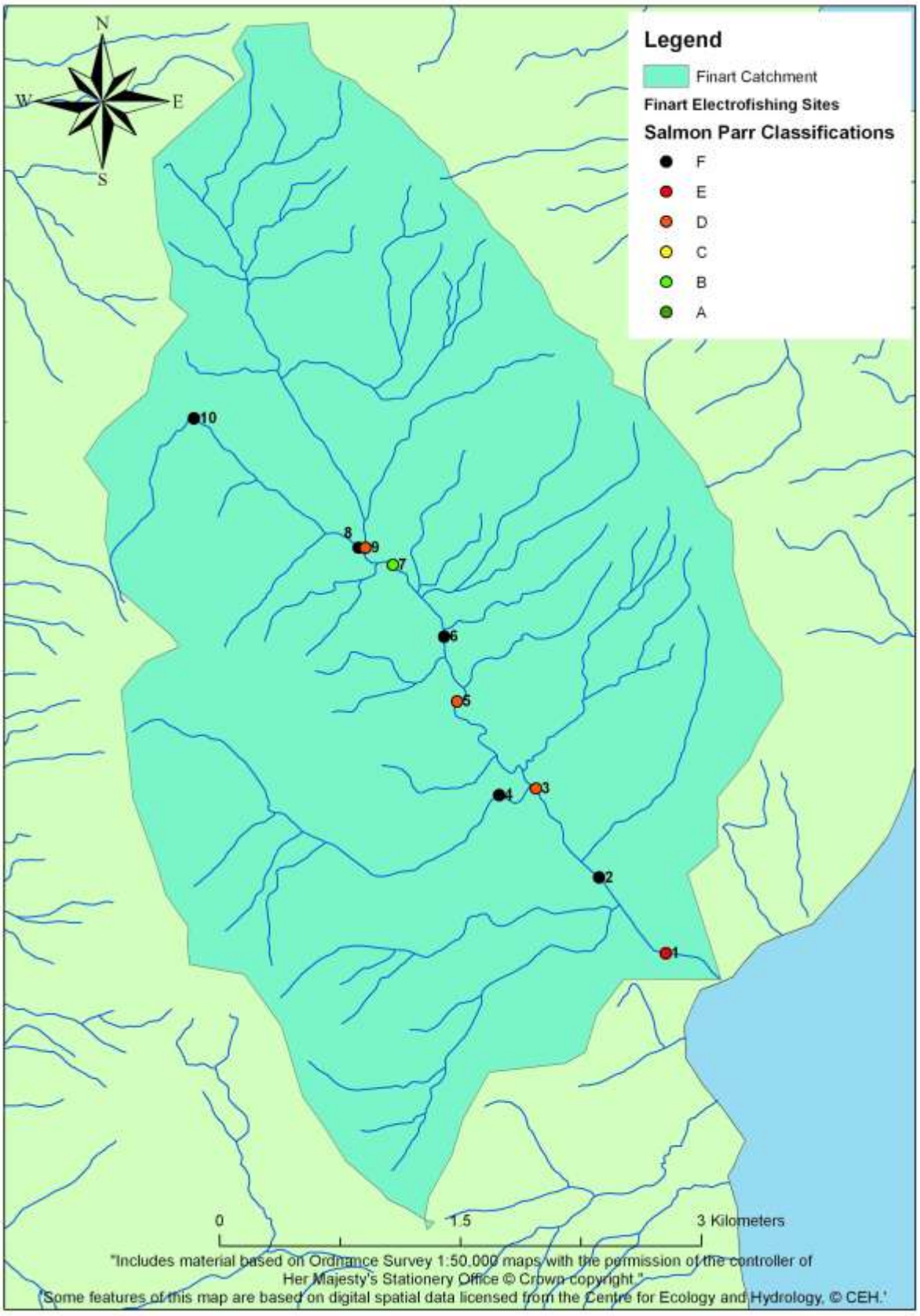

Figure 3.10 Middle Loch Long salmon parr distribution and relative abundance (SFCC classification)

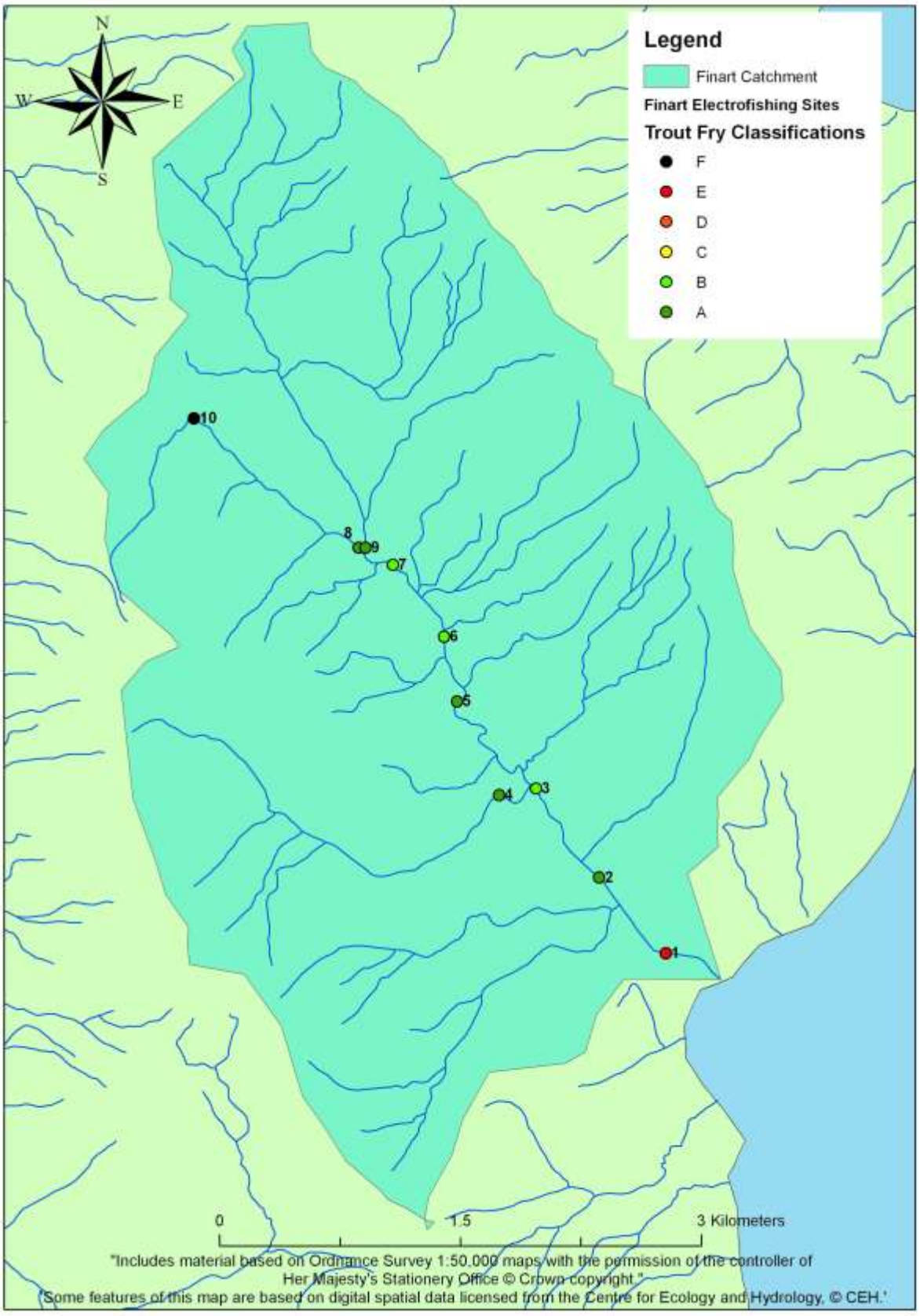

Figure 3.11 Middle Loch Long trout fry distribution and relative abundance (SFCC classification)

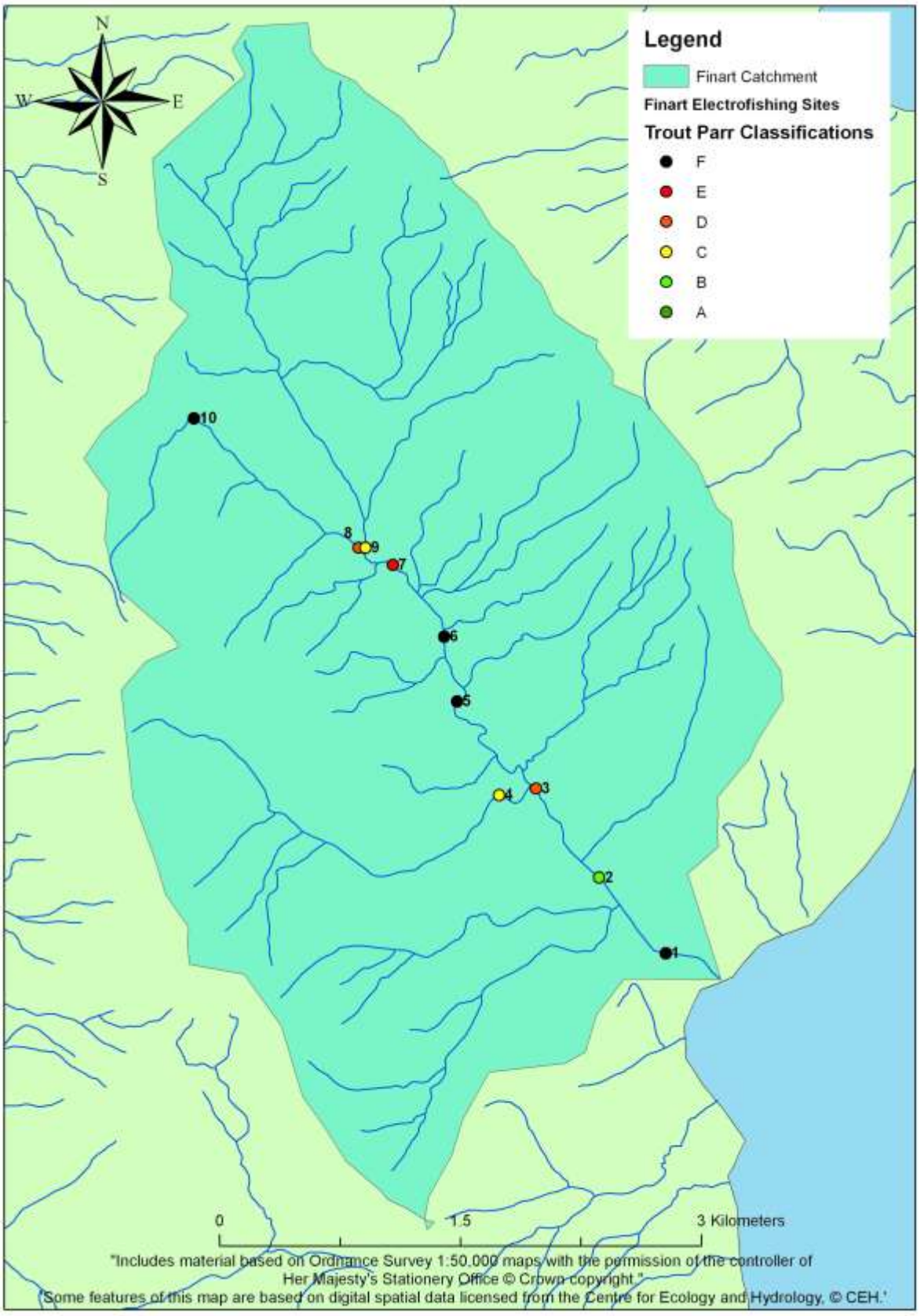

Figure 3.12 Middle Loch Long trout parr distribution and relative abundance (SFCC classification)

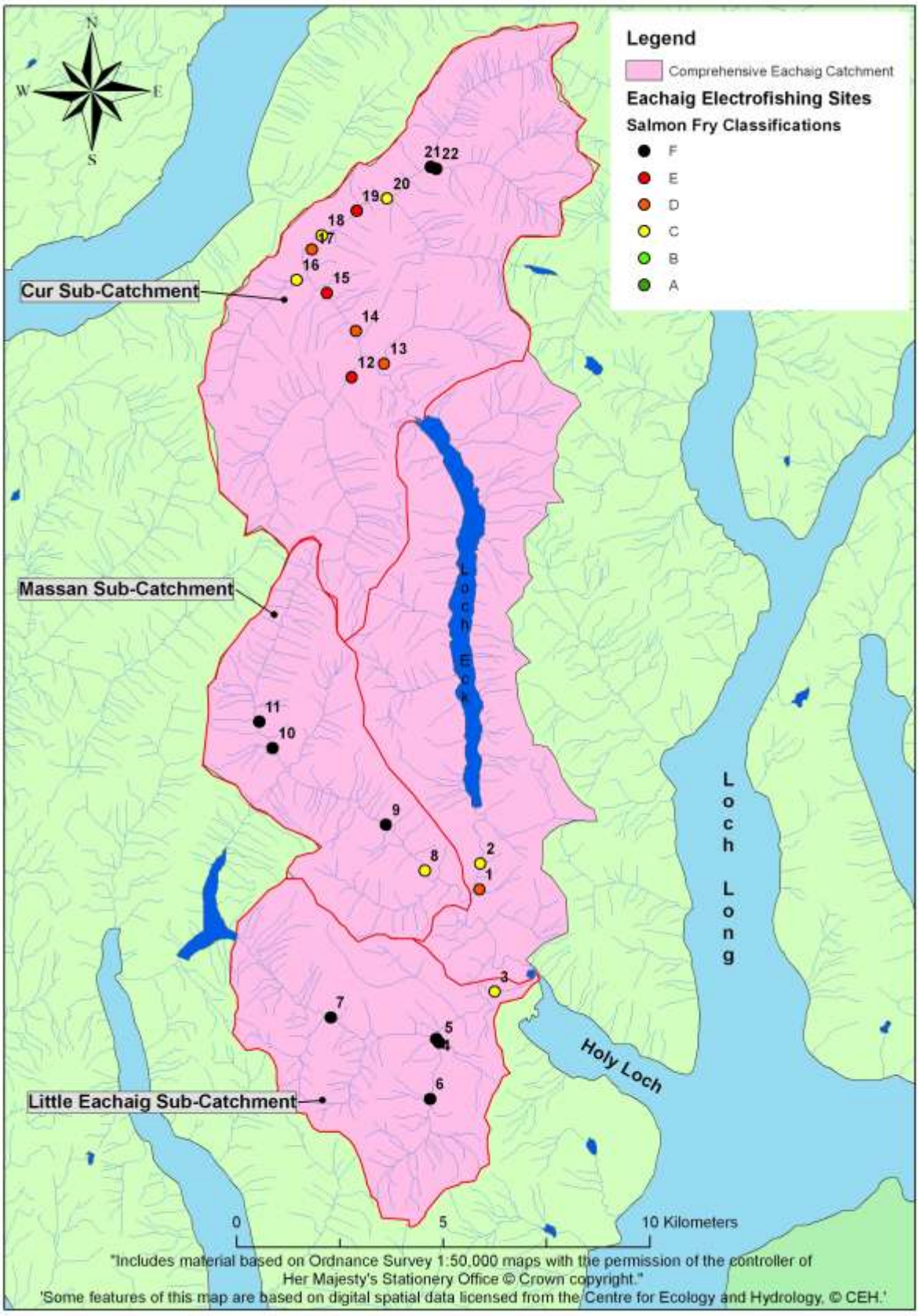

Figure 3.13 Eachaig catchment salmon fry distribution and relative abundance (SFCC classification)

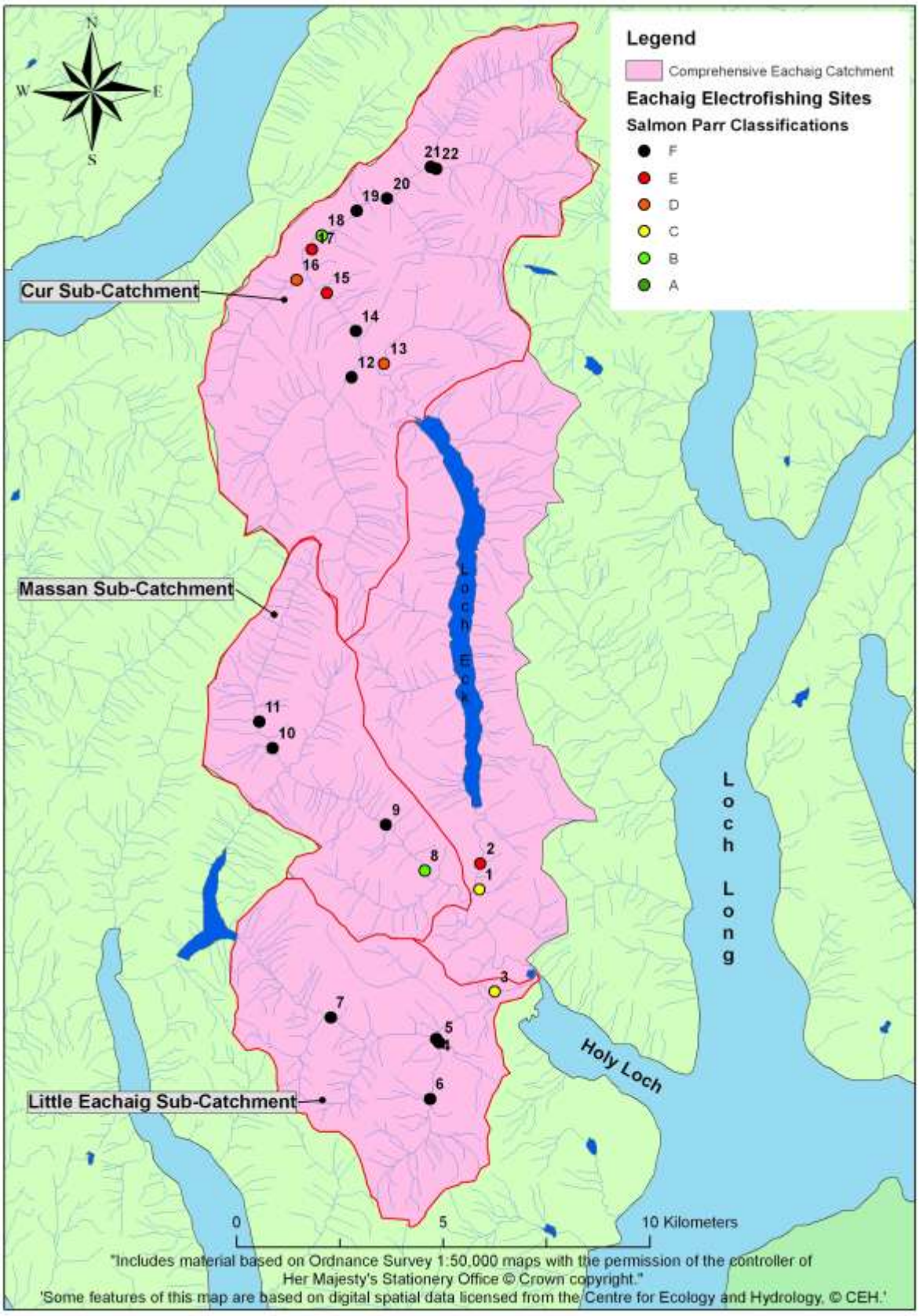

Figure 3.14 Eachaig catchment salmon parr distribution and relative abundance (SFCC classification)

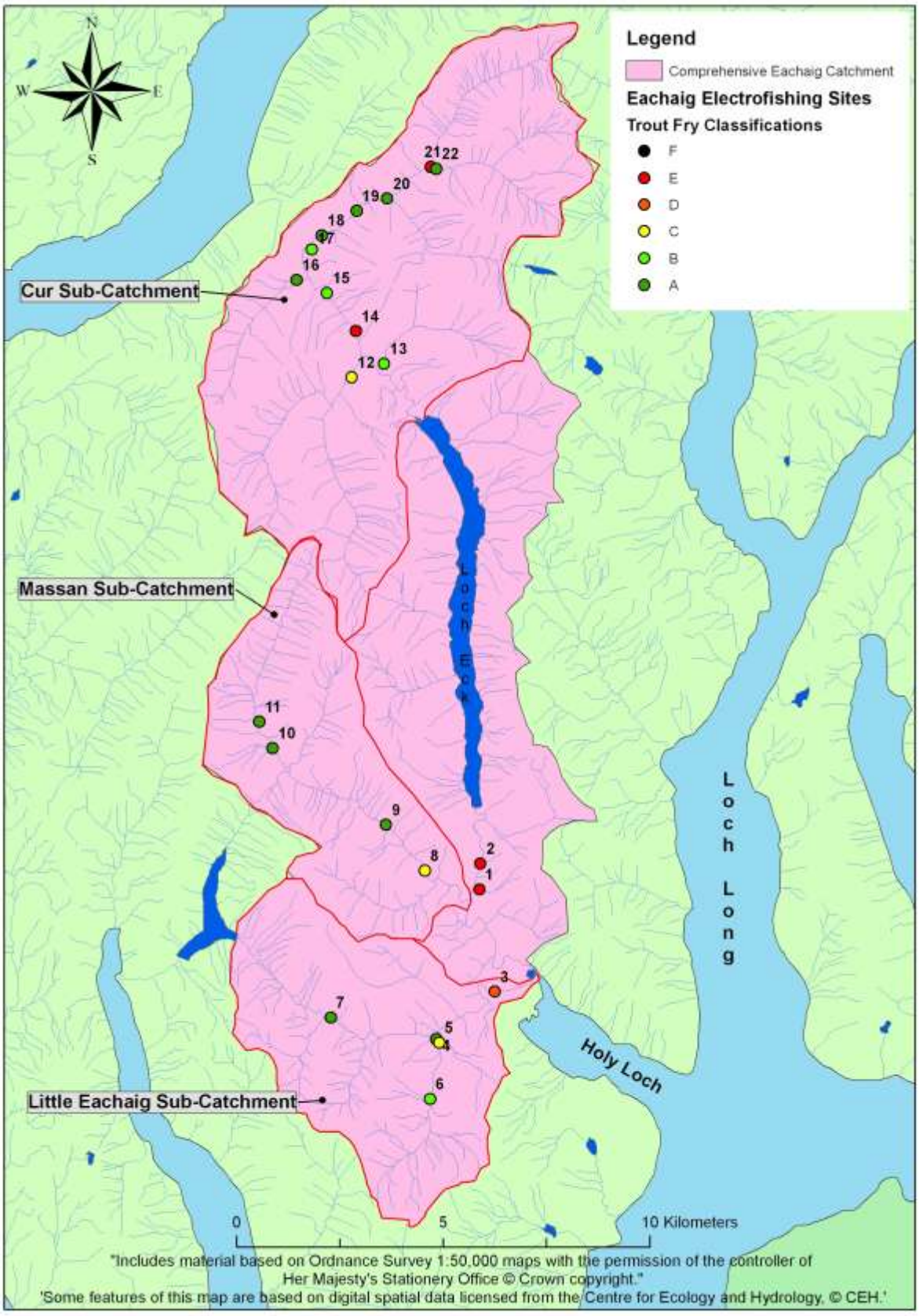

Figure 3.15 Eachaig catchment trout fry distribution and relative abundance (SFCC classification)

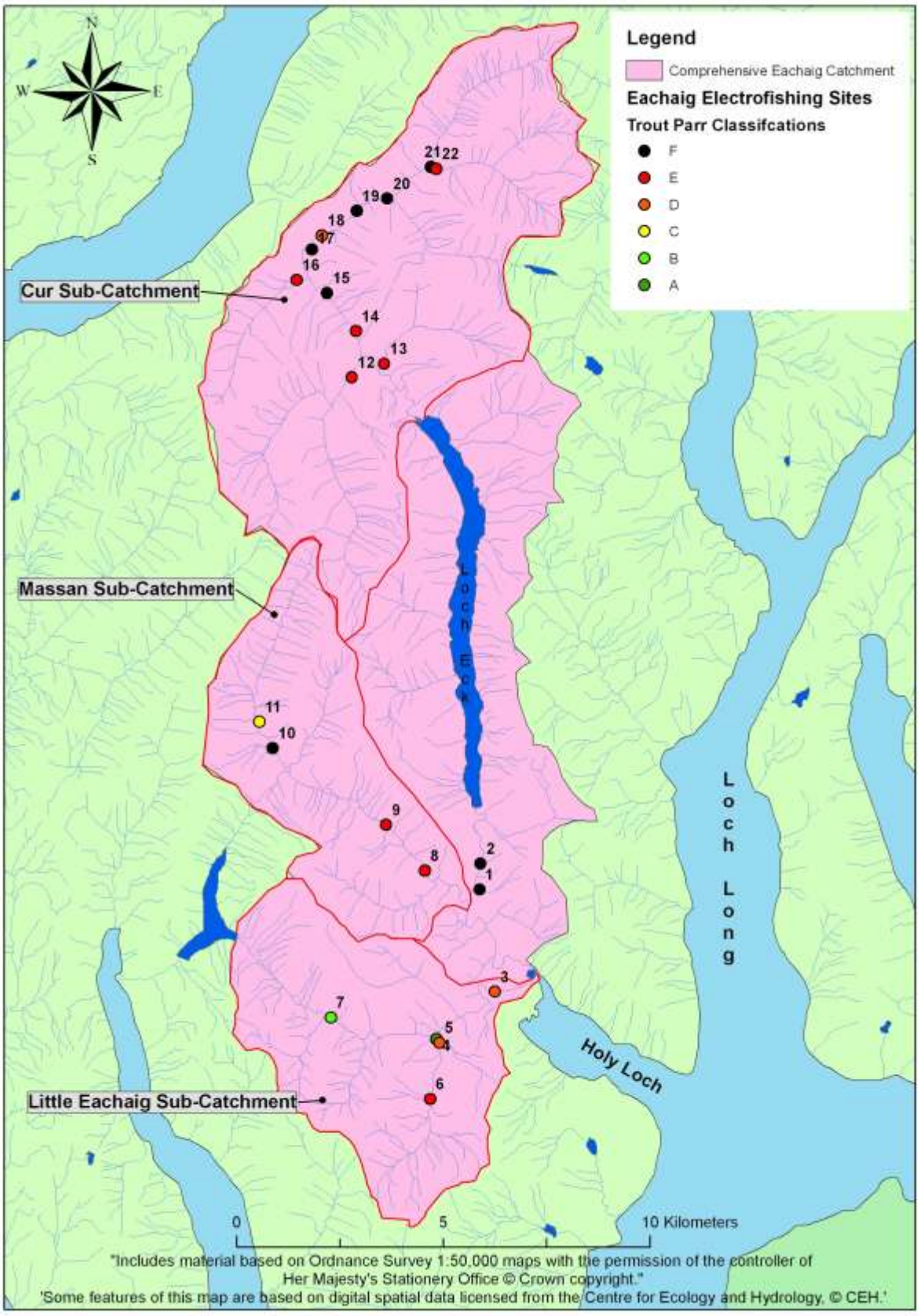

Figure 3.16 Eachaig catchment trout parr distribution and relative abundance (SFCC classification)

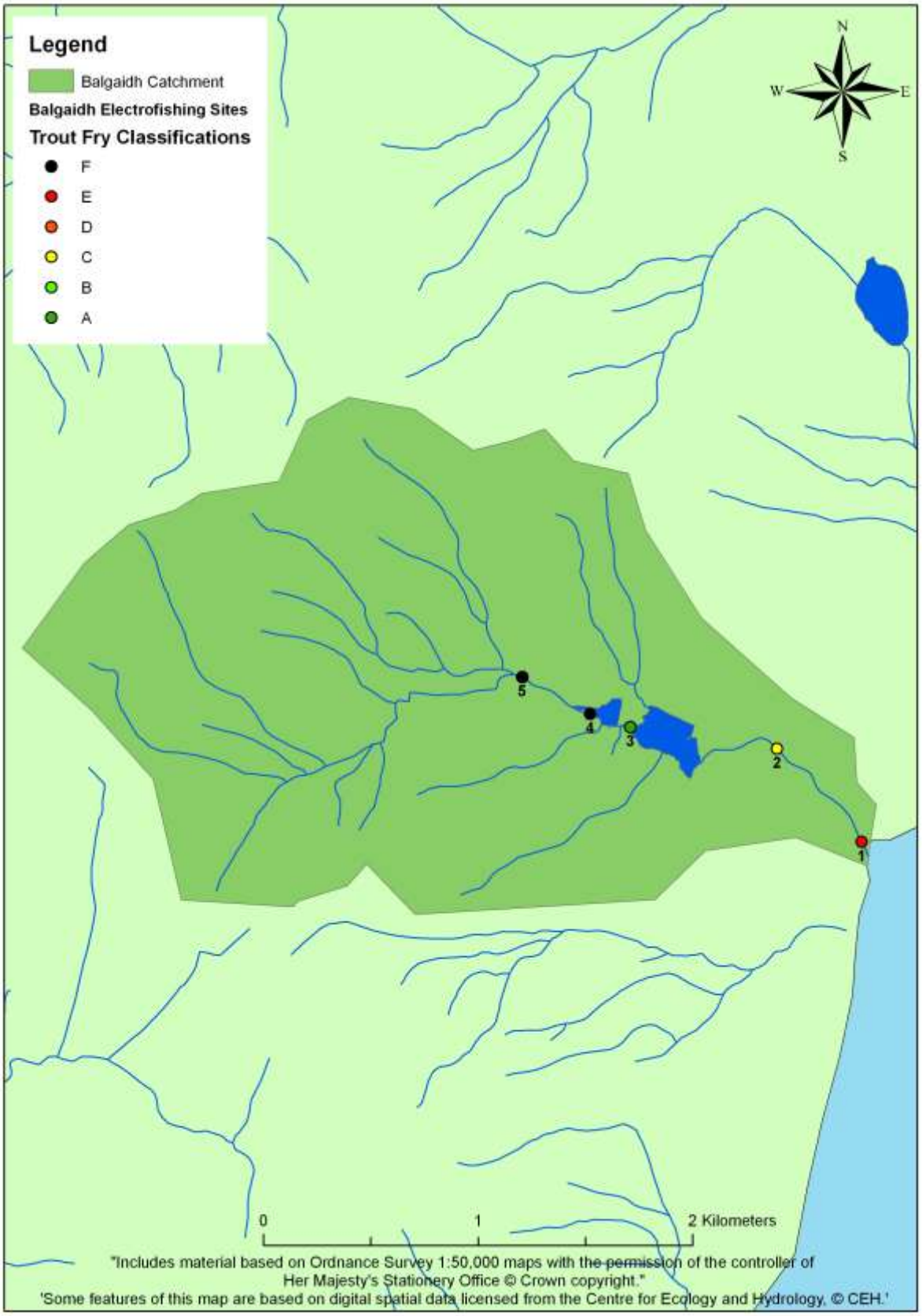

Figure 3.17 Lower Loch Long trout fry distribution and relative abundance (SFCC classification)

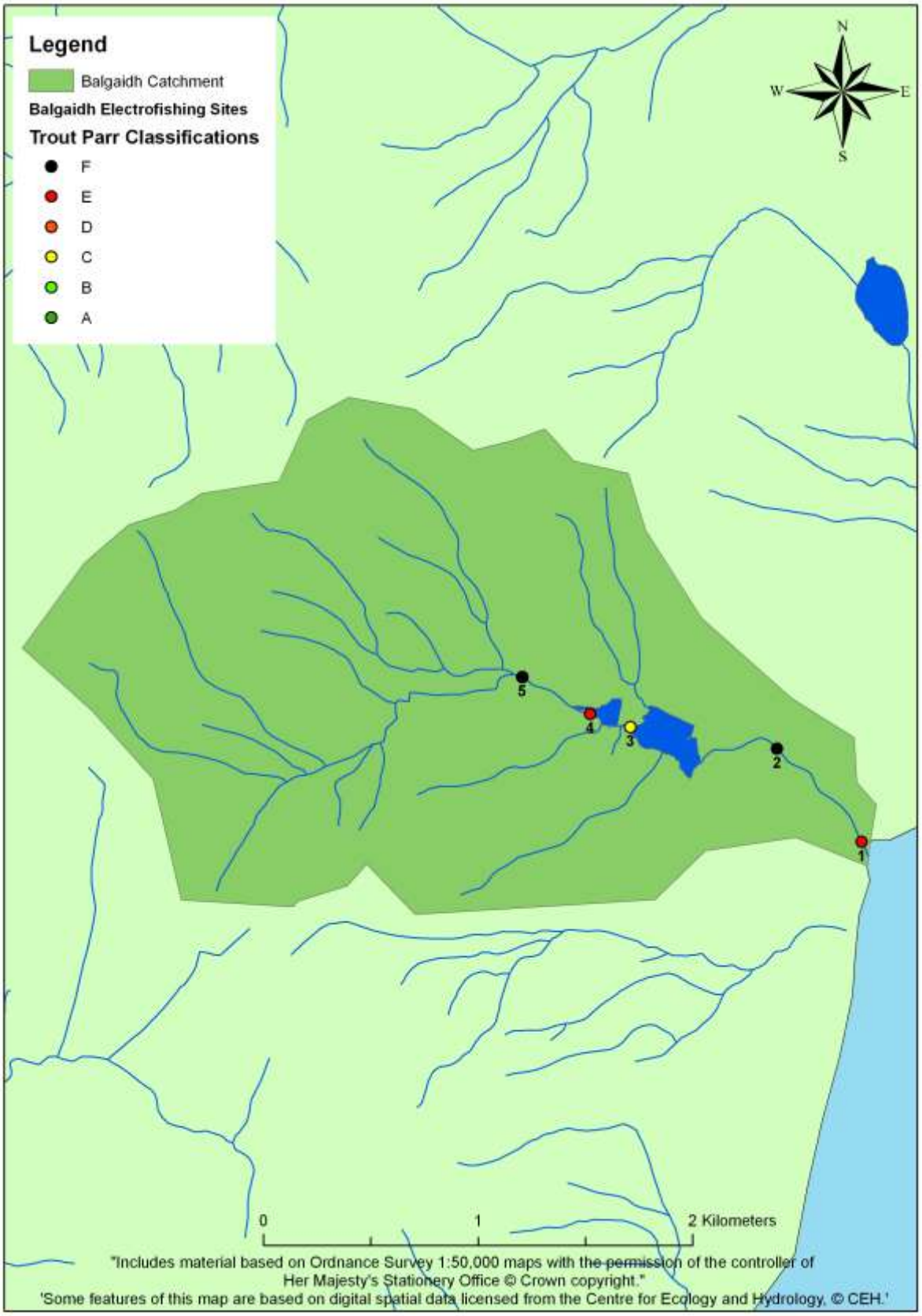

Figure 3.18 Lower Loch Long trout parr distribution and relative abundance (SFCC classification)

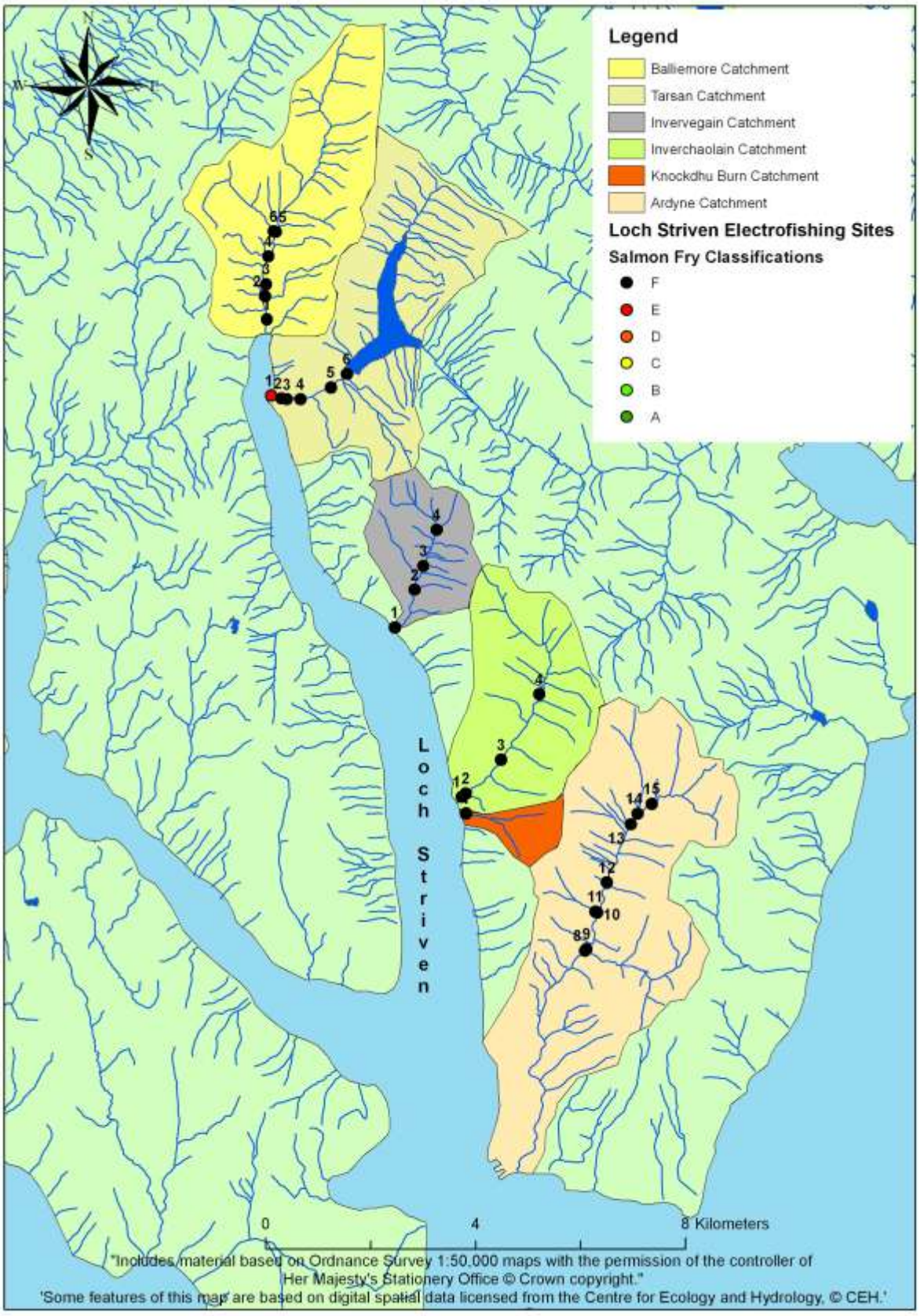

Figure 3.19 Loch Striven salmon fry distribution and relative abundance (SFCC classification)

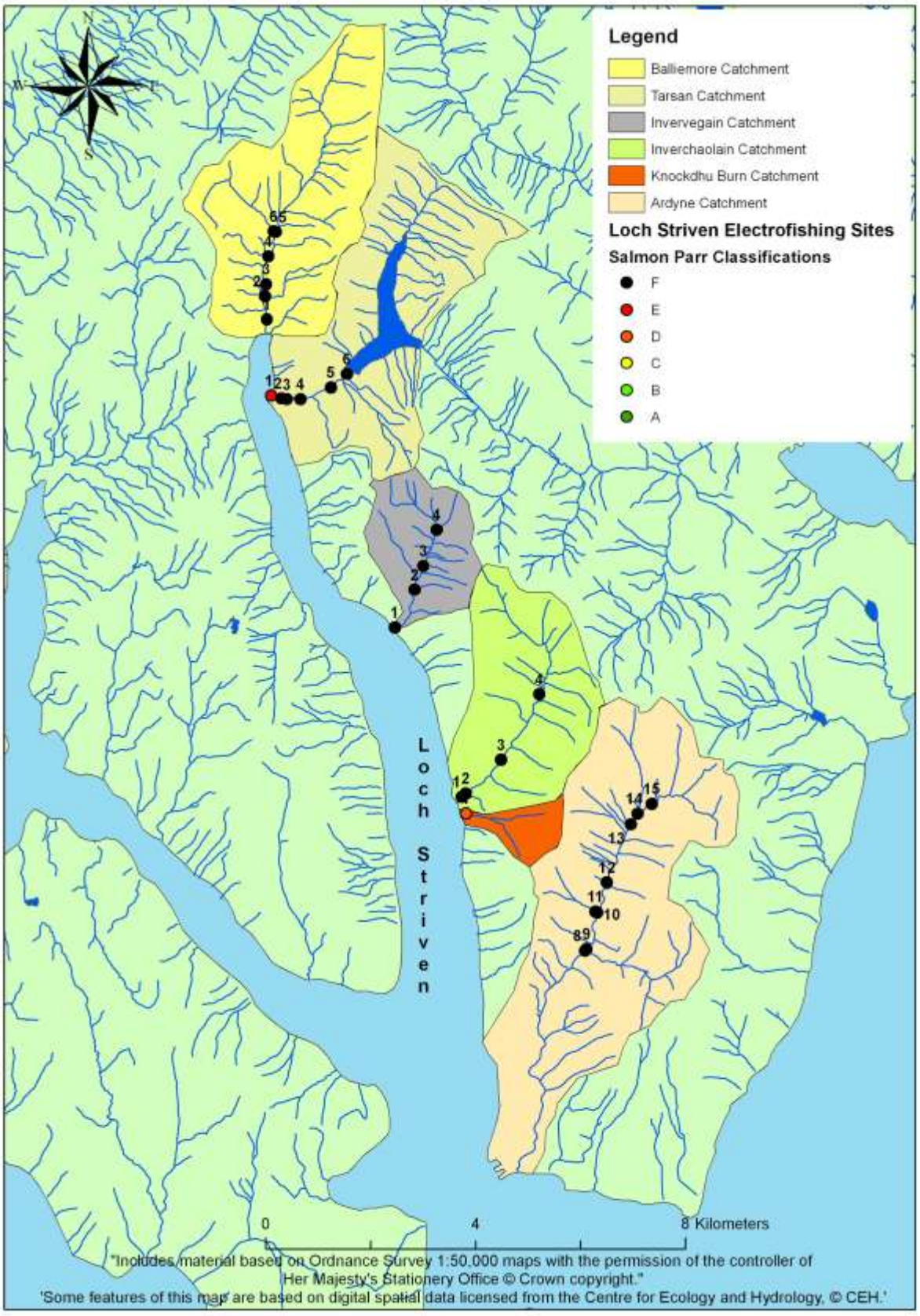

Figure 3.20 Loch Striven salmon parr distribution and relative abundance (SFCC classification)

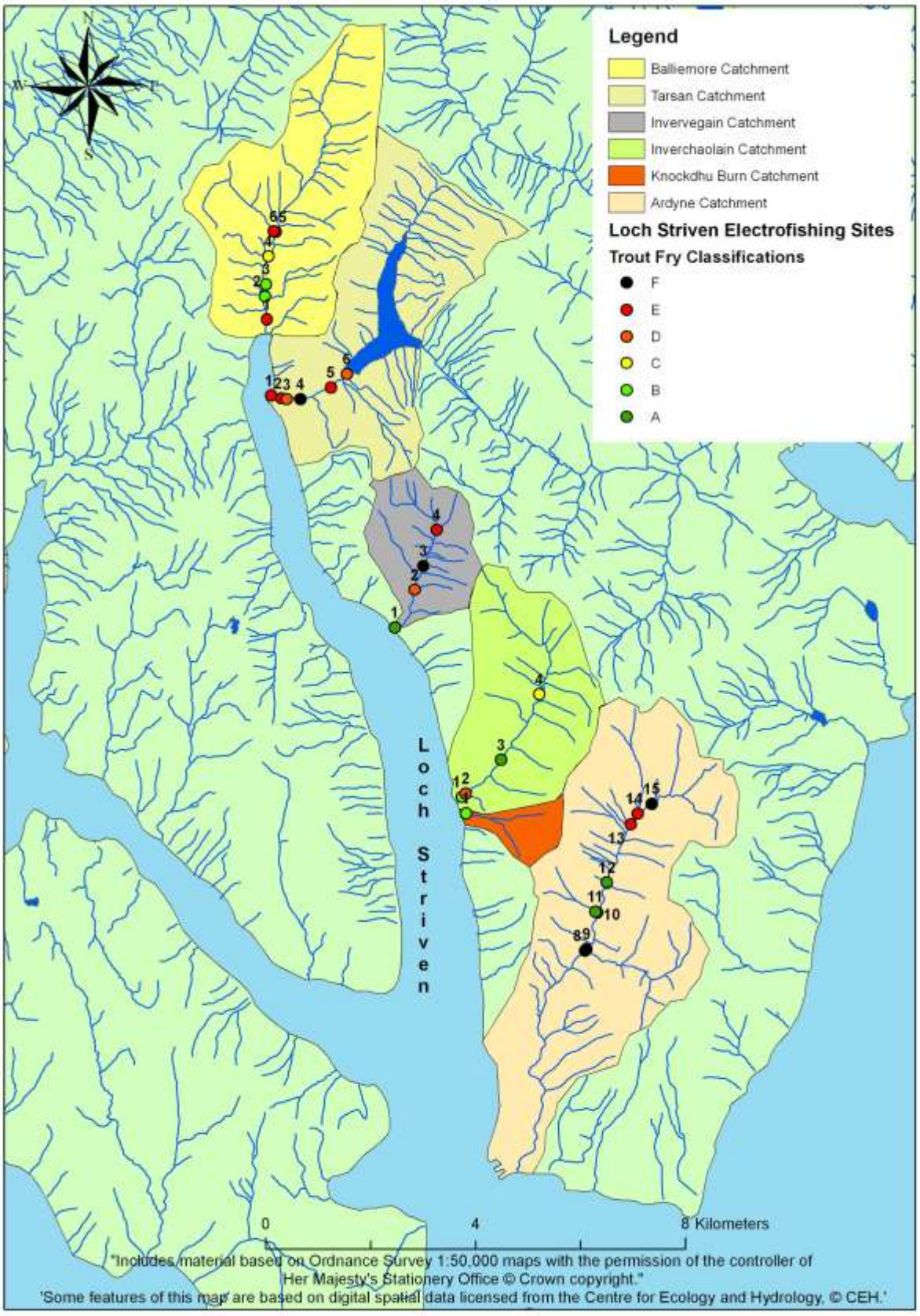

Figure 3.21 Loch Striven trout fry distribution and relative abundance (SFCC classification)

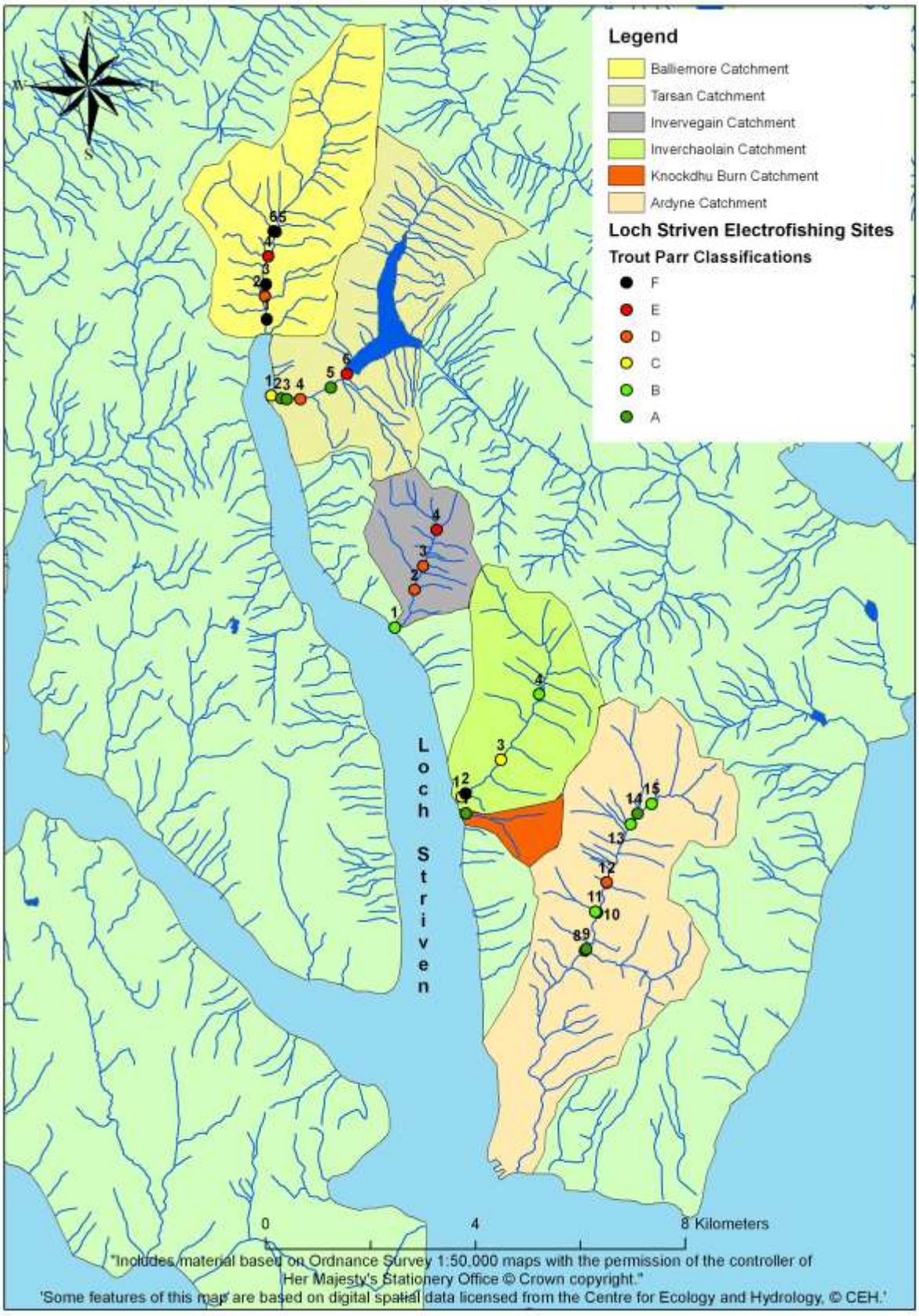

Figure 3.22 Loch Striven trout parr distribution and relative abundance (SFCC classification)

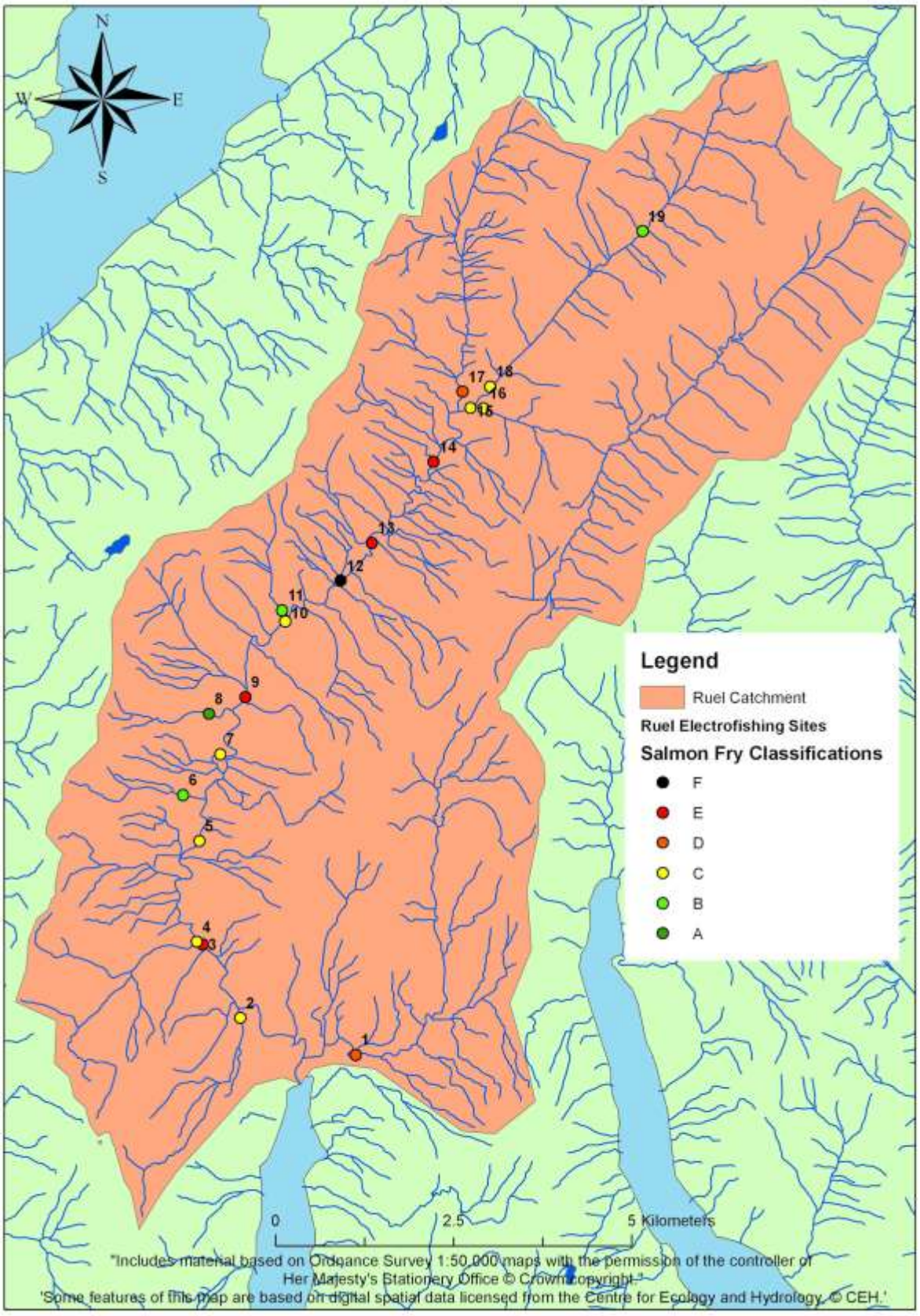

Figure 3.23 Loch Riddon salmon fry distribution and relative abundance (SFCC classification)

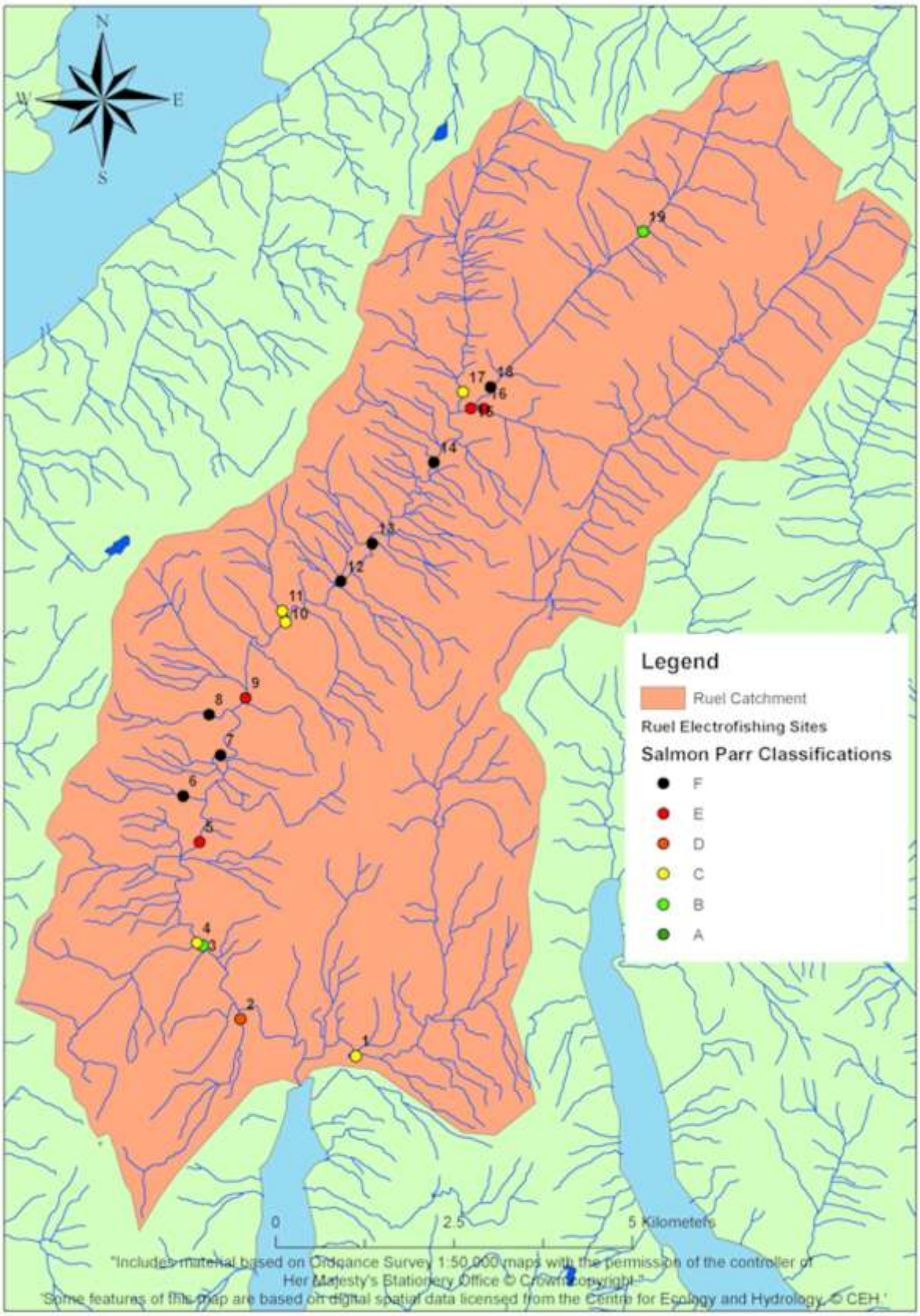

Figure 3.24 Loch Riddon salmon parr distribution and relative abundance (SFCC classification)

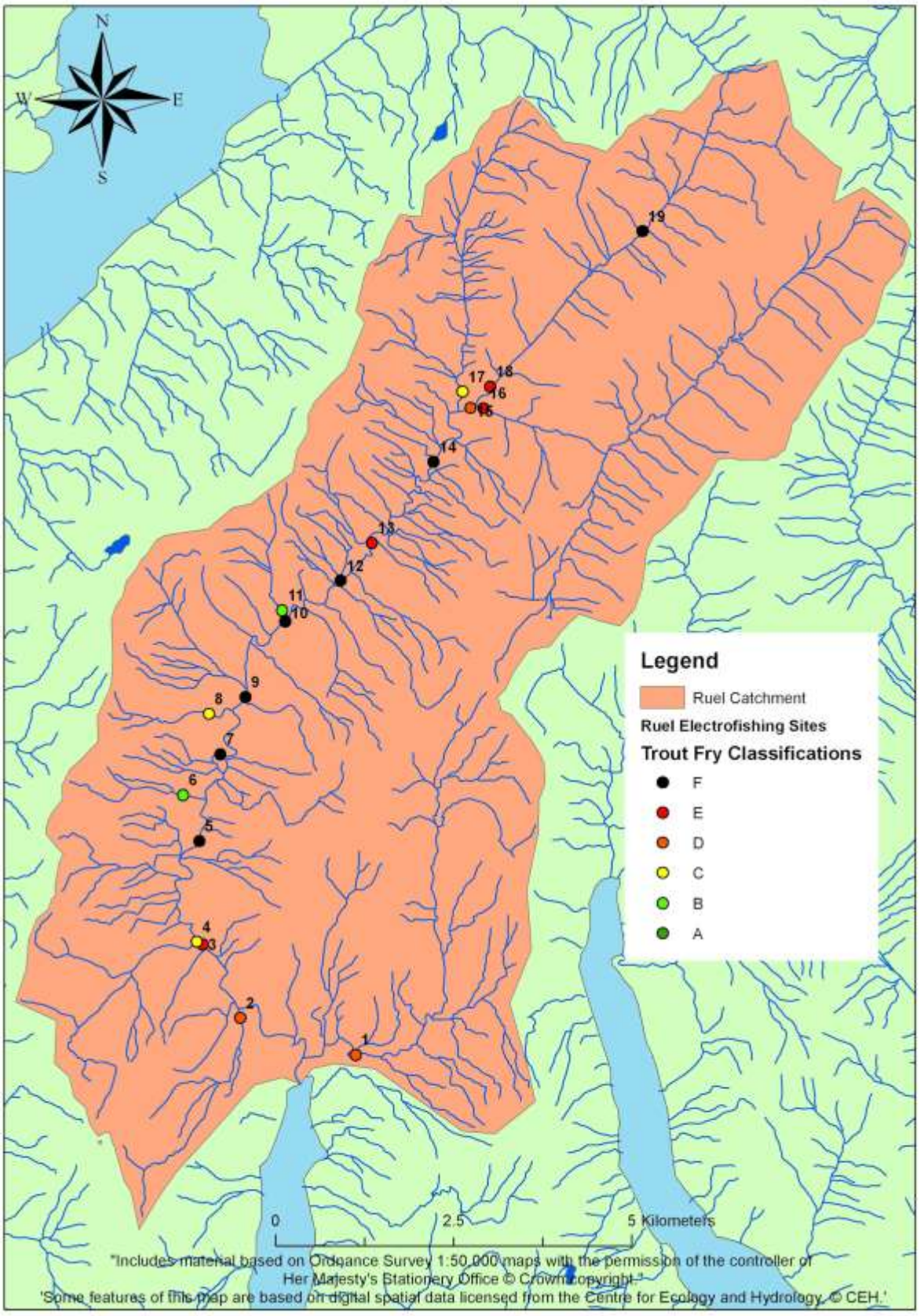

Figure 3.25 Loch Riddon trout fry distribution and relative abundance (SFCC classification)

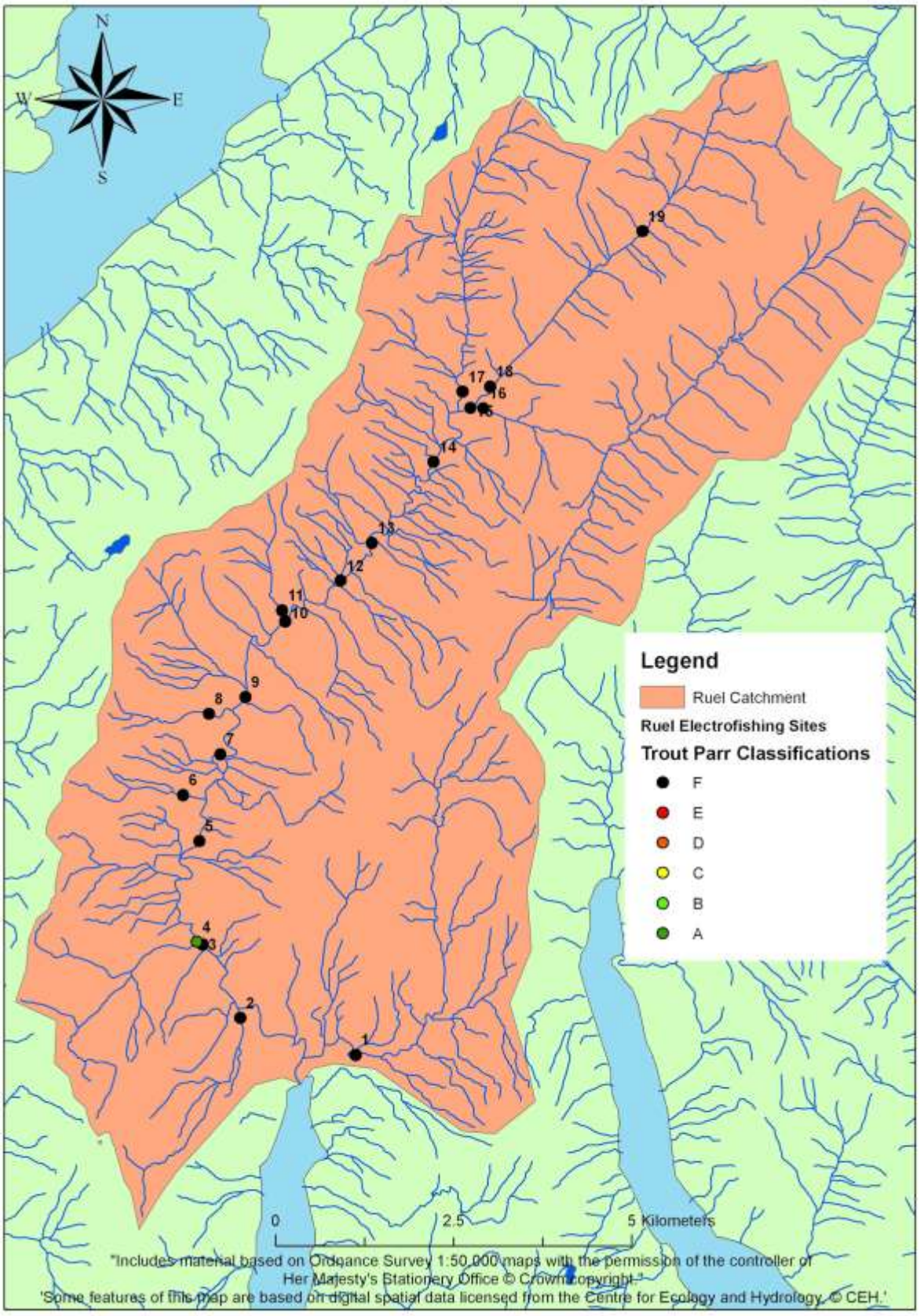

Figure 3.26 Loch Riddon trout parr distribution and relative abundance (SFCC classification)

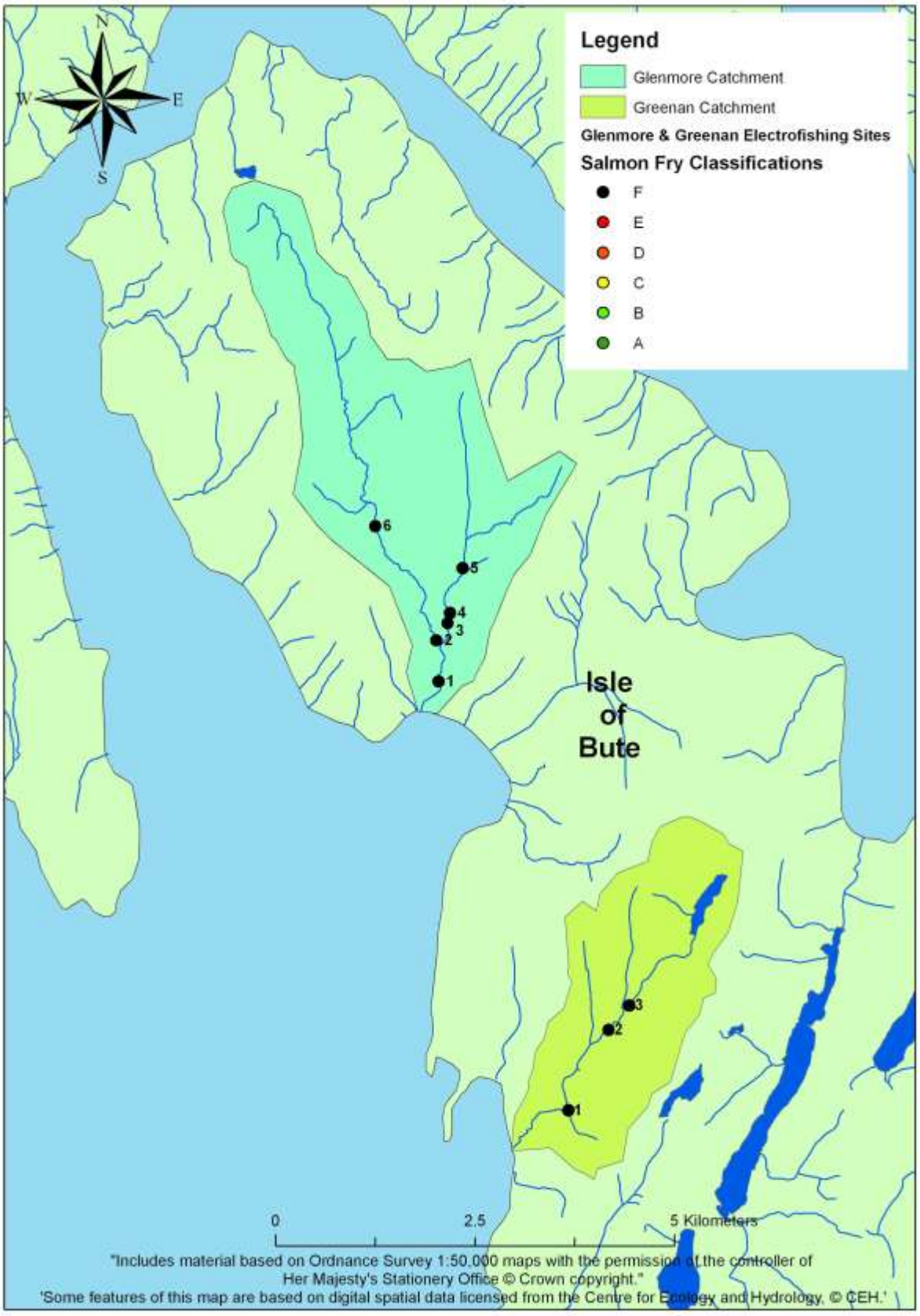

Figure 3.27 Isle of Bute salmon fry distribution and relative abundance (SFCC classification)

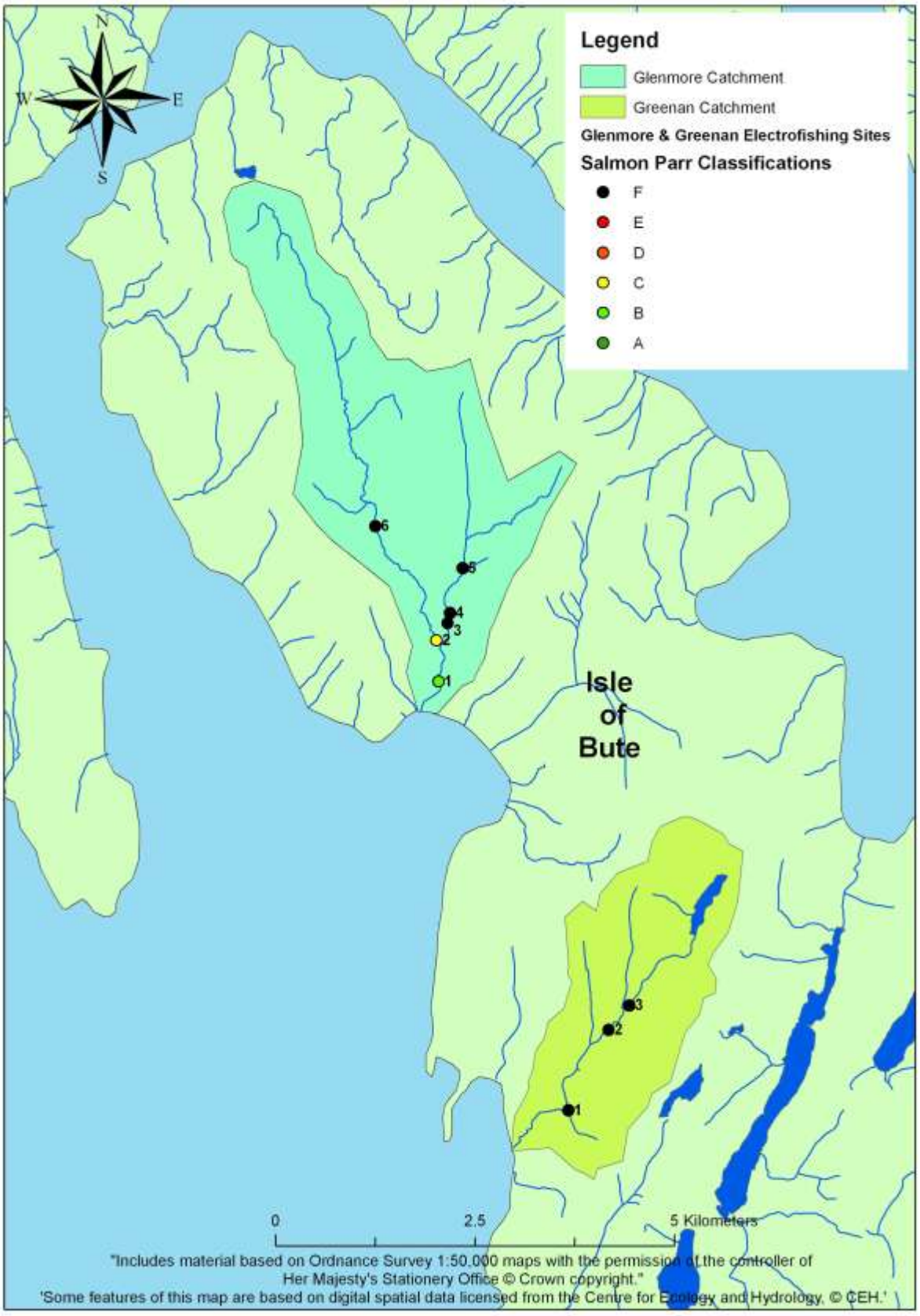

Figure 3.28 Isle of Bute salmon parr distribution and relative abundance (SFCC classification)

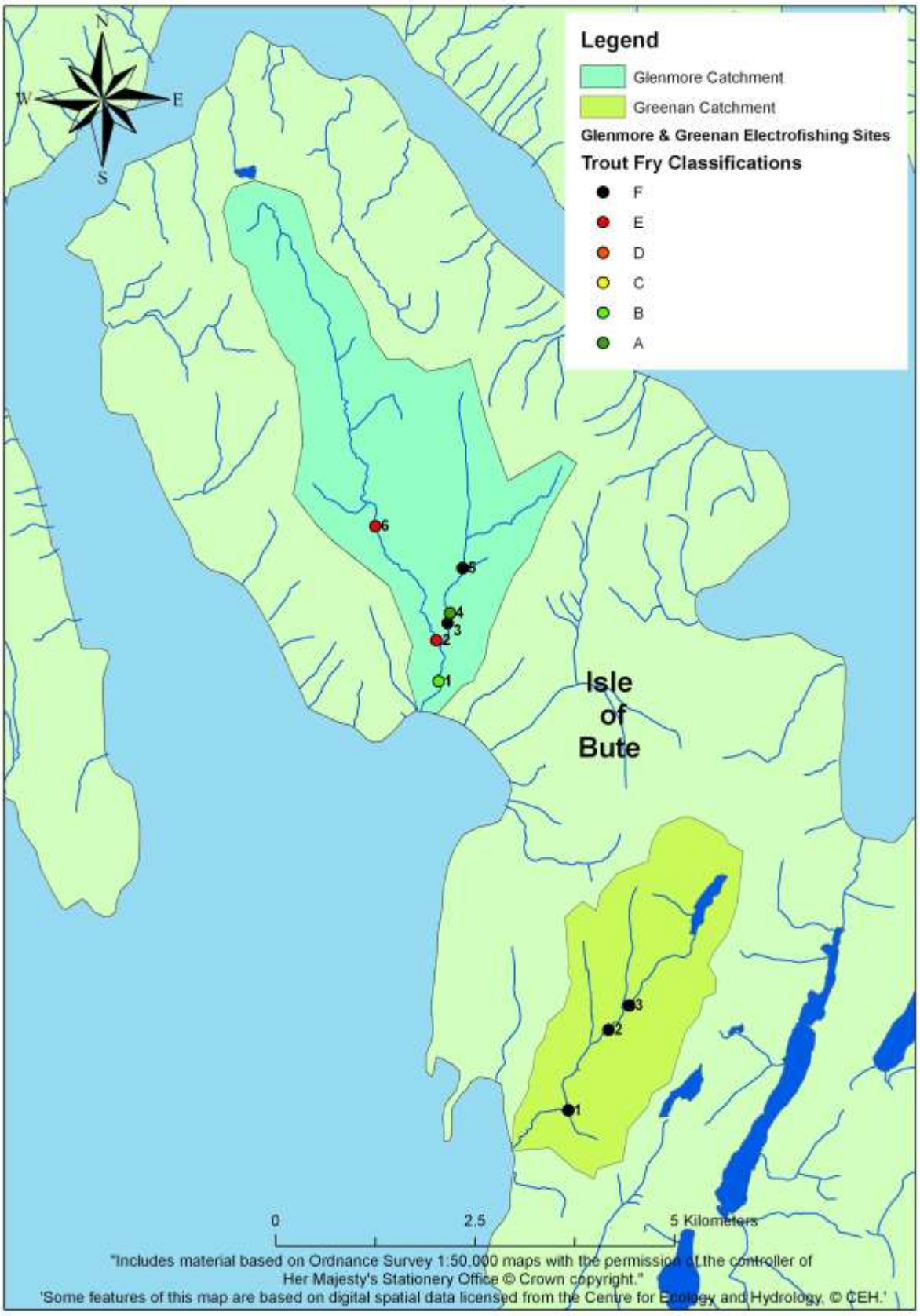

Figure 3.29 Isle of Bute trout fry distribution and relative abundance (SFCC classification)

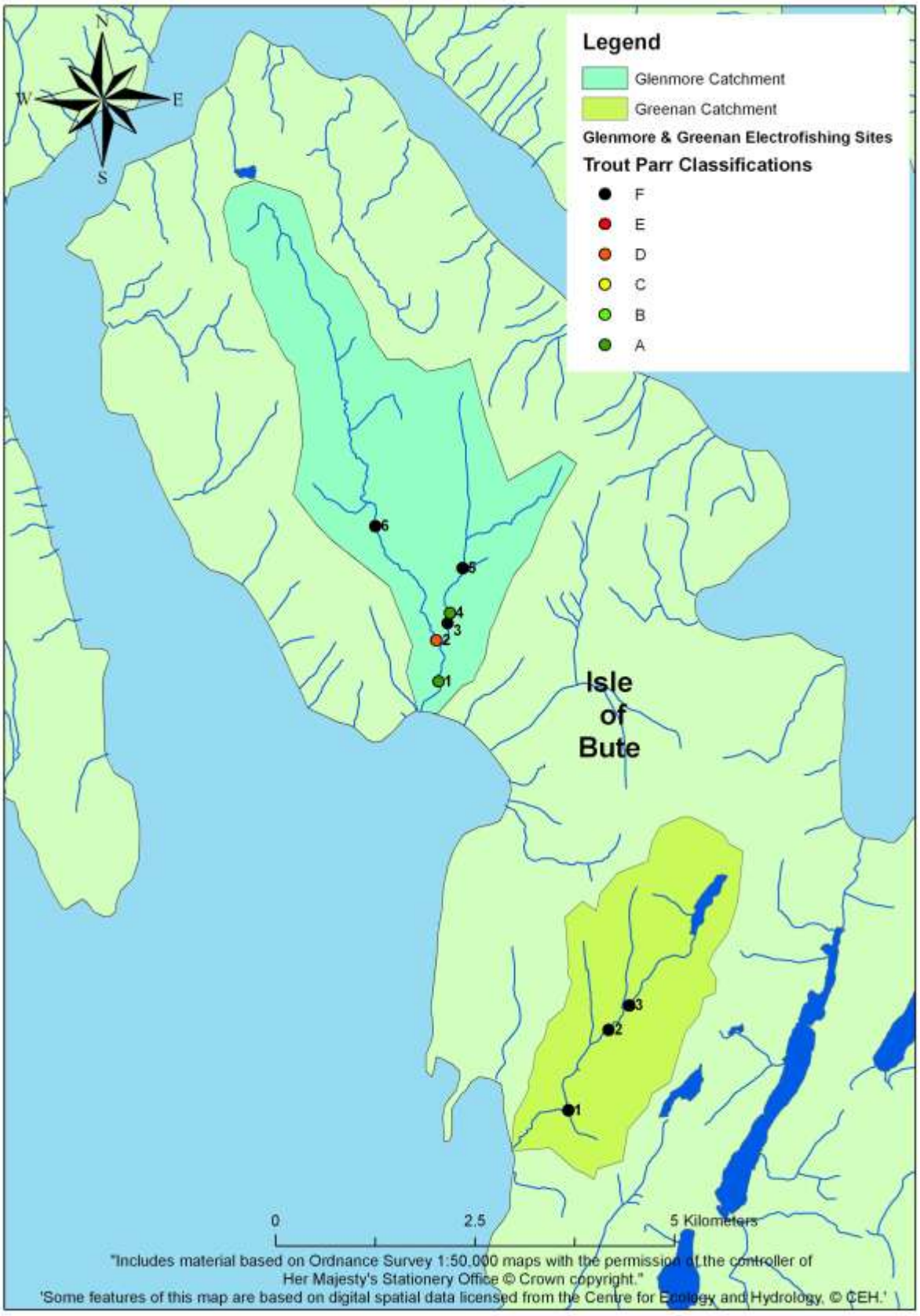

Figure 3.30 Isle of Bute trout parr distribution and relative abundance (SFCC classification)

3.1.3 Non-salmonid fish

The electrofishing surveys sampled European eels at 34 (24%) of sites. Flounder were sampled at 6 sites, 2 in the River Ruel, and one each in the Finart, the Litle Eachaig, the Balgaidh and the Balliemore. Three spine sticklebacks were sampled at 4 sites, one in the Eachaig and Glenmore catchments and two in the River Ruel. Lamprey ammocoetes (Lampetra spp.) were sampled at 9 sites, 4 in the Eachaig catchment, 2 sites in the Ruel and one each in the Loin Water, the Croe and the Finart (Table 3.3).

Table 3.3 Distribution of non-salmonid fish (no. of sites)

Catchment	No. sites	European Eel	Flounder	Lamprey spp.	Three-Spine Stickleback
Upper Loch Long					
Loin*	7	3		1	
Croe	7	1		1	
Loch Goil					
Goil	16				
Lettermay	3				
Carrick	2	1			
Loch Goil coastal	3				
Middle Loch Long					
Finart Burn*	11	3	1	1	
Eachaig Catchment					
Eachaig*	3	2		1	1
Little Eachaig*	6	2	1	1	
Massan*	5	1		1	
Cur*	12	3		1	
Lower Loch Long					
Balgaidh	5	2	1		
Coastal burns	4	2			
Loch Striven					
Ardyne	8				
Balliemore	6	1	1		
Inverchaolain	4				
Invervegain	4				
Tarsan	6	2			
Knockdhu Burn	1				
Loch Riddon					
Ruel (inc Auchenbreck)*	21	6	2	2	2
Bute					
Glenmore	6	3			1
Greenan	3	2			
Totals	**143**	**34**	**6**	**9**	4

* includes lamprey e-fish sites

3.2 Habitat survey

Approximately 90.15km of stream were surveyed in 304 survey sections (generally of 250m) in 18 catchments (Table 3.4).

Table 3.4 Habitat survey coverage

Catchment	No. sections	Survey Length (km)
Upper Loch Long		
Loin	10	2.5
Croe	27	6.75
Loch Goil		
Goil	19	4.75
Lettermay	3	0.6
Carrick	2	0.5
Middle Loch Long		
Finart Burn	8	4
Eachaig Catchment		
Eachaig	25	6.35
Little Eachaig	19	4.75
Massan	36	9.15
Cur	38	9.5
Lower Loch Long		
Balgaidh	7	1.7
Loch Striven		
Ardyne	34	8.5
Balliemore	12	2.8
Inverchaolain	16	3.9
Invervegain	2	0.5
Tarsan	3	0.75
Loch Riddon		
Ruel (inc Auchenbreck)	36	21.4
Bute		
Glenmore	7	1.75
Totals	**304**	**90.15**

3.2.1 Distribution and status of key habitats

The location and status of 163 significant obstacles, 375 adult fish holding pools and 285 spawning sites recorded in the surveys are described below.

3.2.1.1 Obstacles to fish passage

A total of 163 significant obstacles to fish passage were recorded during the surveys (Table 3.5). The number of obstacles recorded in each catchment ranged from 1 in the Eachaig to 18 in the Balgaidh and Inverchaolain systems. Natural bedrock waterfalls were the most common type of the 114 (70%) natural obstacles identified. The survey also identified 49 (30%) man-made obstacles that were a mixture of bridge aprons, weirs and fishing pool modifications. A total of 140 (86%) of the obstacles recorded were adjudged to be potentially passable and a further 19 to be impassable to migratory salmonids. The potential passability of a further 4 other obstacles were not confidently assigned.

Table 3.5 Obstacles survey results (no. of obstacles)

Catchment	No. of obstacles	Man-Made	Natural	Passable	Unsure	Not Passable
Upper Loch Long						
Loin	5	2	3	4	0	1
Croe	11	0	11	10	0	1
Loch Goil						
Goil	6	2	4	4	1	1
Lettermay	3	1	2	2	0	1
Carrick	4	1	3	3	0	1
Middle Loch Long						
Finart Burn	11	10	1	11	0	0
Eachaig Catchment						
Eachaig	1	0	1	1	0	0
Little Eachaig	10	0	10	8	2	0
Massan	11	0	11	10	1	0
Cur	12	0	12	9	0	3
Lower Loch Long						
Balgaidh	18	8	10	17	0	1
Loch Striven						
Ardyne	15	4	11	15	0	0
Balliemore	8	6	2	6	0	2
Inverchaolain	18	1	17	17	0	1
Invervegain	7	3	4	5	0	2
Tarsan	7	6	1	5	0	2
Loch Riddon						
Ruel (inc Auchenbreck)	7	4	3	6	0	1
Bute						
Glenmore	9	1	8	7	0	2
Totals	**163**	**49**	**114**	**140**	**4**	**19**

3.2.1.1 Adult holding pools

A total of 375 significant adult fish holding pools was recorded during the surveys (Table 3.6). The number of pools recorded in each catchment range from 2 in the Carrick Burn to 66 in the River Ruel. A total of 179 pools (48%) were assessed as being sub-optimal with the remaining 185 (52%) assessed as being optimal.

Table 3.6 Adult holding pools results

Catchment	No. Pools	Sub optimal	Optimal	Primary cover	Secondary cover	Pool Area (m^2)
Upper Loch Long						
Loin	3	2	1	Depth / Canopy	Bank	445
Croe	21	12	9	Depth	Canopy / Bank	1973
Loch Goil						
Goil	21	17	4	Depth	Bank	3507
Lettermay	4	3	1	Depth	Canopy	219
Carrick	2	2	0	Depth	Canopy / Bank	38
Middle Loch Long						
Finart Burn	18	6	12	Depth	Canopy	3130
Eachaig Catchment						
Eachaig	23	5	17	Depth	Canopy	19950
Little Eachaig	28	8	20	Depth	Canopy / Bank	4970
Massan	56	23	30	Depth	Bank	8450
Cur	20	10	10	Depth	Canopy	7760
Lower Loch Long						
Balgaidh	13	7	6	Depth	Canopy	639
Loch Striven						
Ardyne	37	22	13	Depth	Canopy / Bank	1782
Balliemore	20	13	7	Depth	Canopy	1282
Inverchaolain	19	16	3	Depth	Bank	576
Invervegain	6	5	1	Canopy / Bank	Depth	196
Tarsan	4	2	2	Depth	Canopy	196
Loch Riddon						
Ruel (inc Auchenbreck)	66	20	41	Depth	Canopy / Bank	17080
Bute						
Glenmore	14	6	8	Depth	Canopy	445
Totals	**375**	**179**	**185**			**72638**

The predominant type of cover available to fish was the depth of water and from boulders within the pools, with bankside vegetation or the overhang tree canopy providing additional cover. The area of pool habitat potentially available ranged from 38m² in the Carrick Burn to 19950m^2 in the River Eachaig.

3.2.1.1 Spawning sites

A total of 285 significant salmonid fish spawning sites was recorded during the surveys (Table 3.7). The number of sites recorded in each catchment range from 1 in the Lettermay Burn to 41 in the River Ruel. The area of potential spawning habitat recorded in each catchment ranged between being abundant in the River Eachaig (2400m^2) and River Ruel (1186m²), relatively moderate abundance in the River Finart (468m²) and the Little Eachaig (439m²) to low abundance in the Lettermay (6m² site) and Carrick (16m²) catchments. A total of 167 (59%) sites were identified as being sub-optimal with the remaining 99 (41%) as having optimal conditions.

The predominant type of spawning habitat available in most catchments was for both salmon and for trout (moderate size of substrates) with the exception of the catchments in Loch Striven which had predominantly smaller spawning substrates suitable mainly for trout. Habitat features associated with spawning sites were mostly pools and braids, along with other features such as fords and bends in the river channel.

Table 3.7 Significant salmonid spawning sites

Catchment	No. sites	Total area (m²)	Sub-optimal	Optimal	Predominant suitability	Predominant features
Upper Loch Long						
Loin	8	60	4	4	Trout	Ford
Croe	14	282	7	7	Trout / Salmon	Ford / Pool
Loch Goil						
Goil	22	2182	16	6	Salmon	Braid
Lettermay	1	6	1	0	Trout	Bend
Carrick	4	16	4	0	Salmon	Braid / Pool
Middle Loch Long						
Finart Burn	17	468	6	10	Trout / Salmon	Braid / Pool
Eachaig Catchment						
Eachaig	29	2400	4	16	Salmon	Braid / Pool
Little Eachaig	13	439	7	6	Trout / Salmon	Braid / Pool
Massan	31	804	14	11	Salmon	Pool
Cur	28	1168	21	5	Salmon	Braid
Lower Loch Long						
Balgaidh	6	317	6	0	Trout	
Loch Striven						
Ardyne	18	631	11	6	Trout	Pool
Balliemore	18	865	12	6	Trout	Pool
Inverchaolain	15	551	11	4	Trout	Braid
Invervegain	2	28	2	0	Trout	
Tarsan	2	27	2	0	Trout	
Loch Riddon						
Ruel (inc Auchenbreck)	41	1186	27	14	Trout	Ford / Island
Bute						
Glenmore	16	71	12	4	Trout	Pool
Totals	**285**	**11501**	**167**	**99**		

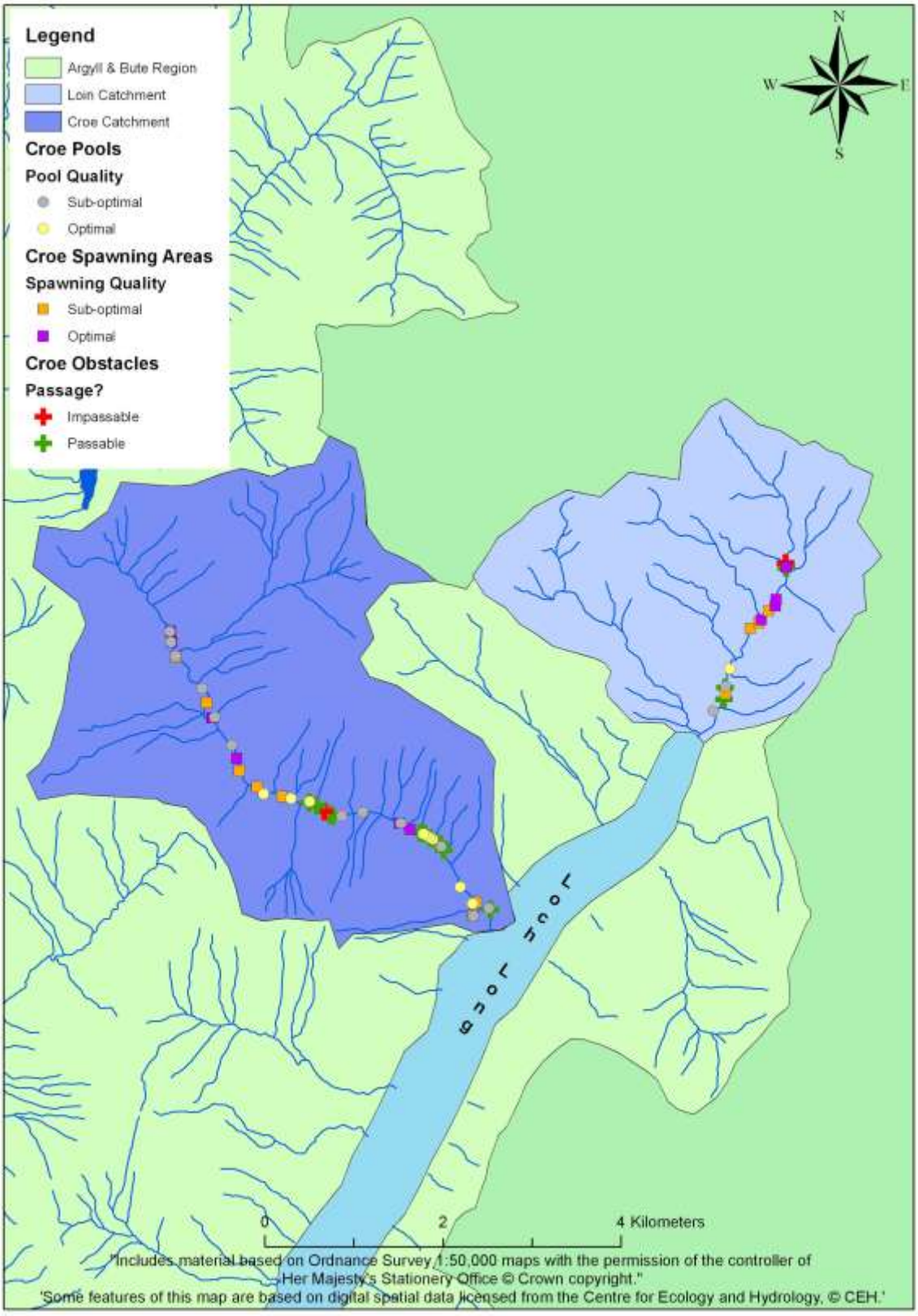

Figure 3.31 Distribution of obstacles ,adult holding pools and spawning areas in the Upper Loch Long catchments

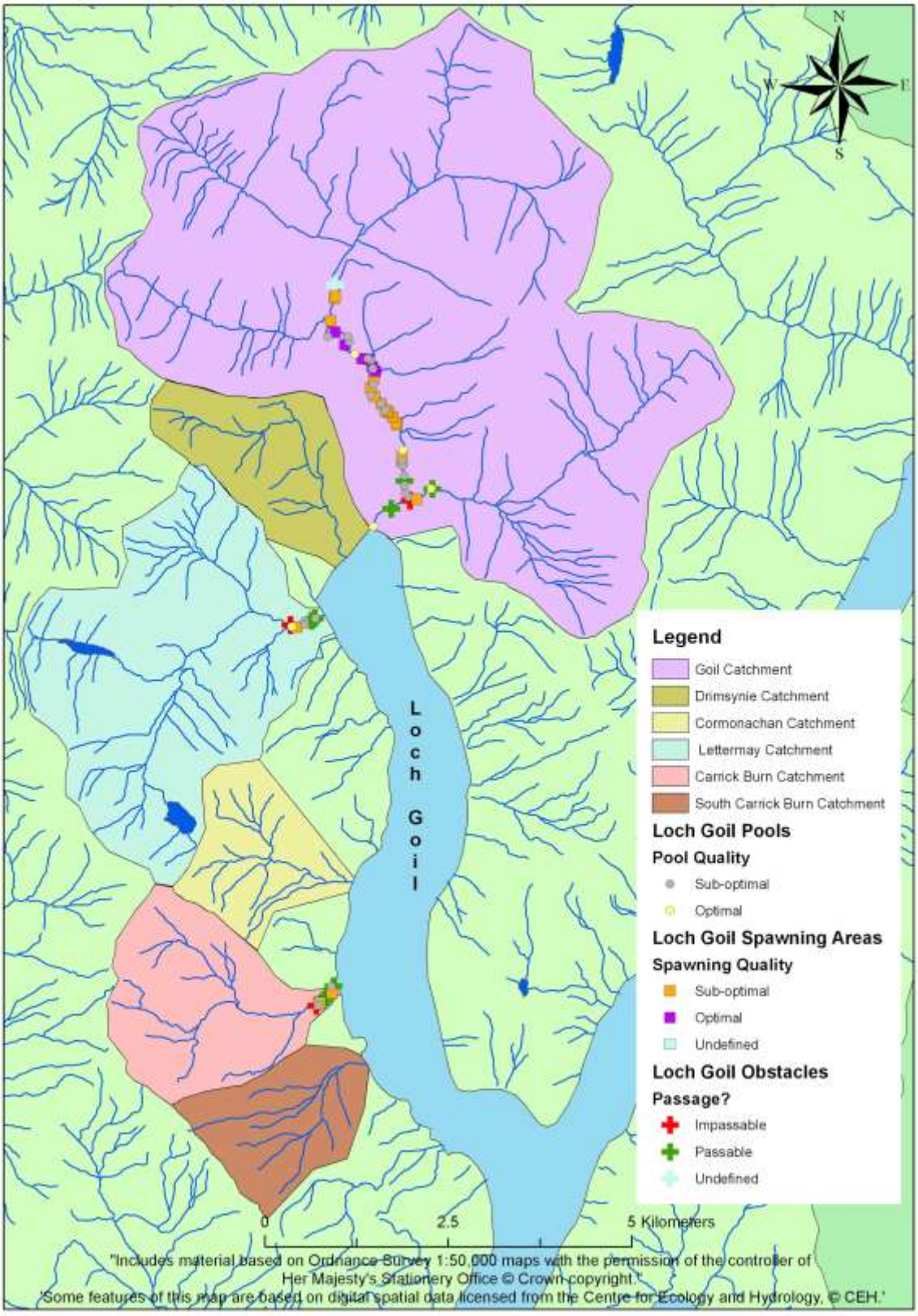

Figure 3.32 Distribution of obstacles ,adult holding pools and spawning areas in the Loch Goil catchments

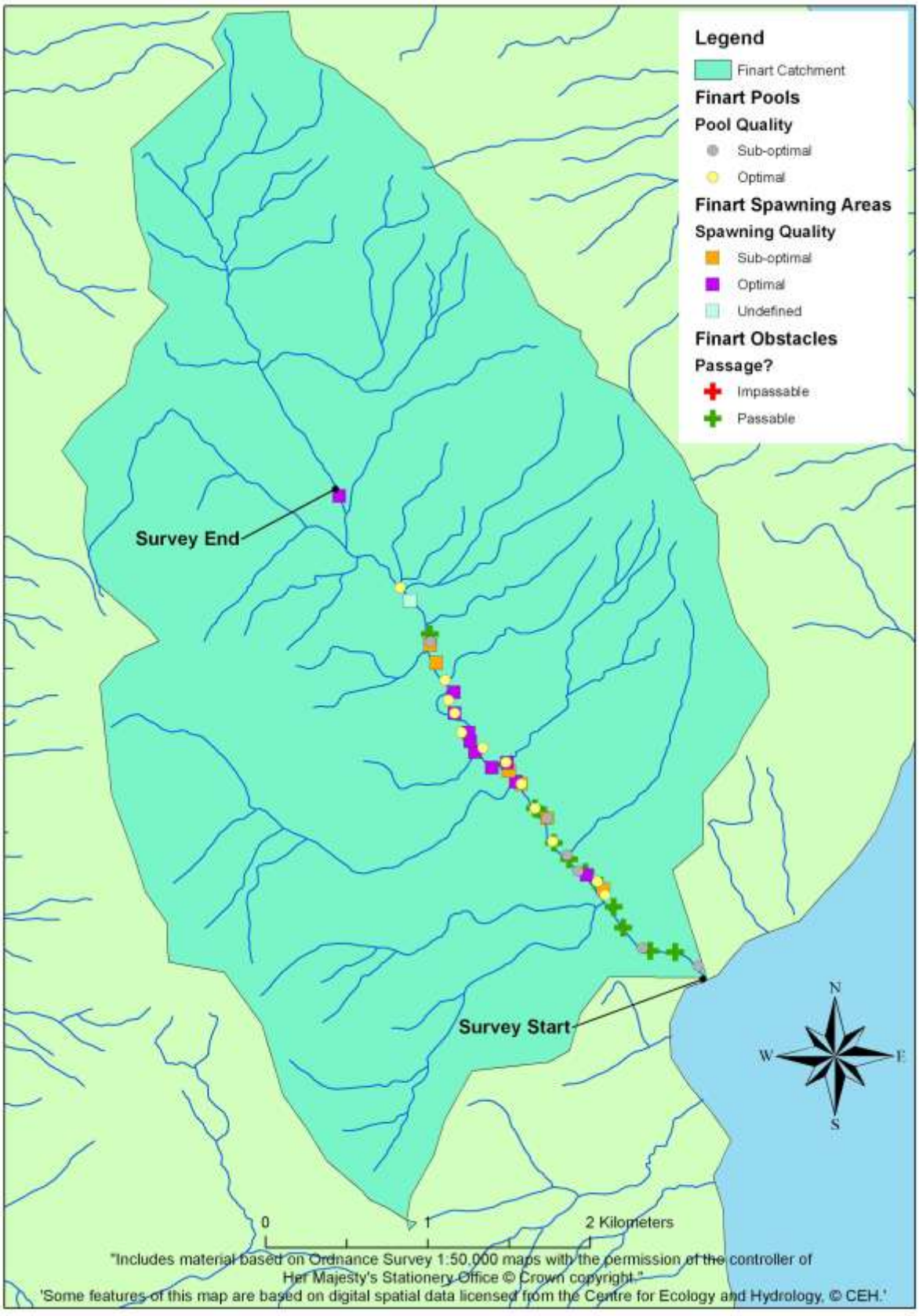

Figure 3.33 Distribution of obstacles ,adult holding pools and spawning areas in Middle Loch Long

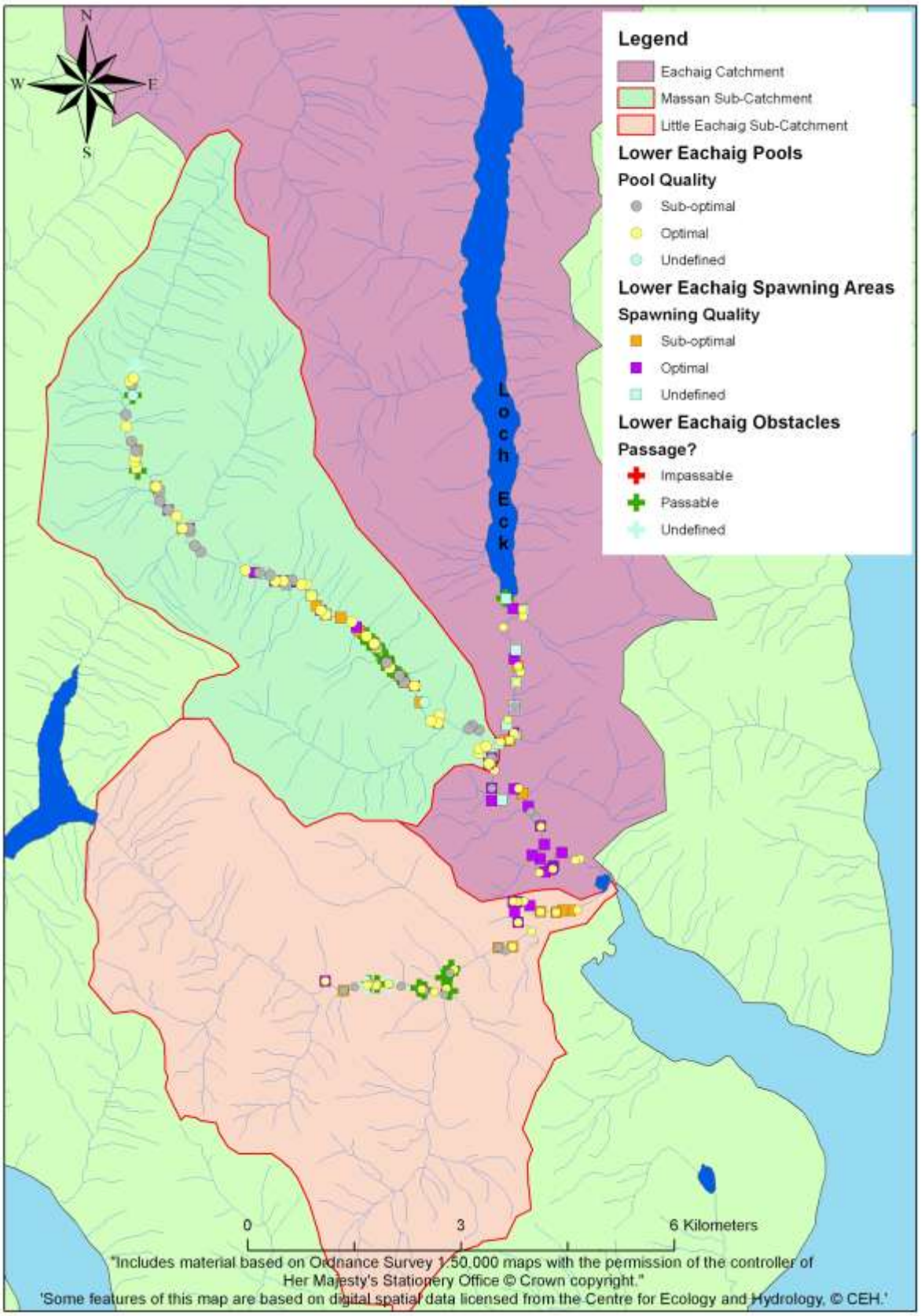

Figure 3.34 Distribution of obstacles ,adult holding pools and spawning areas in the lower Eachaig catchments

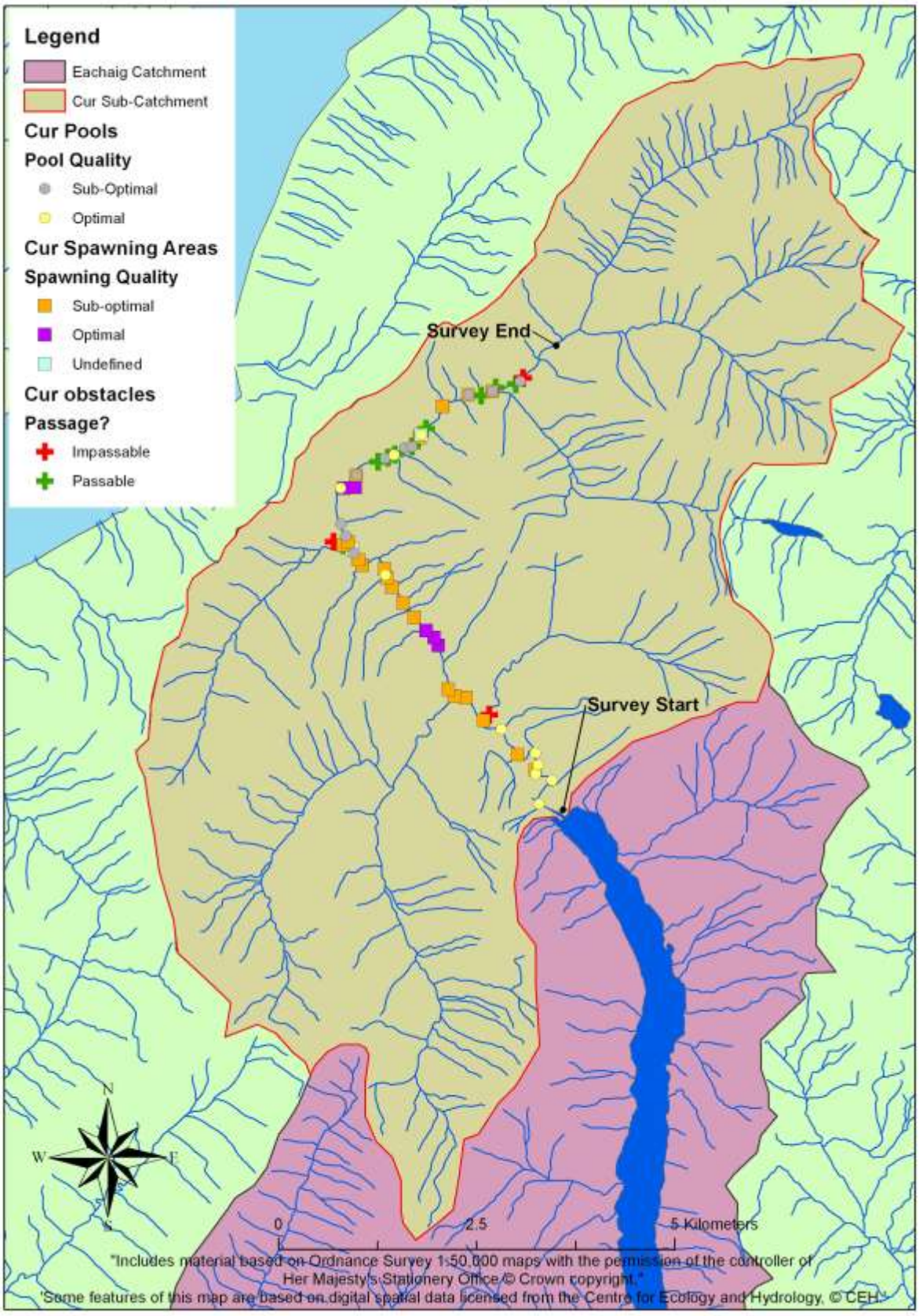

Figure 3.35 Distribution of obstacles ,adult holding pools and spawning areas in the upper Eachaig catchment

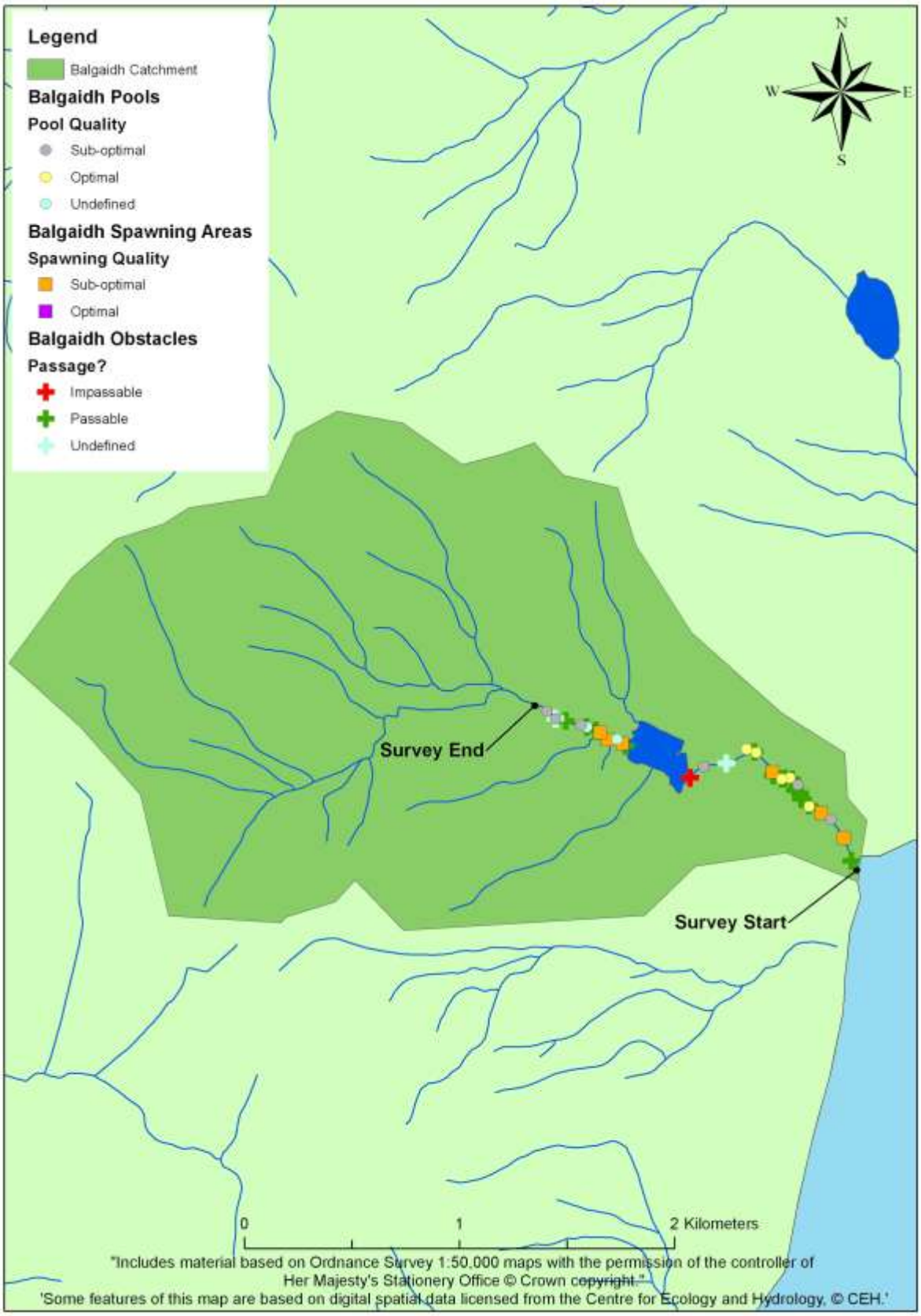

Figure 3.36 Distribution of obstacles, adult holding pools and spawning areas in Lower Loch Long

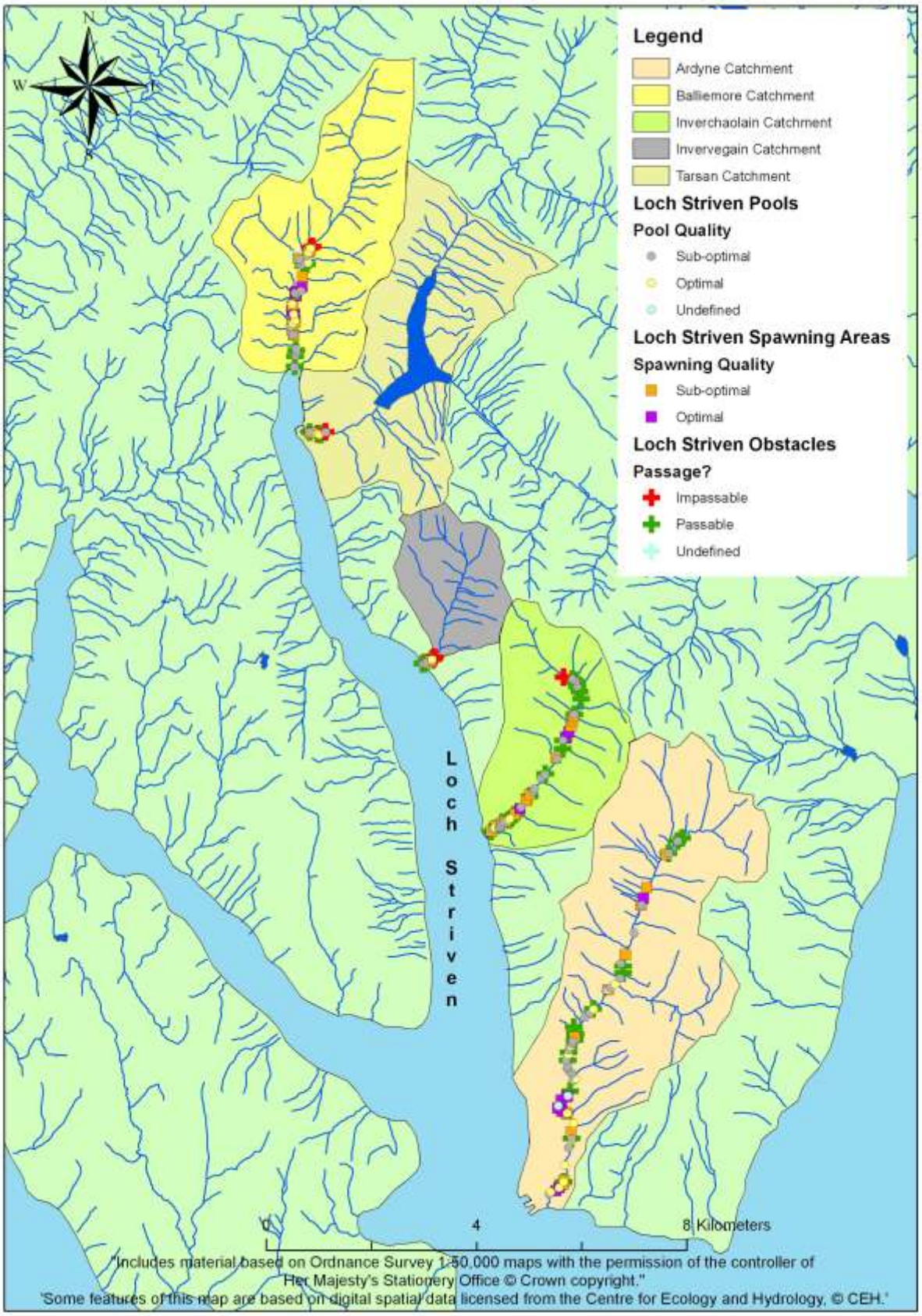

Figure 3.37 Distribution of obstacles, adult holding pools and spawning areas in the Loch Striven catchments

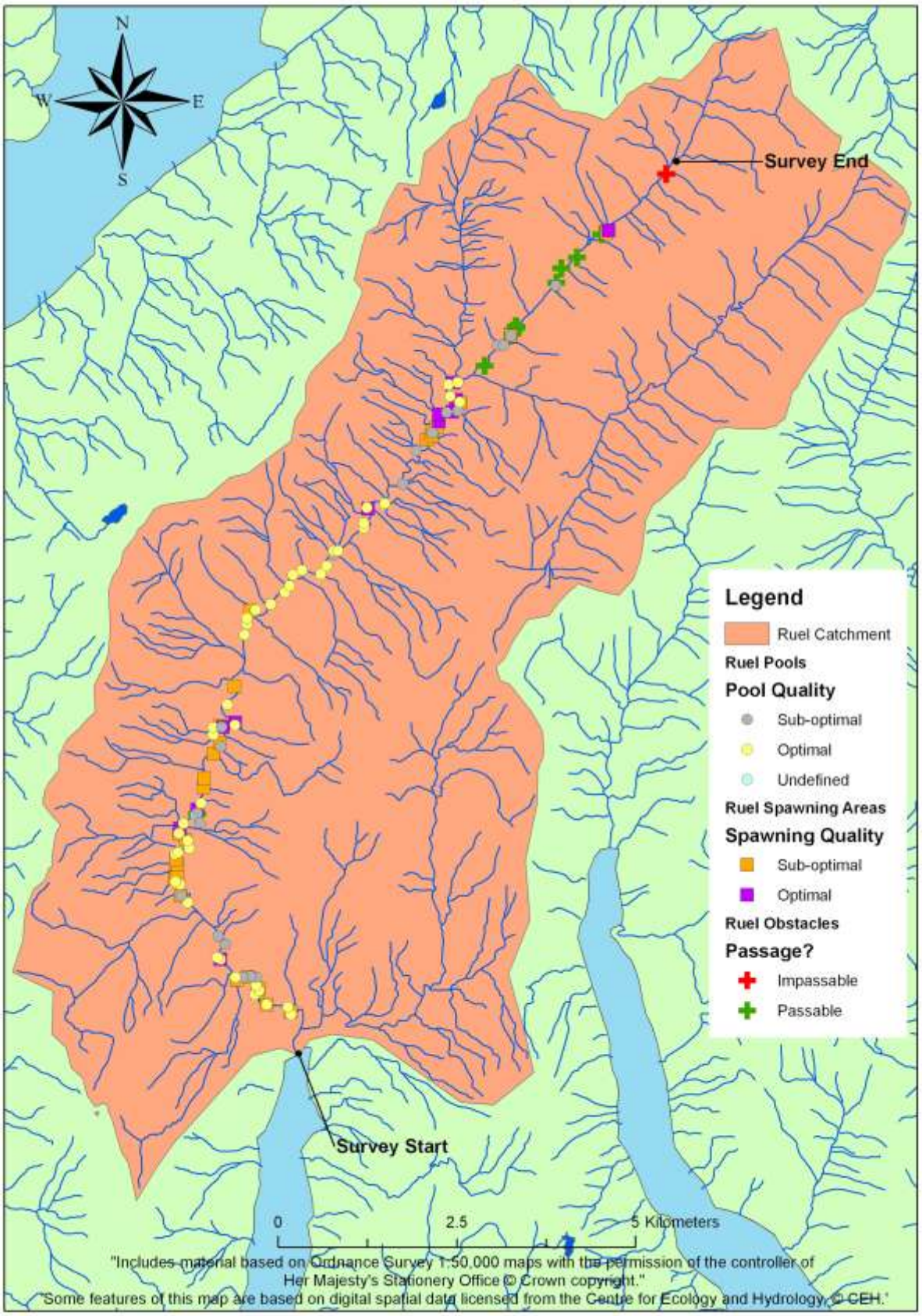

Figure 3.38 Distribution of obstacles, adult holding pools and spawning areas in the Loch Riddon catchment

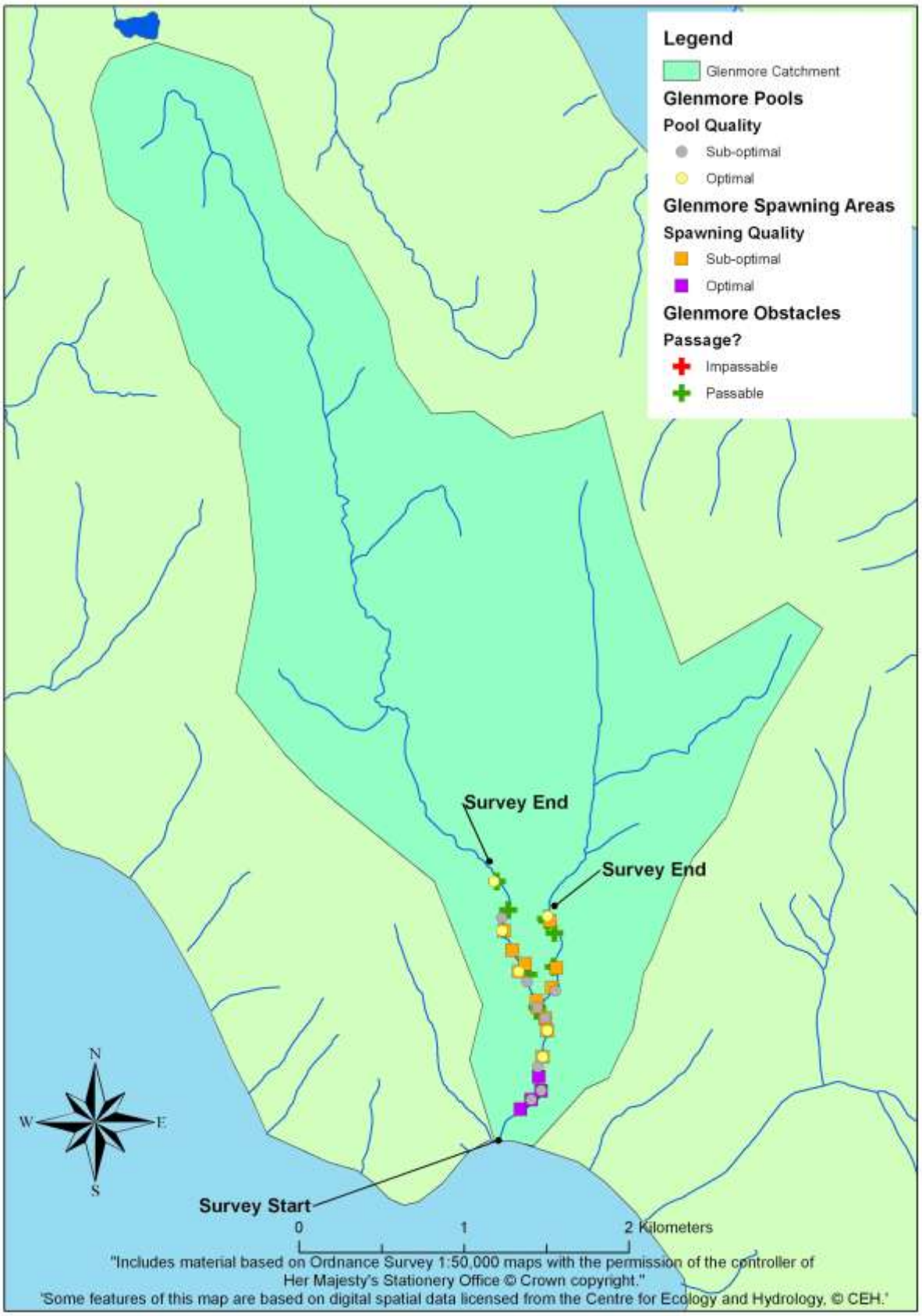

Figure 3.39 Distribution of obstacles, adult holding pools and spawning areas in the Isle of Bute catchments

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.

3.2.2.1 Habitat suitability for juvenile salmonid fish

The juvenile salmonid fish habitats recorded (Table 3.8) consisted of shallow, mixed and deep habitats. Significant areas of fry habitat were recorded in the Ruel, Ardyne, Eachaig and Croe catchments and scores of suitability were relatively poor-to-moderate (scores 1, 2 and 3 out of a possible 5). Fry habitat was present in 44% of sections surveyed. Mixed habitats were recorded in all catchments and scores were relatively poor-to-moderate (range between 2 and 3). Mixed juvenile habitat was present in 80% of sections. Deep juvenile habitat was largely absent from the rivers of Loch Striven, with the exception of some poor habitat (score 1) in the Balliemore. Deep habitat in the other catchments of South Argyll was generally poor with the exception of the River Eachaig with a median deep habitat score of 4. Deep juvenile habitat was present in 38% of sections.

Table 3.8 Scores of suitability of habitats for juvenile salmonid fish

Catchment	No. of Survey Sections	Fry		Mixed Juv		Deep Juv	
		Sections Present	Score	Sections Present	Score	Sections Present	Score
Upper Loch Long							
Loin	10	4	2	8	3	2	2
Croe	27	4	3	26	3	11	2
Loch Goil							
Goil	19	12	1.5	13	2	9	1
Lettermay	3	1	3	3	3	2	2
Carrick	2	0		2	3	0	
Middle Loch Long							
Finart Burn	8	0		8	3	7	2
Eachaig Catchment							
Eachaig	25	12	3	17	4	20	4
Little Eachaig	19	2	3	16	3.5	8	2
Massan	36	5	3	34	3	13	2
Cur	38	30	3	14	3	10	3
Lower Loch Long							
Balgaidh	7	1	1	4	1.5	0	
Loch Striven							
Ardyne	34	17	1	30	1.5	0	
Balliemore	12	11	2	11	2	6	1
Inverchaolain	16	10	1	16	2	0	
Invervegain	2	1	1	1	2	0	

Catchment	No. of Survey Sections	Fry		Mixed Juv		Deep Juv	
		Sections Present	Score	Sections Present	Score	Sections Present	Score
Tarsan	3	2	1	3	1	0	
Loch Riddon							
Ruel (inc Auchenbreck)	36	21	2	31	2	28	2
Bute							
Glenmore	7	0		6	2	0	
Totals	**304**	**133**		**243**		**116**	

3.2.2.2 Factors potentially affecting productivity

The main characteristics of habitats potentially affecting productivity of juvenile salmonid fish recruitment were recorded as downgrades for in-stream (Table 3.9) and riparian (Table 3.10) habitats.

The total number of in-stream downgrades identified per km of survey varied between 3.0 on the Finart Burn to 11.7 on the Lettermay Burn and averaged 7.3 per km for all catchments surveyed.

Table 3.9 Downgrades of in-stream habitat condition (no. per km)

Catchment	Total No.	Fine Sediments	Bed-rock	In-stream Cover	Unstable substrates	Gradient
Upper Loch Long						
Loin	8.4	4.0	0.0	3.2	0.0	1.2
Croe	5.6	3.0	0.7	1.3	0.1	0.4
Loch Goil						
Goil	7.6	1.7	0.6	2.1	1.5	1.7
Lettermay	11.7	5.0	1.7	0.0	0.0	5.0
Carrick	4.0	2.0	0.0	0.0	0.0	2.0
Middle Loch Long						
Finart Burn	3.0	1.5	0.3	1.0	0.0	0.3
Eachaig Catchment						
Eachaig	3.5	0.3	0.0	1.3	1.3	0.6
Little Eachaig	5.9	0.4	1.3	1.3	1.9	1.1
Massan	10.1	2.8	0.9	2.2	3.3	0.9
Cur	8.9	1.9	1.2	1.7	2.6	1.6
Lower Loch Long						
Balgaidh	7.6	0.0	2.9	1.2	1.2	2.4
Loch Striven						
Ardyne	10.4	2.0	2.6	3.1	1.3	1.4
Balliemore	7.5	2.1	1.1	3.9	0.0	0.4
Inverchaolain	8.2	0.0	4.1	1.5	1.0	1.5

Catchment	Total No.	Fine Sediments	Bed-rock	In-stream Cover	Unstable substrates	Gradient
Invervegain	10.0	2.0	4.0	0.0	2.0	2.0
Tarsan	9.3	2.7	4.0	0.0	2.7	0.0
Loch Riddon						
Ruel (inc Auchenbreck)	3.3	1.3	0.3	1.2	0.1	0.4
Bute						
Glenmore	6.3	2.9	2.3	0.6	0.6	0.0
Average	**7.3**	**2.0**	**1.6**	**1.4**	**1.1**	**1.3**

Downgrades identified during the surveys were mostly attributed to fine sediments in the substrate matrix (2.0 per km) and bedrock (1.6 per km). The relatively poor in-stream cover from lack of size and variety of substrates (1.4 per km) was also a common feature of in-stream habitats. Lower numbers of downgrades were attributed to instability of substrates (1.1 per km), and high or low river gradients (1.3 per km).

The total number of riparian downgrades identified per km of survey varied between 0.0 on the River Eachaig to 7.4 on the Inverchaolain Burn and averaged 3.3 per km for all catchments surveyed.

Downgrades identified during the surveys were mostly attributed to a low provision of bank-side cover for fish (average 1.5 per km), which was mainly identifiable in the River Goil, Inverchaolain, Invervegain and Tarsan Burns. Over-shading of the channel from a dense canopy of trees (average 1.3 per km) was also identified in smaller catchments and conversely a lack of shading from trees (0.6 per km) was identified on the Balliemore and Inverchaolain.

Table 3.10 Downgrades of riparian habitat condition (no. per km)

Catchment	Total No.	No Shade	Over Shade	Bank Cover	Predominant Land use
Upper Loch Long					
Loin	2.8	0.0	2.4	0.4	Broadleaf woodland / Rough pasture
Croe	2.7	1.8	0.7	0.1	Broadleaf woodland / Conifer plantation
Loch Goil					
Goil	5.5	0.8	1.3	3.4	Improved grazing
Lettermay	5.0	0.0	5.0	0.0	Improved grazing
Carrick	2.0	0.0	2.0	0.0	Improved grazing
Middle Loch Long					
Finart Burn	1.5	0.3	1.0	0.3	Improved grazing
Eachaig Catchment					
Eachaig	0.0	0.0	0.0	0.0	Improved grazing
Little Eachaig	3.4	0.0	2.1	1.3	Improved grazing / Conifer plantation
Massan	2.8	1.6	0.7	0.5	Conifer plantation
Cur	2.1	0.0	1.9	0.2	Broadleaf woodland
Lower Loch Long					
Balgaidh	2.9	0.0	0.0	2.9	Broadleaf woodland
Loch Striven					
Ardyne	2.5	0.0	1.2	1.3	Broadleaf woodland / Conifer plantation
Balliemore	5.7	2.5	0.0	3.2	Rough pasture
Inverchaolain	7.4	2.8	0.5	4.1	Broadleaf woodland / Rough pasture
Invervegain	4.0	0.0	0.0	4.0	Broadleaf woodland
Tarsan	6.7	0.0	2.7	4.0	Broadleaf woodland
Loch Riddon					
Ruel (inc Auchenbreck)	1.3	0.6	0.2	0.5	Improved grazing
Bute					
Glenmore	1.1	0.0	1.1	0.0	Improved grazing
Average	**3.3**	**0.6**	**1.3**	**1.5**	

3.2.3 Invasive Non-Native Species (INNS)

The presence on INN plant species were recorded on each section surveyed (table 3.11). The most prevalent INNS recorded was *Rhododendron ponticum*, which was present in 34% of sections, and was also the most widespread INNS recorded, being present in all catchments except the Glenmore. Japanese knotweed was present in 21% of sections, while Himalayan balsam was only present in 1.3% of sections and was limited to 2 catchments, the Loin Water and the Lettermay.

Table 3.11 Distribution of Invasive Non-Native Species in South Argyll riparian zones.

Catchment	No. of Survey Sections	INNS - no. of sections where present		
		Japanese Knotweed	Rhododendron ponticum	Himalayan balsam
Upper Loch Long				
Loin	10	2	2	3
Croe	27		10	
Loch Goil				
Goil	19	3	5	
Lettermay	3		1	1
Carrick	2	1	2	
Middle Loch Long				
Finart Burn	8	7	8	
Eachaig Catchment				
Eachaig	25	7	9	
Little Eachaig	19	17	11	
Massan	36		11	
Cur	38	16	3	
Lower Loch Long				
Balgaidh	7	5	5	
Loch Striven				
Ardyne	34	7	20	
Balliemore	12		2	
Inverchaolain	16		3	
Invervegain	2		1	
Tarsan	3		3	
Loch Riddon				
Ruel (inc Auchenbreck)	36		6	
Bute				
Glenmore	7			
Totals	**304**	**65**	**102**	**4**

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 factors affecting the results of the survey.

4.1 Fish distribution

4.1.1 Atlantic salmon

Atlantic salmon were found in the relatively large catchments surveyed, but were absent from the relatively smaller catchments despite having suitable habitats available. This is likely to be an artefact of a combination of population dynamics and the marine survival of post-smolts; populations need to have sufficient freshwater habitat to be able to generate enough smolts to survive to complete their life cycle. Smaller catchments may not be able to generate effective population sizes, particularly during periods of low adult sea returns to sustain a population.

In healthy populations of Atlantic salmon, natural impassable barriers or large areas of unsuitable habitat are likely to limit the distribution of juveniles within a catchment. The data collected in this survey indicates there is some fragmentation of the distribution of fry and parr and are also absent in some suitable habitats that are accessible from the sea. The causes of the fragmented distribution are potentially due to a mixture of factors that are associated with reduced abundance of adult sea returns at this time (Webb et. al, 2009). The patchy distribution of age classes also indicates that spawning activity may be infrequent and not likely to occur at all potential sites in all years. Alternately it may be argued that the post-spawning survival of ova and early fry stages may be affected by freshwater habitat conditions. However, if this were the case then such patchy distribution may be expected in one or two rivers with significant habitat problems. This survey indicates that the poor distribution of salmon is widespread in all catchments and therefore is likely to be attributable to low numbers of adult sea returns.

4.1.2 Brown trout

Brown trout fry were widely distributed in coastal burns, headwaters and tributary streams in all catchments with the exception of the Greenan Burn on the Isle of Bute, which was surveyed in less than ideal conditions and therefore may not reflect the actual distribution of trout. The wide distribution may be partly due to the brown trout's ability to complete their life cycle within the

freshwater environment which is reflected by their presence upstream of impassable waterfalls. This trait is likely to stimulate smolt production even when the number of adult sea returns from migratory trout is low and therefore they are able to sustain and regenerate their distribution more effectively compared to salmon. Juvenile trout, particularly parr, were less well distributed in the main channels of the River Ruel and parts of the Finart and Eachaig catchments. This is likely to be partly due to habitat preferences, particularly where there is little bankside cover or there are alternate deeper pool habitats available, which were not sampled due to the inefficiency of the sampling technique in water deeper than 0.5 to 1m.

4.1.3 Non-salmonid species

Although not sampled in all sites the distribution of European eel was relatively wide. Unlike salmon and sea trout this migratory species utilises freshwaters for their adolescent growth phase and their distribution is an artefact of the relative suitability of available habitats rather than spawning activity in previous years. While there are international concerns over the status of eel populations, their wide distribution recorded in this survey indicate that they remain relatively well established, but there are no data on their density or age class distribution to assess their relative abundance and age class presence.

Although lamprey ammocoetes (*Lampetra spp.)* were sampled at only 7 sites this does not accurately reflect their actual distribution. Further sampling will be required to establish their range, which is likely to be reflected in habitat availability. Flounder were sampled in the lower reaches of six catchments. While more commonly known to inhabit estuarine and coastal marine habitats (Maitland & Campbell, 1994), flounder are also capable of spending long periods in freshwater where suitable habitats are accessible from the sea before returning to sea to breed. Three-spine stickleback were sampled in larger catchments of the Ruel and Eachaig during the study, but this apparently limited distribution may be an artefact of the type of habitat surveyed, which was faster flowing turbulent flow types primarily suited to juvenile salmonid fish.

4.2 Fish abundance

4.2.1 Atlantic salmon

Where present the generally low abundance of salmon fry and parr found by the survey indicate that adult sea returns are not currently sufficient to maintain recruitment at optimal levels. It is also likely that smolt production is subsequently relatively low, potentially inhibiting the maintenance and recovery of salmon populations. Time series data on the larger catchments such as the Ruel and

Eachaig catchments will be required to better understand trends over time in relation to changes in sea adult return rates and resulting juvenile recruitment.

Habitat data indicate that freshwater habitat condition may not be sufficient at a number of the sites visited to support relatively healthy populations of salmonid fish. Although the primary factors affecting salmon populations are likely to be marine-based at this time it is likely that freshwater-based factors are affecting productivity and may limit recovery of populations if sea survival improves. Fishery catch and fish counter data from other sources in Argyll indicate some intermittent improvement in salmon abundance in recent years (2000 to 2007) following significant declines during the 1990s, but there is little or no time series data to suggest that there is significant widespread recovery in the rivers sampled as part of this survey. Where data is available, particularly the Ruel, there are indications of an improvement in juvenile trout and salmon abundance compared to data collected between 1998 and the present, but there are some factors such as stocking and interaction with known fish farm escapes that make comparisons difficult to interpret (Argyll Fisheries Trust, 2009). Although there are no baseline data to compare juvenile abundance prior to the collapse in fishery performance recorded on the west coast of Scotland, it is likely that current abundance is sub-optimal, which is reflected in the classes assigned by the SFCC scheme which is based on data collected on populations that may have already been affected by a decrease in adult sea returns.

4.2.2 Brown and sea-run trout

The relatively moderate-to-good abundance of trout fry sampled at most sites indicate that in comparison to salmon, the trout populations in these catchments are relatively healthy. The higher abundance of fry sampled in sites accessible to the sea compared to those found upstream of impassable barriers indicate that they are likely to be, in part, the progeny of sea-run adults. Unlike salmon, sea trout post-smolts tend to remain relatively close in coastal waters, indicating that the current local marine survival of sea trout in the South Argyll region is sufficient to stimulate fry recruitment at current levels. Similarly to salmon, it is not likely that trout recruitment is currently at optimal levels, which is reflected in the classes assigned by the SFCC scheme.

4.3 Factors affecting productivity in freshwater habitats

In relatively healthy populations of salmon and trout where the number of adult sea returns are sufficient to fully populate freshwater habitats with juveniles, density dependant factors are likely to affect growth and survival. Juvenile salmonids are territorial and enlarge their territories as they grow in competition with other juveniles and therefore density dependant mortality is associated

with high abundance of post-emergent fry and older juveniles and the limited availability of resources (suitable habitats or food) to support them. The relatively low level of juvenile salmon recruitment observed in this study indicates that density dependant mortality is unlikely to be a factor significantly affecting these populations at this time.

Density independent mortality of juveniles is associated with factors not related to competition between individuals, which can be an artefact of extreme weather events such as high flows that can mobilise bed materials associated with redds or drought conditions that reduces habitat availability to fish. Other density independent factors related to water chemistry and quality can also potentially cause significant mortality of early fry stages. Habitat survey data indicated that common aspects of land use, such as historical morphological changes, grazing of livestock on river banks associated with the loss of riparian woodland and conifer plantations are likely to have reduced the productivity of freshwater habitats. The susceptibility of some catchments in South Argyll to unfavourable flow events exacerbated by land drainage, channel modification and abstraction may be a factor potentially affecting productivity, but there are no current studies of sufficient resolution to evaluate this potential. A degree of instability of in-stream substrates was recorded in some sections of the Croe and Eachaig catchments that may potentially contribute to lower than optimal productivity through loss of ova and alevins (yolk-sack fry) if bed materials are mobilised in winter floods.

The data also suggest that common aspects of topography and geology may influence the character of fish habitats and its suitability to specific species. This was particularly apparent in the River Ruel where a combination of relatively low gradient river habitats and storage of smaller sized substrates may be better suited to the recruitment of trout compared to salmon. This is likely to limit the habitat for salmon fry and parr which prefer faster flowing broken water habitats and increase availability of spawning sites which are primarily suitable for both trout and salmon.

Invasive non-native plant species were identified in a number of catchments, which have potential to undermine productivity of fish populations and the performance of fisheries. While plants such as *Rhododendron ponticum* is widespread in the region, other species such as Japanese knotweed have become established in more recent times. The early identification, control and eradication of such species is important to avoid further losses of productivity and local biodiversity.

With the exception of the Glenmore catchment on the Isle of Bute, potential for point source pollution appeared to be limited in relation to water quality and fish populations, indicating that any water quality issues acting on fish populations are likely to be diffuse in nature.

4.4 Factors affecting productivity in marine habitats

The wider marine survival of post-smolt salmon and sea trout associated with climate change are less well understood (Todd et. al., 2008) compared to that of local marine factors known to affect migratory salmonids. There is potential that aquaculture related factors such as sea lice burdens affecting survival of post-smolts (Butler & Watt, 2002) and interaction with farmed escapee salmon (McGinnity et. al., 2004) may have an influence on the current status of migratory salmonid fish. Some data are now being collected on sea lice burdens of sea trout as part of the Area Management Agreement process (TWG, 2009), which indicate some reduction of sea lice burdens of post-smolt sea trout in Loch Riddon following recent reorganisation of fish farm production in the Firth of Clyde area. There are some signs of improvements in the abundance of salmon in catchments in neighbouring upper Loch Fyne where sufficient data over time has been collected to make such an evaluation. The data collected for South Argyll Rivers are not yet currently sufficient to establish strong trends in changes in fish abundance, but the data collected as part of this study will form a useful baseline upon which to make future assessments in adult sea returns and subsequent recruitment in freshwater habitats over a broad area.

4.5 Factors affecting survey results and interpretation of data

Historical records of stocking indicate that relatively few rivers have received significant introductions of hatchery reared fish in recent time, but in response to falling catches, stocking of juvenile salmon and trout has been undertaken on the River Ruel. Therefore it is possible that some juvenile fish sampled during the survey are of hatchery origin and the results given may not be fully representative of the distribution and abundance of wild spawned fish.

Similarly reports of escape events of farm fish reported to government agencies since 2003 in the Firth of Clyde management area indicate that there have potentially been some significant numbers of farm fish interacting with wild fish. The numbers of escaped fish reported in the area were significant in 2005; 22,500 in one event and in 2006; 13,505 in three events. The data collected on salmon parr abundance in 2008 may therefore have been potentially influenced by progeny of fish farm escapees.

The juvenile salmon found in the Tarsan survey are highly likely to be derived from escapes from a local smolt hatchery and therefore are not likely to be present as part of a natural population.

The abundance of fish sampled at survey sites may be influenced by the location and timing of sampling in relation to the actual distribution of fish in any one catchment. Therefore surveys

undertaken close to spawning sites early in the summer may record higher abundance of fry compared to those undertaken later in the year when juveniles have dispersed or mortality has taken place. It is also likely that the actual abundance of fish is somewhat higher than recorded by this survey as one-run sampling does not catch all the fish present at the site. Classification of juvenile salmonid fish abundance may also be somewhat biased toward higher classes as the quintile ranges utilised in the SFCC scheme are collected from fish populations undergoing a period of low abundance due to poor marine survival of migratory salmonids. Therefore, classification is likely to be somewhat higher for this study than compared to other populations in Scotland that have similar fish abundance.

4.6 Use of data on fish populations and habitat

It is likely that the data collected as part of this survey will provide valuable baseline data of fish populations and their habitats and may be used to inform management of the natural resource. At a local level, the data may be used to inform the development of fishery and catchment management plans that have potential to stimulate improvement initiatives. The data will also be important in providing resource users and agencies with information upon which to manage future development of resources.

5 IMPLICATIONS FOR MANAGEMENT

The data on fish and their habitats collected in the 2008 and 2009 provide an indication of the implications for the management of fish populations in these catchments.

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, particularly salmon, brown trout and the migratory form, sea trout, which also have potential to support fisheries that are important to local recreation and economy. The data on juvenile salmonids indicate that there is some potential for sustainable fisheries for sea trout at this time. However, it is understood that sea trout numbers have only recently begun to stabilise and potentially recover and therefore it is essential to control fisheries effectively. Conversely, the current status of salmon populations indicate that they are not able to support sustainable fisheries at this time and further exploitation is likely to decrease potential for restoration and possibly increase the potential for local extinctions.

5.1.1 Maximise spawning escapement

The low number of adult sea returns and consequent poor status of juvenile populations indicate that it is essential to maximise the spawning escapement in the fishery. Operating fisheries on conservation-minded principles through effective catch and release angling techniques and protecting adult fish from poaching and other losses 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 better understand the genetic structuring of stocks to inform hatchery management and avoid out-breeding depression.

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 maintain and improve the status of freshwater habitats by improving the management 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. The development of catchment-based management plans is likely to provide wider benefits to biodiversity and fisheries if they are successful in engaging a wide range of land and water users into improving aquatic and riparian habitats. Such are the wide-ranging issues affecting habitat productivity for fish, restoration initiatives undertaken by fisheries in isolation to other resource users is unlikely to provide a sufficient scale of improvement to make significant differences to fishery performance. Such plans are also required to tackle emerging threats such as biosecurity and invasive non-native plants and better inform the future development of resources, particularly for renewable energy schemes.

5.3 Aquaculture management

Changes to the management of marine salmon fish farm production as part of the Firth of Clyde Area Management Agreement have potential to better control sea lice on farms and improve the health of farmed and wild fish. Avoiding infestation of post-smolt salmonids by higher than natural burdens of sea lice is an important aspect of local management that is an on-going issue for both the aquaculture and wild fishery sectors. The data collected on trout populations indicate that control of sea lice on local farms has improved in recent times and improvements in juvenile populations may be expected, but further information on older adolescent and mature age classes are required to fully evaluate the current status. Maintaining high efficiency in strategic fallowing and lice control treatments will also be required in combination with on-going development of effective sea lice treatments to minimise potential impact of sea lice on wild fish recruitment.

Containment of farm stock is also a priority for aquaculture and fishery sectors as the vulnerable status of local wild salmon populations recorded in the survey indicates that they are susceptible to biological (genetic) and ecological (competition) elements that have potential to further erode wild populations.

6 CONCLUSIONS

Interpretation of the data collected by fish and habitat surveys in 2008 and 2009 provides a number of conclusions in this early phase of the project.

6.1 Fish distribution

Fish surveys undertaken sampled 5 native fish species; Atlantic salmon, brown trout, European eel, three-spine sticklebacks and flounder. The distribution of juvenile salmon was patchy, but juvenile trout were sampled at most sites surveyed. The distribution of salmon recorded is likely to principally an artefact of catchment size and potentially the recent declines in adult sea returns. One salmon population found is likely to be derived from a smolt hatchery.

6.2 Juvenile salmonid fish abundance

Where present the abundance of juvenile salmon was low indicating that recruitment of this species is sub-optimal. Juvenile trout abundance was generally moderate-to-high when compared to data from other rivers in the Clyde coast region by the SFCC classification scheme.

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 water and land use; conifer plantation forestry, grazing of livestock and hydroelectric generation schemes. Morphological alterations to river channels were also found to be widespread and are likely to reduce productivity of habitats and affect performance of fisheries.

6.5. Implications for 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 effective catch and release angling techniques and protecting adult fish from unnatural losses will be essential to maximise spawning escapement and stimulate recruitment.

While causes of wider marine mortality of Atlantic salmon may not be addressed at a local management level, inshore marine factors affecting migratory fish, such as aquaculture, may be better managed to reduce potential for sea lice infestation of vulnerable post-smolts and interaction

with fish farm escapes. Continued improvement in containment of farm fish and sea lice is essential if restoration of wild fish populations and fisheries is to be achieved.

Improvement in the management of land and water resources is required to further stimulate recovery in salmonid fish populations. Catchment-scale approaches to engaging all resource users into better management of the aquatic environment are required if sufficient scales of improvement are to be obtained that will deliver benefits to both fisheries and biodiversity.

It is likely that the data collected as part of this survey will provide valuable baseline data of fish populations and their habitats and may be used to inform management of natural resources.

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. Time constraints and weather conditions meant that the number of sites sampled for lamprey was minimal in this survey.

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 fishery conservation limits. This information may also be used to develop the catchment management phase of the River Basin Planning process. However, it will be important to develop a more robust fish habitat survey protocol that will provide data that is useful to a wider range of interest groups, particularly in relation to geomorphology and other catchment-scale processes and activities.

7.3. Future work

Establishing baseline information is an important first step to assess the current status of the fishery resource. Repeat electrofishing data collected over a number of generations (3-5 years per generation) will be essential to assess changes in juvenile abundance, particularly for salmon. Consultation with centres of expertise will provide useful information to further assess the data and implications for restoration of fisheries. Additional information on genetic structuring, wild spawning (redd counts) and river processes will be essential to further interpret the findings of this study.

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