# S U R V E Y  R E P O R T

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# Isle of Arran Rivers Project, Phase 2 of 2: Survey of Fish Populations & Habitats

## 2008-09

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SURVEY REPORT

# Summary

## Isle of Arran Rivers Project, Phase 2 of 2: Survey of fish populations and habitats 2008/09.


**Background**

Argyll Fisheries Trust undertook electrofishing surveys of fish populations on 20 catchments and habitat surveys on 14 catchments on the Isle of Arran in 2008 and 209. The aim of the surveys was to establish baseline information on fish species distribution, their relative abundance and the status of habitats.

**Main findings**

Electrofishing surveys were undertaken at 142 sites in 20 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.*) and flounder (*Platichthys flesus*).

Juvenile Atlantic salmon were sampled in 9 (45%) catchments sampled. Salmon fry were sampled at 32% of sites and salmon parr were sampled in 33% of sites. Where present their abundance was relatively low when compared to the SFCC classification scheme.

Juvenile Brown trout were sampled in all 20 catchments sampled. Trout fry were sampled at 81% of sites and trout parr were sampled at 82% of sites. Their abundance was relatively moderate-to-good at most sites when compared to the SFCC classification scheme.

Habitat surveys were undertaken on 70.25km of main channels in 14 catchments. The location and assessment of 134 obstacles to fish passage, 219 significant adult holding pools and 132 spawning was recorded. Mixed juvenile habitat category was the most abundant habitat and was mostly of moderate-to-good status.

The factors affecting productivity of juvenile habitats were identified for in-stream conditions (average 4.9 downgrades per km) including sections of bedrock and fine sediments. Factors affecting riparian habitats (average 3.3 downgrades per km) included over-shading of the stream channel and lack of bank cover (vegetation) for fish.

## 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 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 mixture of natural channel features and a consequence of land use.

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.

## Acknowledgements

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Scottish Natural Heritage (SNH), the Scottish Government, European Union and the Leader plus programme, Arran Angling Association, fishery owners; Stephen Gibb and Caroline Fleming and the Argyll District Salmon Fishery Board.

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.

**Table of Contents** **Page**

**List of Figures** **Page**



**List of Tables** **Page**

# 1 INTRODUCTION

Argyll Fisheries Trust undertook electrofishing surveys of fish populations on 20 catchments and habitat surveys on 14 catchments on the Isle of Arran in 2008 and 2009 (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. 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 in 2008 and 2009 and complements catchment specific reports that provide more detailed information on the study findings (see appendices).

## 1.1 Fish populations and fisheries

The freshwater habitats of the Isle of Arran consist of a number of relatively moderate-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*), 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.

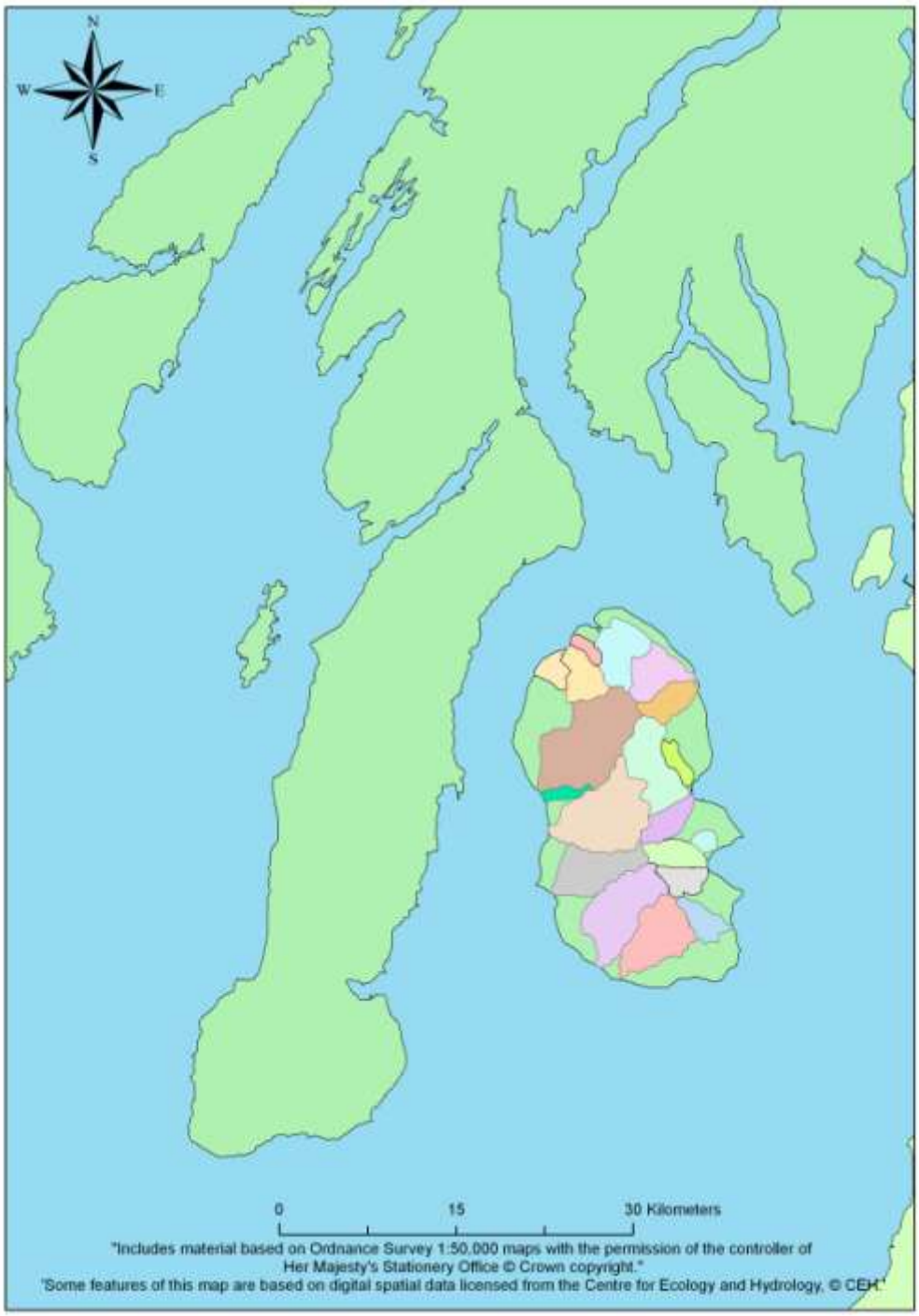



*Figure 1.1 Arran catchments surveyed in 2008 and 2009*

# 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 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.

### *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 100$^{th}$ percentile represents the highest density found at any one of the 151 sites compared.

### *2.1.4 Survey sites*

A total of 142 fish survey sites and one lamprey survey site were sampled in 14 larger catchment and 6 smaller coastal burns (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 Arran electrofishing survey site summary*

| Catchment | Catchment Size | No. Of e-fish sites |
|---|---|---|
| **North Arran** | | |
| Abhainn Mor | 14 | 7 |
| Chalmadale | 18 | 12 |
| North Sannox | 15 | 7 |
| Sannox | 10 | 9 |
| Abhainn Bheag | <5 | 1 |
| Allt Mor | <5 | 1 |
| **Total** | | **37** |
| **East** | | |
| Glen Rosa | 24 | 9 |
| Glen Shurig | 5 | 6 |
| Glencloy | 11 | 6 |
| Benlister | 18 | 5 |
| Glen Ashdale | 9 | 5 |
| Kilmory | 26 | 9 |
| Cnochan | <5 | 1 |
| Blairmore | <5 | 1 |
| Monamore | <5 | 2 |
| **Total** | | **44** |
| **West** | | |
| Iorsa Water | 51 | 15 |
| Machrie Water | 38 | 16 |
| Black Water | 26 | 11 |
| Sliddery | 33 | 18 |
| Auchencar | <5 | 1 |
| **Total** | | **61** |

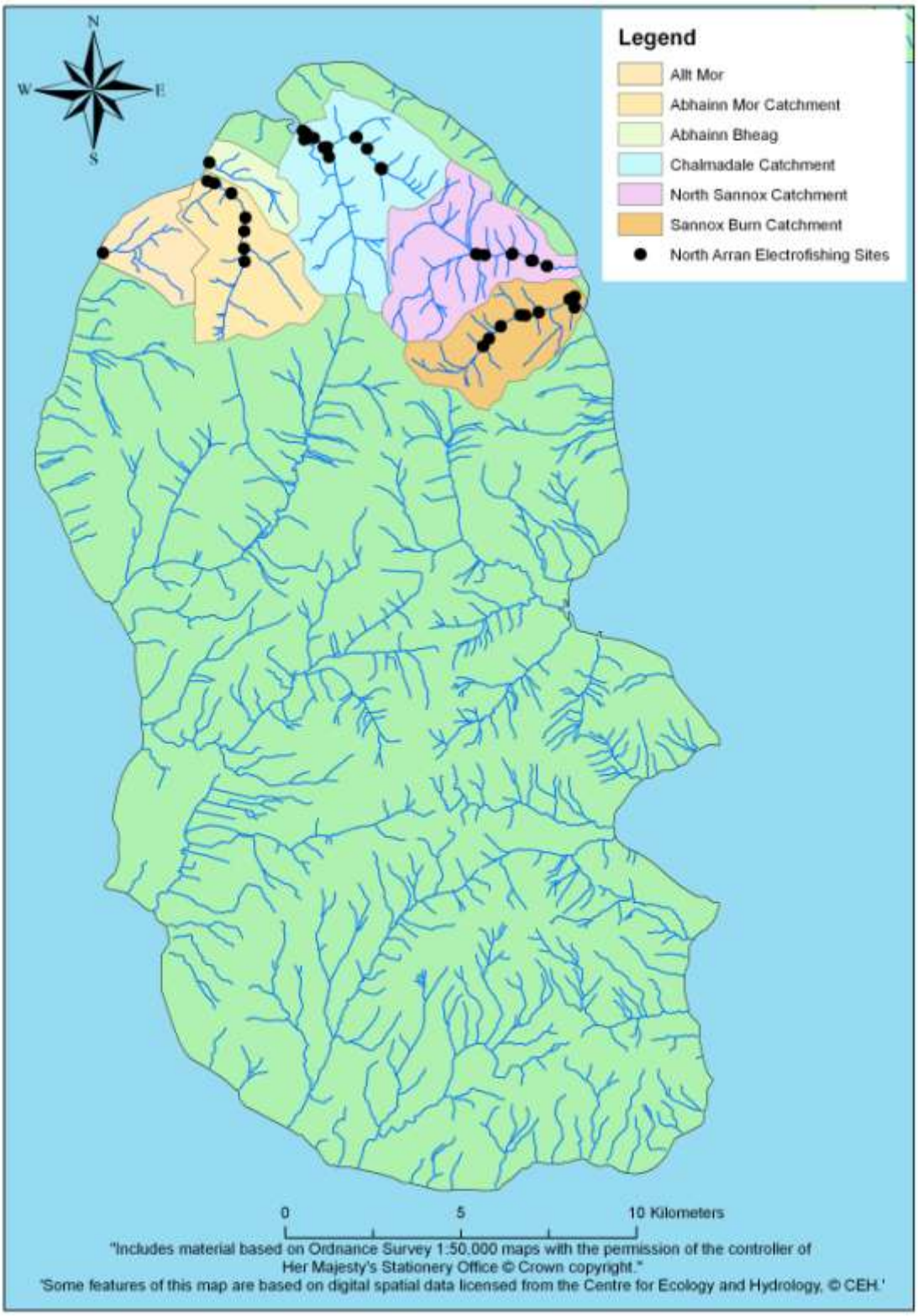



*Figure 2.1 North Arran electrofishing locations*

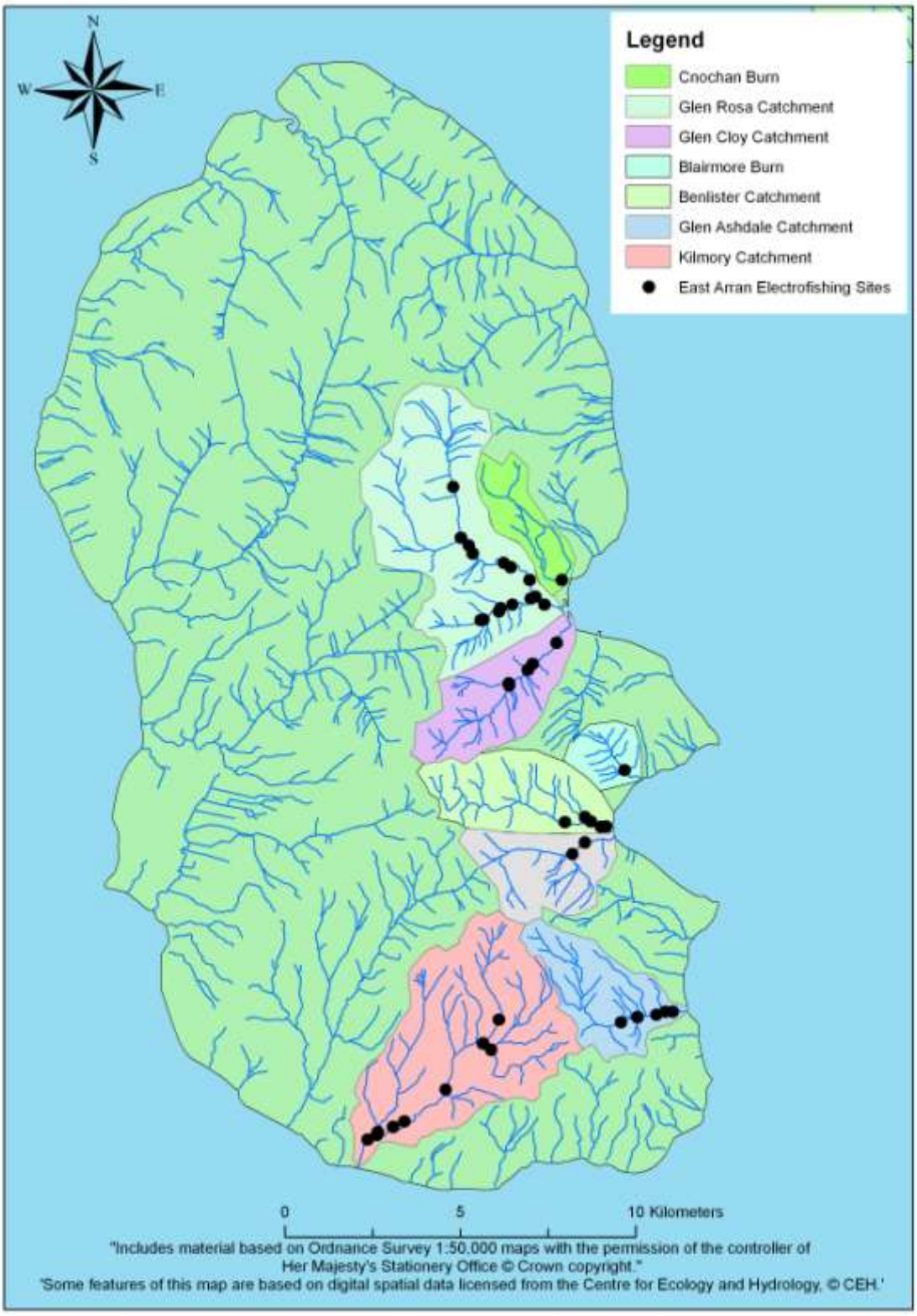



*Figure 2.2 East Arran electrofishing survey locations*

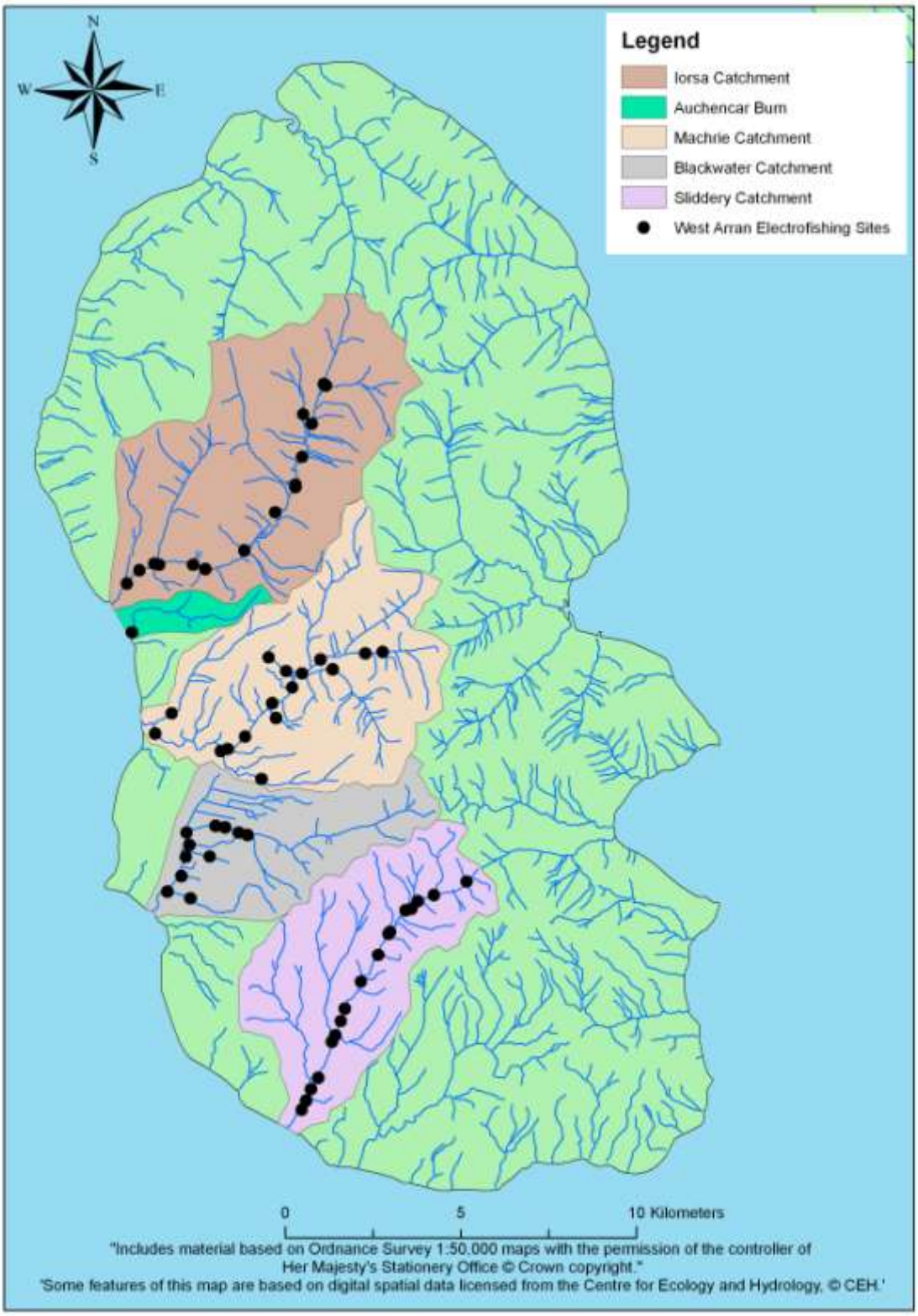



*Figure 2.3 West Arran electrofishing locations*

## 2.2 Habitat surveys

A walkover habitat survey was undertaken on main channels of 13 catchments and the Glenshurig Burn, a major tributary of the Glen Rosa Water. 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 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 as described by Rosgen (1996), 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<br>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.<br>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<br>**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<br>**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)<br>**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 (>50$m^2$), deep (>2m), In-stream boulders, overhanging vegetation<br>**Sub-optimal;** Small size (<50$m^2$), 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,<br>**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 survey

The results of electrofishing sampling of salmonid and other fish species are given for separately below. All tables give the results for the Glenshurig tributary of the Glen Rosa Water separately to the main channel.

### *3.1.1 Juvenile salmonid fish distribution*

Juvenile trout were sampled in all 20 catchments surveyed, while juvenile salmon were sampled in 9 catchments (Table 3.1, Figures 3.1, 3.2). Of the 142 electrofishing surveys conducted, trout fry were present at 81% of sites and trout parr at 82% of sites. Juvenile salmon were less well distributed, with salmon fry recorded at 32% of sites, and salmon parr sampled from 33% of sites.

*Table 3.1 Distribution of juvenile salmonid fish (no. of sites where sampled)*

| Catchment | No. sites | Salmon Fry | Salmon Parr | Trout Fry | Trout Parr |
|---|---|---|---|---|---|
| *North* | | | | | |
| Abhainn Mor | 7 | 0 | 0 | 7 | 7 |
| Chalmadale | 12 | 0 | 0 | 11 | 12 |
| North Sannox | 7 | 0 | 0 | 7 | 4 |
| Sannox | 9 | 0 | 0 | 5 | 5 |
| Abhainn Bheag | 1 | 0 | 0 | 1 | 1 |
| Allt Mor | 1 | 0 | 0 | 0 | 1 |
| *West* | | | | | |
| Iorsa Water | 15 | 11 | 5 | 8 | 7 |
| Machrie Water | 16 | 13 | 14 | 9 | 13 |
| Black Water | 11 | 7 | 5 | 7 | 9 |
| Sliddery | 18 | 0 | 5 | 16 | 17 |
| Auchencar | 1 | 0 | 0 | 1 | 1 |
| *East* | | | | | |
| Glen Rosa | 9 | 5 | 6 | 8 | 6 |
| Glen Shurig | 6 | 2 | 3 | 6 | 5 |
| Glencloy | 6 | 0 | 0 | 6 | 6 |
| Benlister | 5 | 2 | 2 | 5 | 5 |
| Glen Ashdale | 5 | 2 | 3 | 5 | 5 |
| Kilmory | 9 | 3 | 4 | 9 | 8 |
| Cnochan | 1 | 0 | 0 | 1 | 1 |
| Blairmore | 1 | 0 | 0 | 1 | 1 |
| Monamore | 2 | 0 | 0 | 2 | 2 |
| **Total** | **142** | **45** | **47** | **115** | **116** |

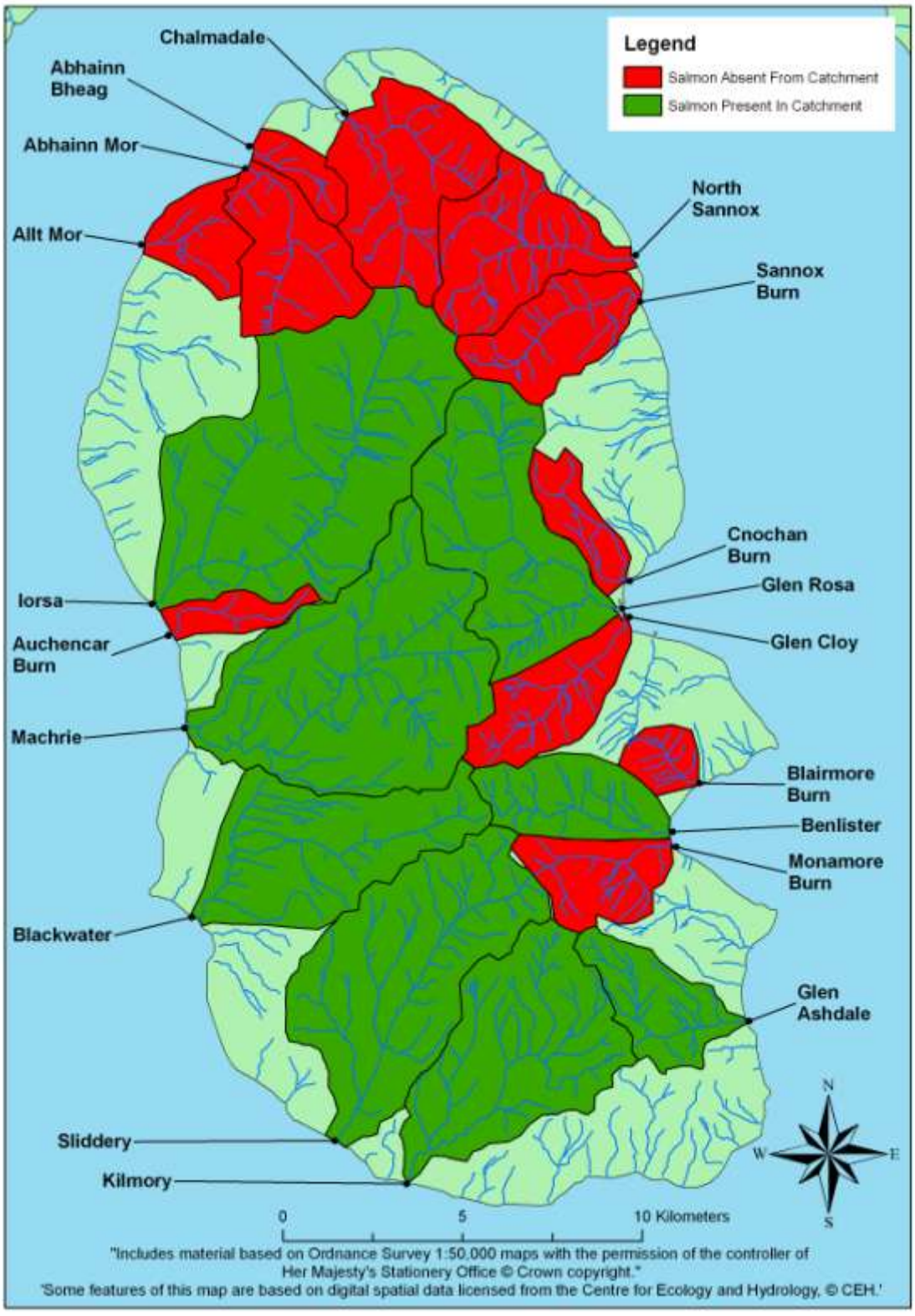



*Figure 3.1 Distribution of juvenile salmon by catchment*

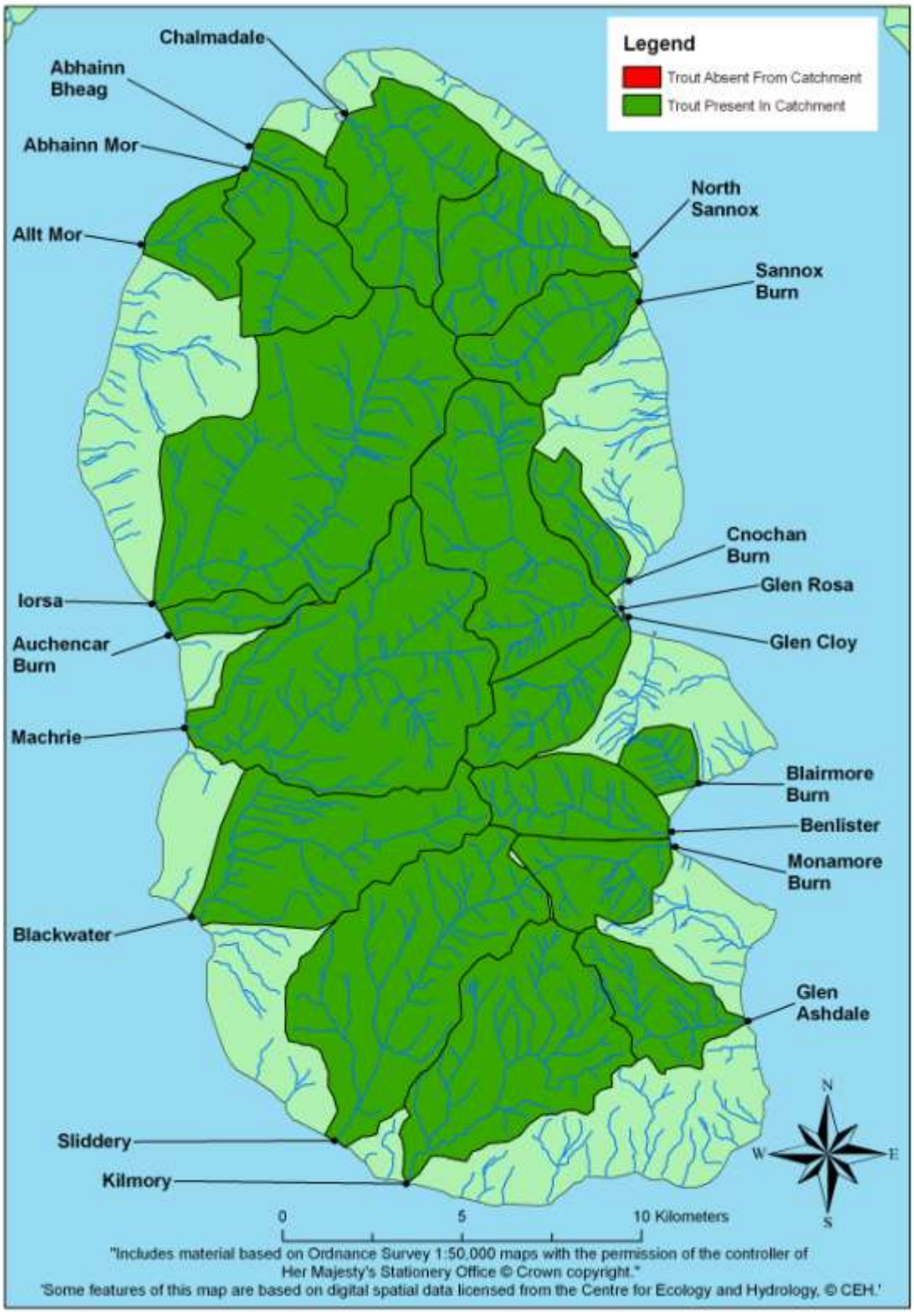



*Figure 3.2 Distribution of juvenile trout by catchment*

### *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 Table 3.2. 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.

*Table 3.2 Classification of salmonid fish abundance*

| Catchment | Salmon Fry | | Salmon Parr | | Trout Fry | | Trout Parr | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max |
| *North* | | | | | | | | |
| Abhainn Mor | F | | F | | E | B | E | B |
| Chalmadale | F | | F | | F | A | D | A |
| North Sannox | F | | F | | E | A | F | B |
| Sannox | F | | F | | F | A | F | A |
| Abhainn Bheag | F | | F | | D | | A | |
| Allt Mor | F | | F | | F | | A | |
| *West* | | | | | | | | |
| Iorsa Water | F | E | F | D | F | A | F | C |
| Machrie Water | F | B | F | A | F | B | F | A |
| Black Water | F | A | F | A | F | C | F | A |
| Sliddery | F | | F | B | F | A | F | A |
| Auchencar | F | | F | | C | | D | |
| *East* | | | | | | | | |
| Glen Rosa | F | B | F | C | F | A | F | C |
| Glen Shurig | F | D | F | A | E | B | F | A |
| Glencloy | F | | F | | E | A | D | A |
| Benlister | F | E | F | B | B | A | C | A |
| Glen Ashdale | F | D | F | B | C | A | C | A |
| Kilmory | F | E | F | B | E | A | F | A |
| Cnochan | F | | F | | D | | B | |
| Blairmore | F | | F | | E | | B | |
| Monamore | F | | F | | B | A | D | A |

No salmon were found in the northern catchments. In the western catchments, where present salmon fry abundances were generally low, however pockets of higher abundances were found in the Machrie Water and Black Water (classes A and B). While no fry were found in the Sliddery, parr abundances of moderate to good were found in the river (classes C and B). For the eastern catchments, classes of salmon fry abundance were generally low (classes E and D) where present with the exception of one site on the Glen Rosa Water (class B). Classes of salmon parr abundance

were more varied between catchments with minimum abundance classes ranging from very low (class E) in three catchments, low class D) in the Glenshurig and high (class B) in the Benlister Burn. Classifications of trout fry abundance were generally higher than that of salmon and trout were present in every catchment surveyed. In the northern catchments, fry abundances were generally moderate to good (classes C, B and A), with the highest abundances found in the Chalmadale catchment. Parr abundances were more varied within and between catchments, with classes ranging from E (very low) to A (very high). In western catchments, minimum values were absent (class F) and very low (class E) in the four main catchments. Maximum values were high (classes A and B) except for the Blackwater, which had a moderate maximum trout fry abundance (class C). Trout parr abundances were similar to that of trout fry, with maximum values of class A except for the Iorsa Water, where the maximum abundance was moderate (class C). In the eastern catchments, minimum values ranged between very low abundance (class E) in four catchments and low (class D) in two others to moderate (class C) in the Glenashdale and high (class B) in the Monamore Burn. Maximum values were generally very high (class A) in most catchments with the exception of the Glenshurig (class B). Classification of trout parr abundance was similar to that of fry and generally higher than that of salmon. The minimum abundance ranged from low (class E) in three catchments, low (class D) in two others to moderate (class C) in the Benlister and Glenashdale catchments. Maximum values ranged from moderate (class C) in the Glen Rosa Water to high abundance (class B) in two coastal burns (Cnochan and Blairmore) and very high (class A) in all other catchments.

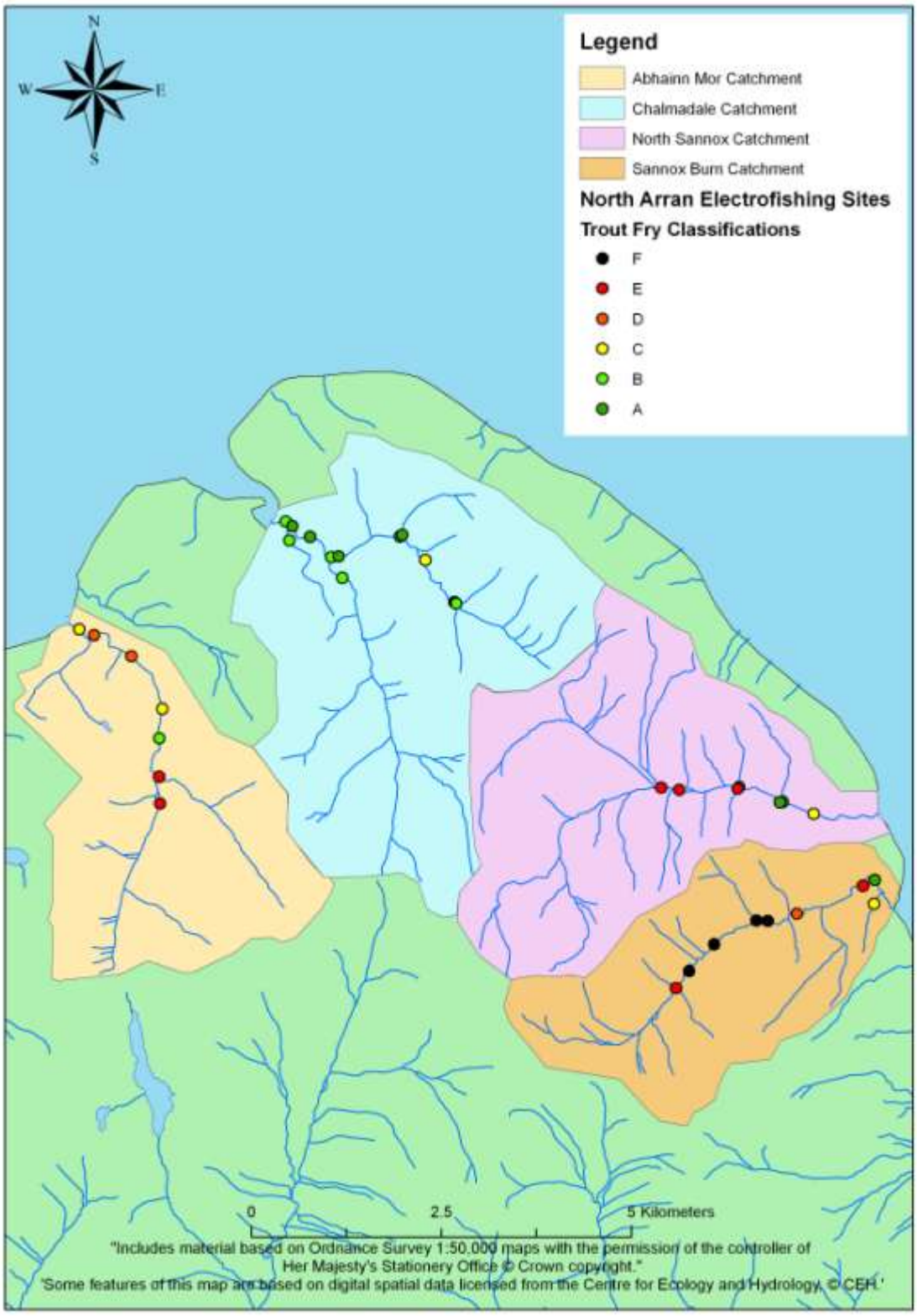



*Figure 3.3 Trout fry distribution and relative abundance in North Arran (SFCC classification)*

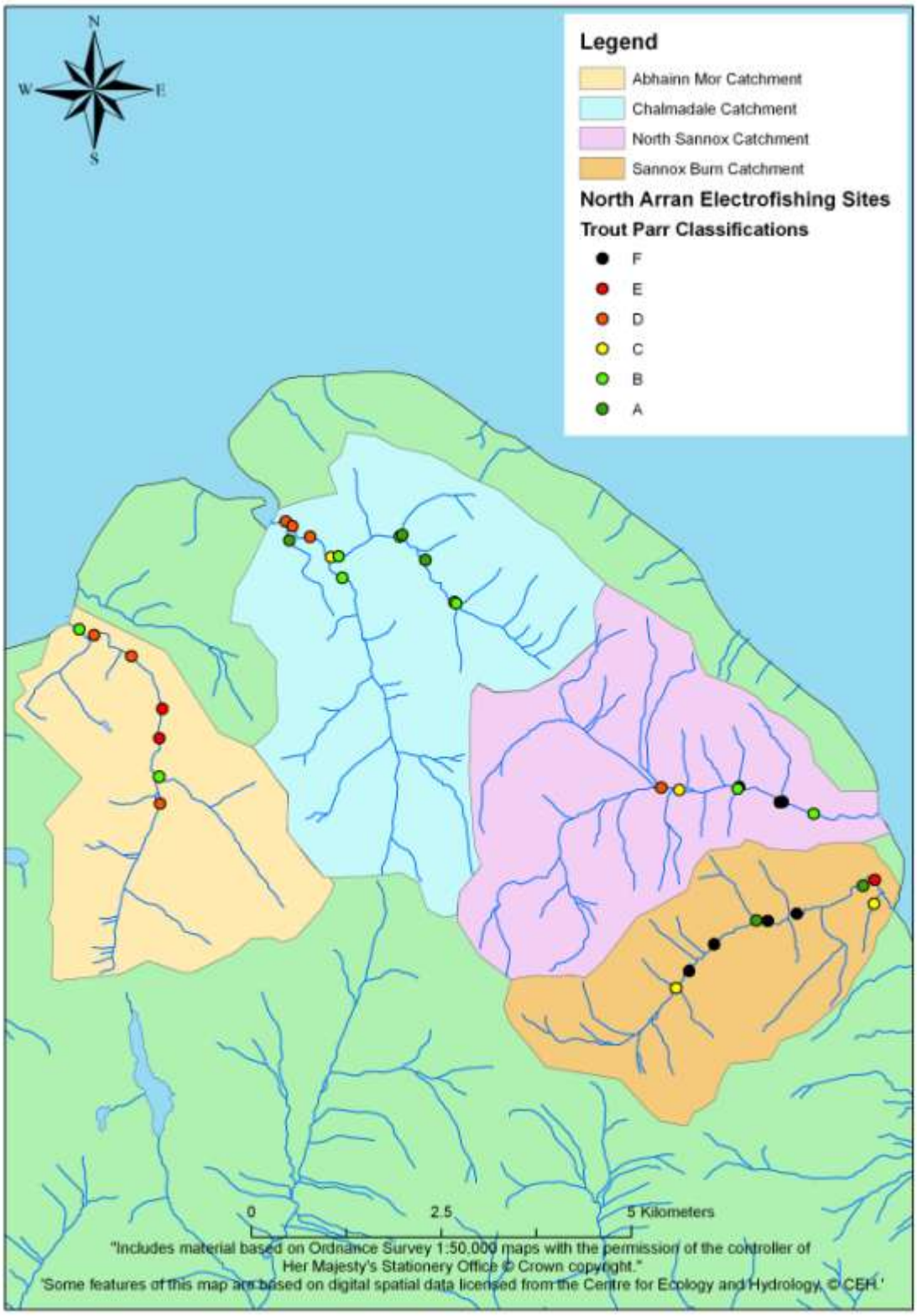



*Figure 3.4 Trout parr distribution and relative abundance in North Arran (SFCC classification)*

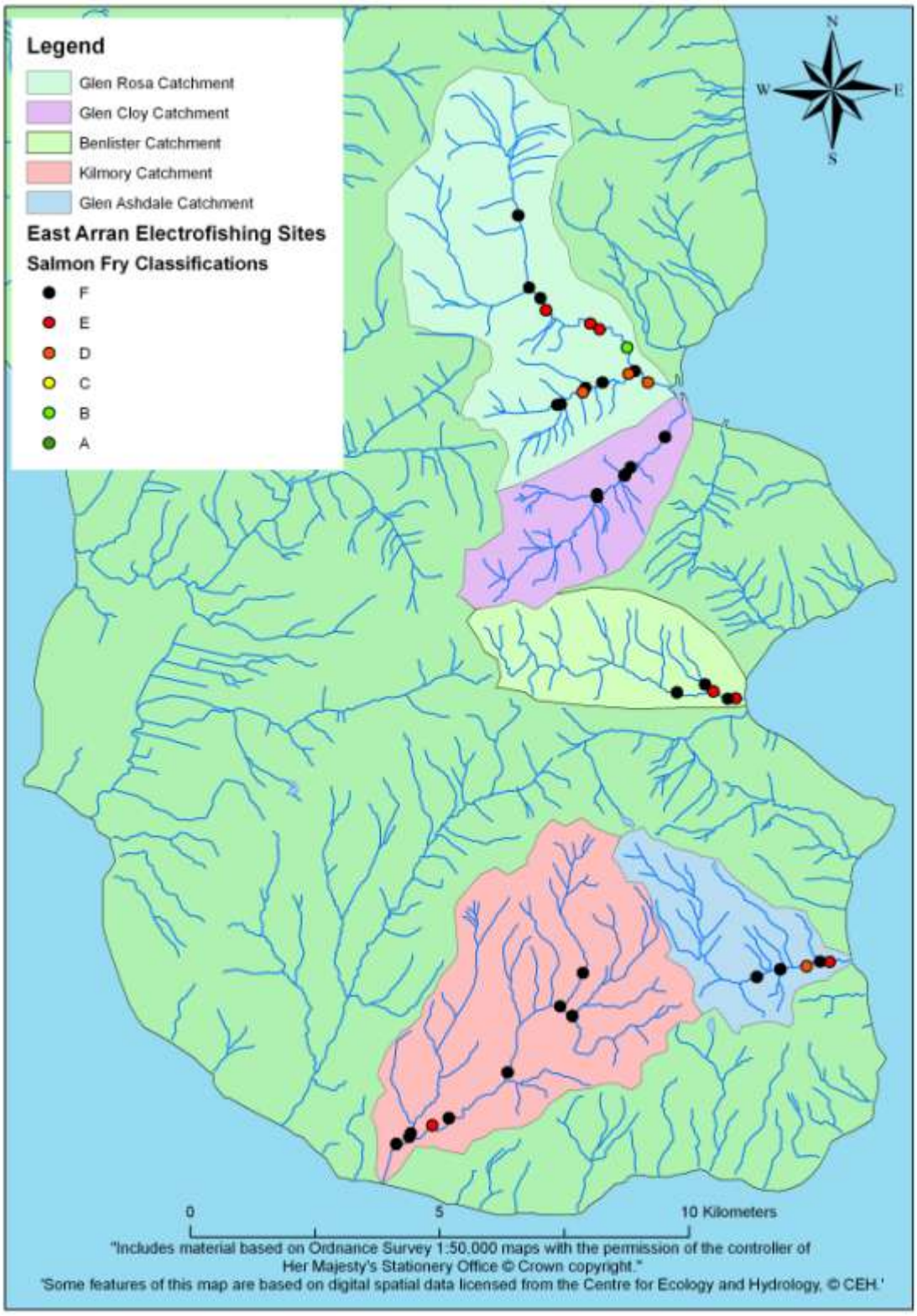



*Figure 3.5 Salmon fry distribution and relative abundance in East Arran (SFCC classification)*

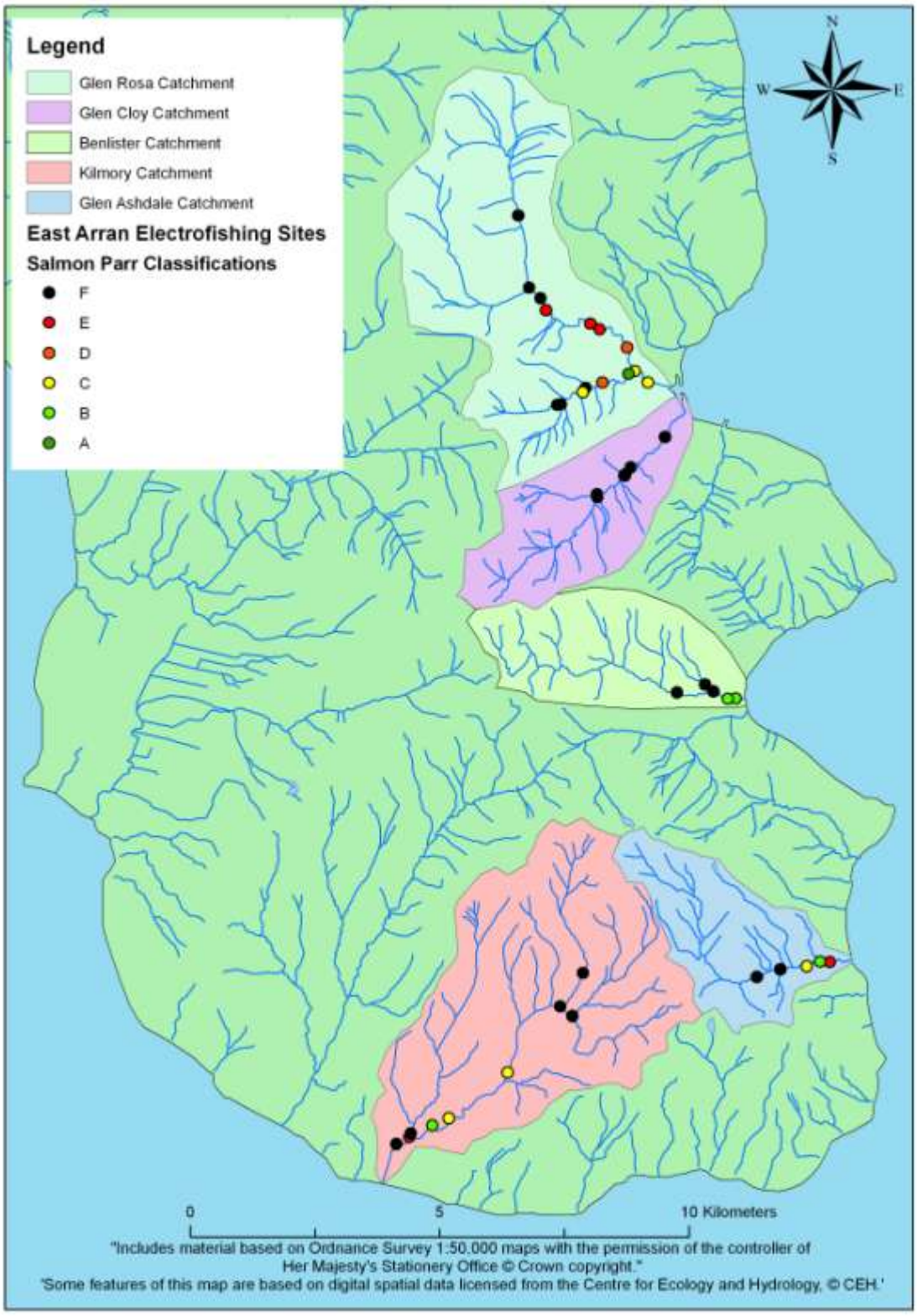



*Figure 3.6 Salmon parr distribution and relative abundance in East Arran (SFCC classification)*

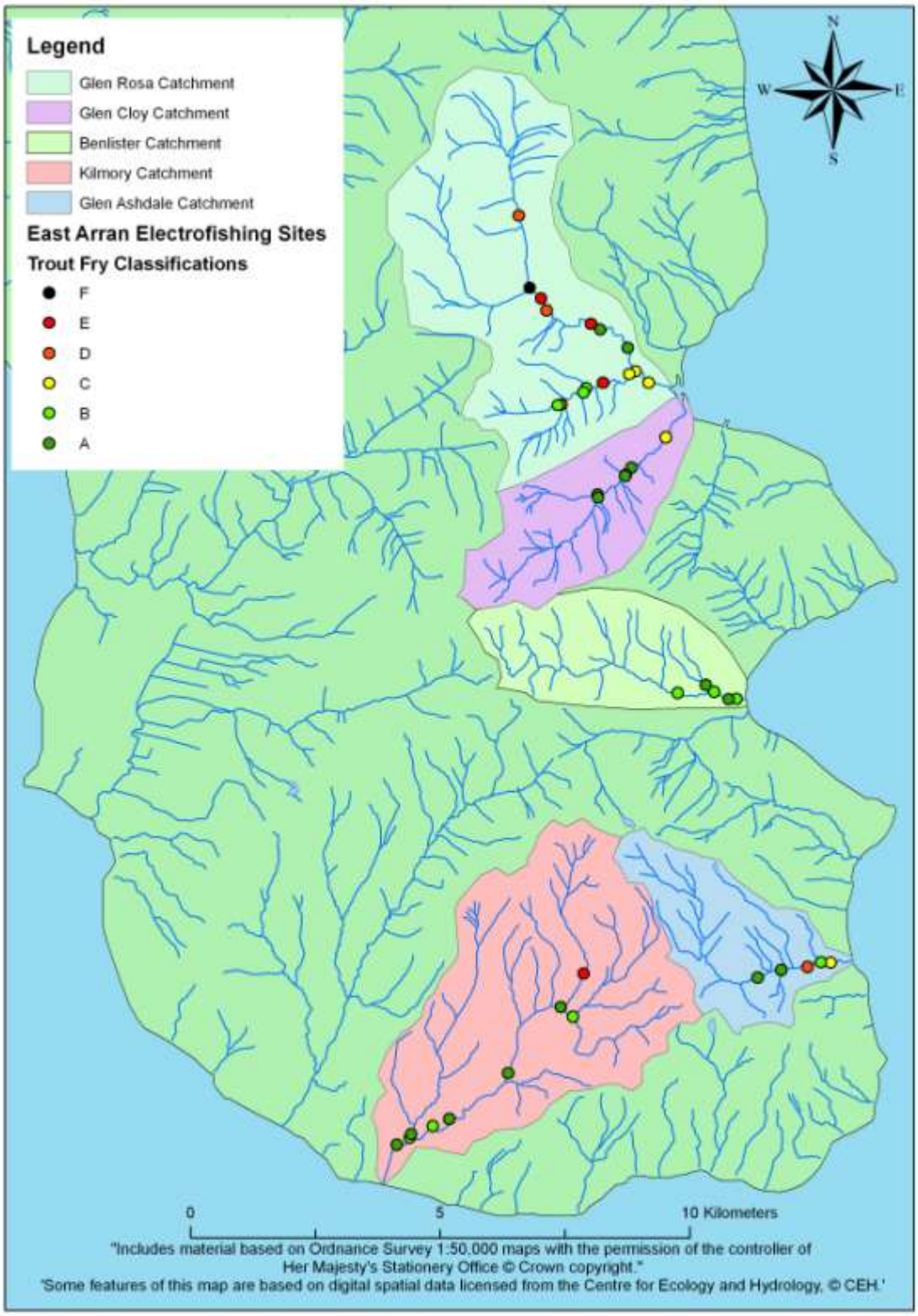



*Figure 3.7 Trout fry distribution and relative abundance in East Arran (SFCC classification)*

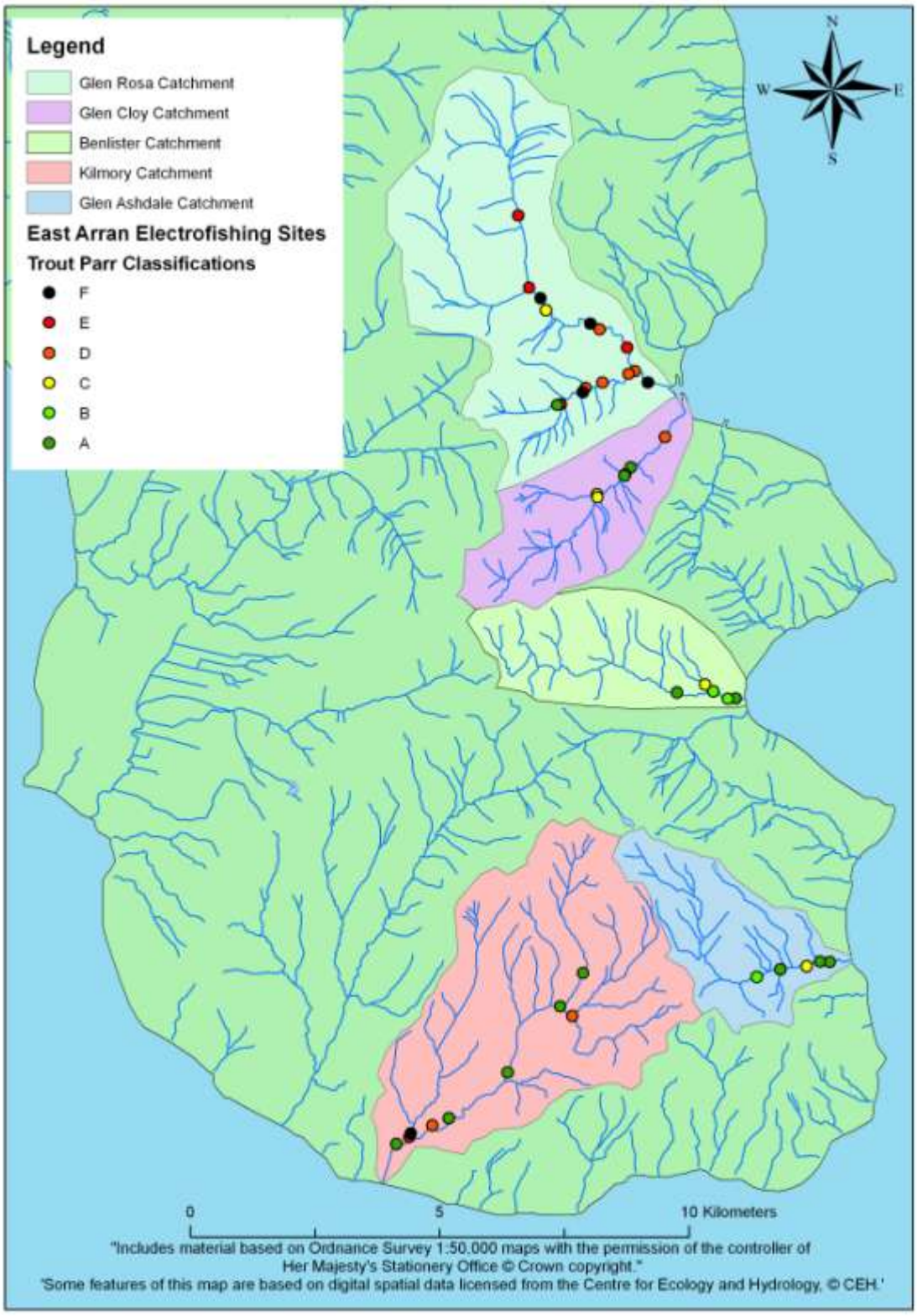



*Figure 3.8 Trout parr distribution and relative abundance in East Arran (SFCC classification)*

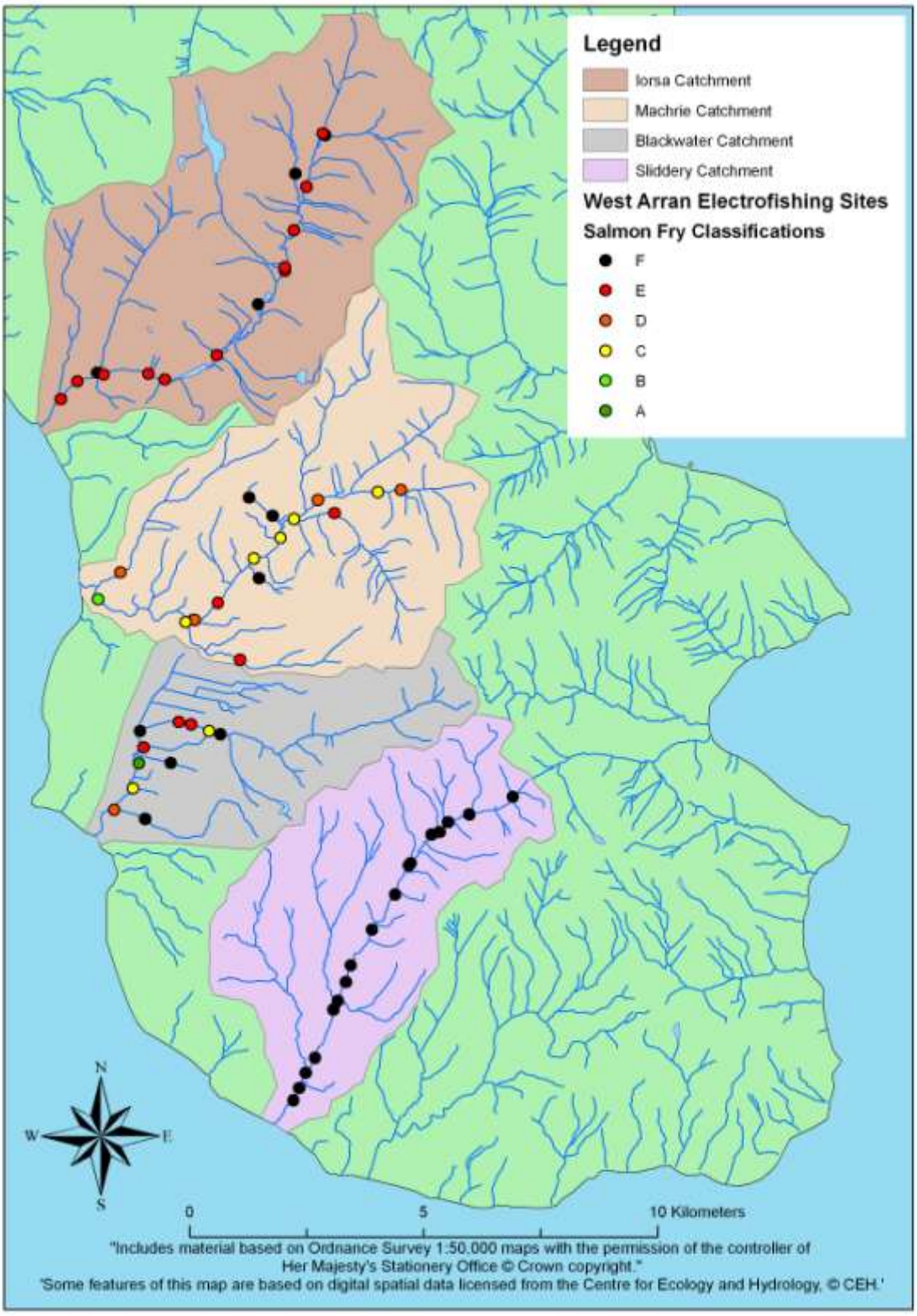



*Figure 3.9 Salmon fry distribution and relative abundance in West Arran (SFCC classification)*

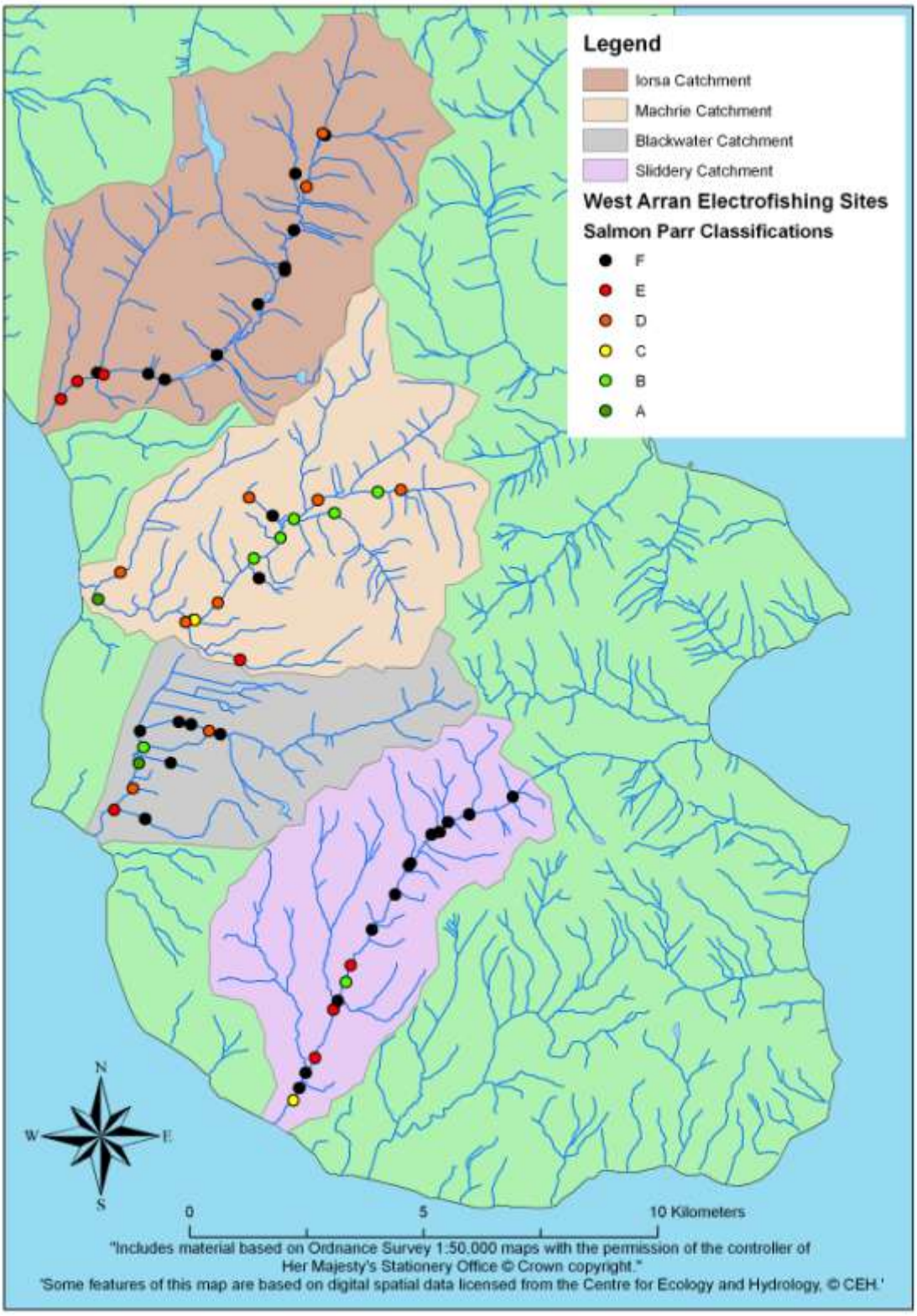



*Figure 3.10 Salmon parr distribution and relative abundance in West Arran (SFCC classification)*

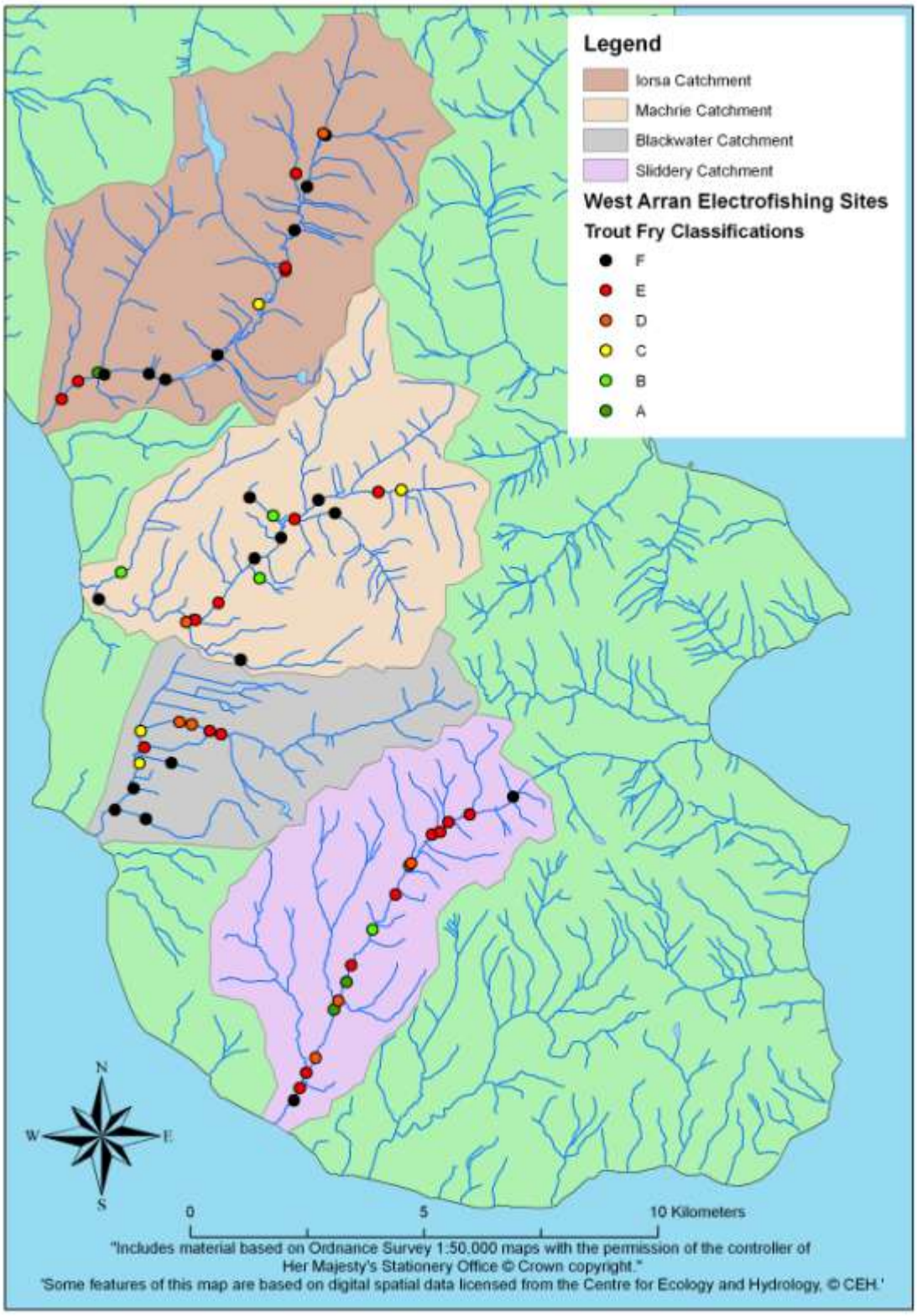



*Figure 3.11 Trout fry distribution and relative abundance in West Arran (SFCC classification)*

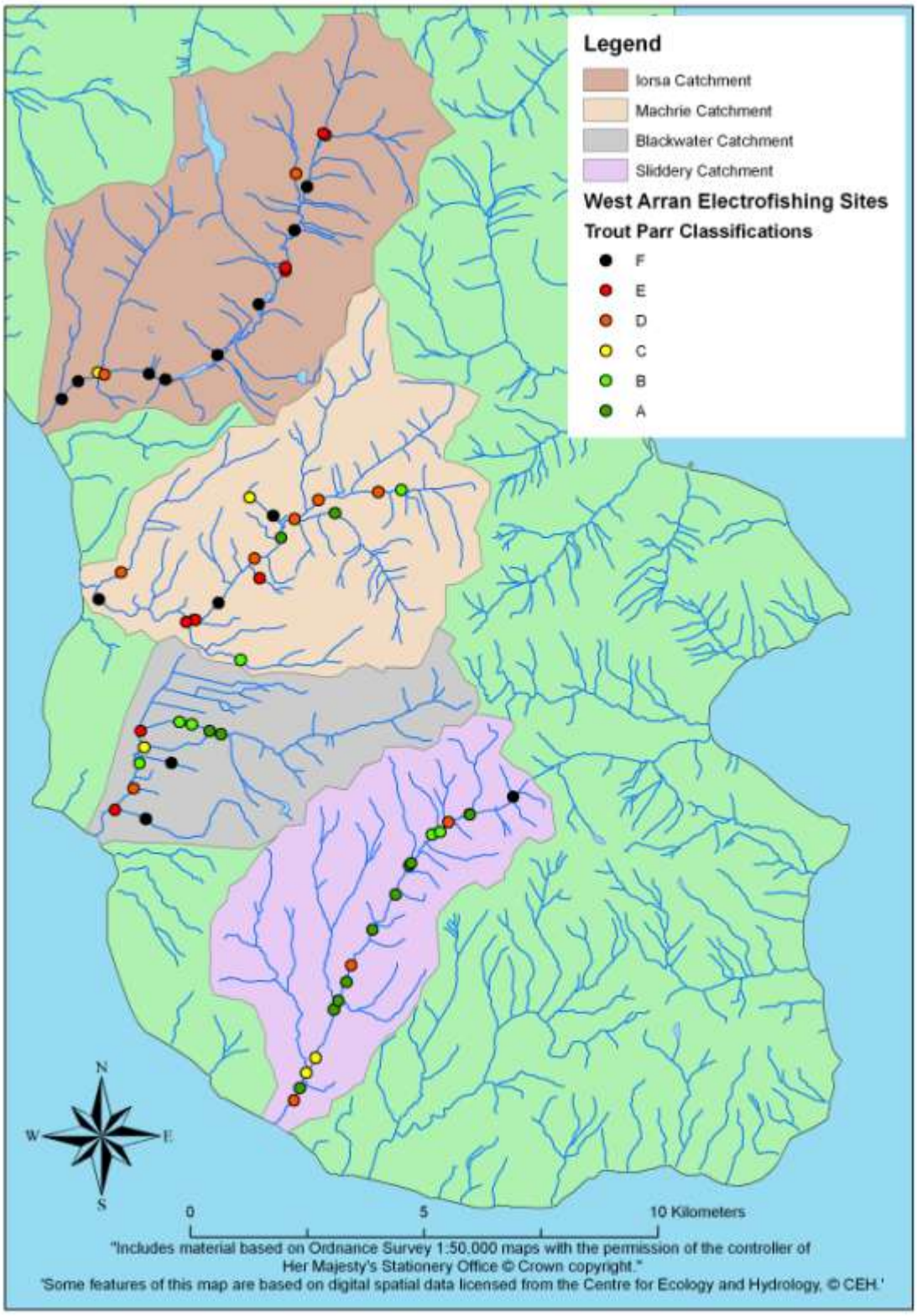


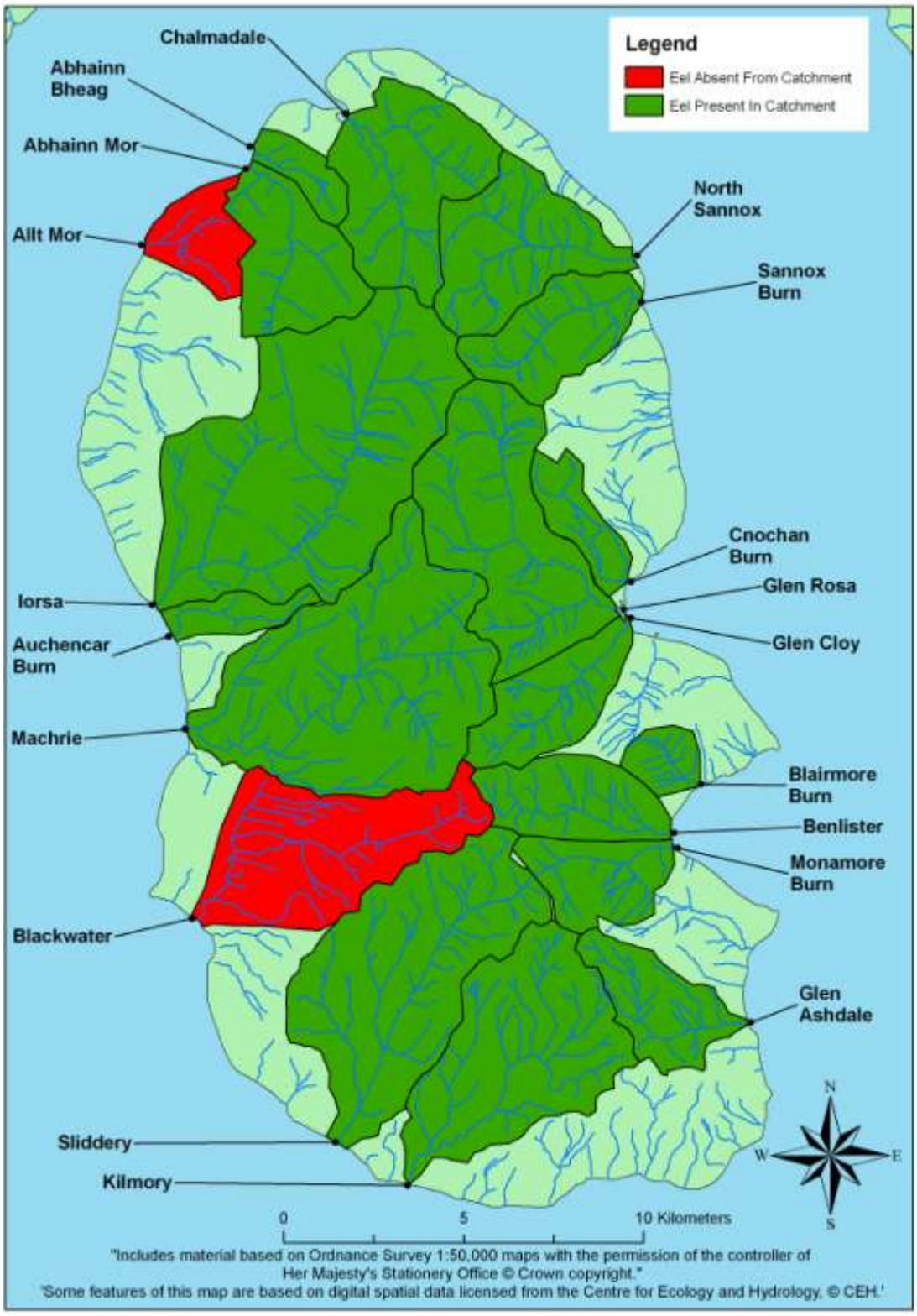

*Figure 3.12 Trout parr distribution and relative abundance in West Arran (SFCC classification)*

### *3.1.3 Non-salmonid fish*

The electrofishing surveys sampled European eels at 47 (33%) of the 142 sites sampled across all catchments surveyed. Flounder were sampled at four sites, two in the Chalmadale, one in the Glen Rosa and one in the Cnochan Burn. Lamprey ammocoetes (Lampetra spp.) were sampled at a single site on the Glen Rosa Water (Table 3.3). The distribution of eels on Arran is described in figure 3.13.

*Table 3.3 Distribution of non-salmonid fish*

| Catchment | No. sites | European Eel | Flounder | Lamprey spp. |
|---|---|---|---|---|
| *North* | | | | |
| Abhainn Mor | 7 | 1 | 0 | 0 |
| Chalmadale | 12 | 5 | 2 | 0 |
| North Sannox | 7 | 2 | 0 | 0 |
| Sannox | 9 | 1 | 0 | 0 |
| Abhainn Bheag | 1 | 1 | 0 | 0 |
| Allt Mor | 1 | 0 | 0 | 0 |
| *West* | | | | |
| Iorsa Water | 15 | 7 | 0 | 0 |
| Machrie Water | 16 | 2 | 0 | 0 |
| Black Water | 11 | 0 | 0 | 0 |
| Sliddery | 18 | 1 | 0 | 0 |
| Auchencar | 1 | 1 | 0 | 0 |
| *East* | | | | |
| Glen Rosa | 9 | 7 | 1 | 1 |
| Glen Shurig | 6 | 6 | 0 | 0 |
| Glencloy | 6 | 1 | 0 | 0 |
| Benlister | 5 | 3 | 0 | 0 |
| Glen Ashdale | 5 | 2 | 0 | 0 |
| Kilmory | 9 | 4 | 0 | 0 |
| Cnochan | 1 | 1 | 1 | 0 |
| Blairmore | 1 | 1 | 0 | 0 |
| Monamore | 2 | 1 | 0 | 0 |
| **Totals** | **142** | **47** | **4** | **1** |




*3.13 Distribution of European eels on Arran (presence/absence)*

3.2 Habitat survey

Approximately 70.25km of stream were surveyed in 284 survey sections (of 250m) in 14 catchments including the Glen Shurig tributary of the Glen Rosa Water (Table 3.4).

*Table 3.4 Habitat survey coverage and river channel type*

| Catchment | No. sections | Survey Length (km) |
|---|---|---|
| *North* | | |
| Abhainn Mor | 16 | 3.8 |
| Chalmadale | 15 | 3.9 |
| North Sannox | 12 | 3 |
| Sannox | 17 | 4.25 |
| *West* | | |
| Iorsa Water | 45 | 11.25 |
| Machrie Water | 37 | 9.25 |
| Black Water | 19 | 4 |
| Sliddery | 34 | 8.5 |
| *East* | | |
| Glen Rosa | 19 | 4.8 |
| Glen Shurig | 12 | 3 |
| Glencloy | 12 | 3 |
| Benlister | 13 | 3.2 |
| Glen Ashdale | 7 | 1.8 |
| Kilmory | 26 | 6.5 |
| **Total** | **284** | **70.25** |

3.2.1 Distribution and status of key habitats

The location and status of 134 significant obstacles, 219 adult fish holding pools and 132 spawning sites recorded in the surveys are described below.

3.2.1.1 Obstacles to fish passage

A total of 134 significant obstacles to fish passage was recorded during the surveys (Table 3.5, Figures 3.14 (North Arran), 3.15 (East Arran), 3.16 (West Arran)). The number of obstacles recorded in each catchment ranged from 4 in the Glen Ashdale Water to 33 in the Iorsa Water. Natural bedrock waterfalls were the most common type of the 50 (37%) natural obstacles identified. The surveys also identified 84 (63%) man-made obstacles that were mostly weirs and bridge aprons. A total of 122 (91%) of the obstacles recorded were adjudged to be potentially passable and 7 to be impassable to migratory salmonids. The potential passability of a further 5 obstacles were not confidently assigned.

*Table 3.5 Obstacles survey results*

| Catchment | No. of obstacles | Man-Made | Natural | Passable | Unsure | Not Passable |
|---|---|---|---|---|---|---|
| *North* | | | | | | |
| Abhainn Mor | 5 | 0 | 5 | 4 | 0 | 1 |
| Chalmadale | 9 | 9 | 0 | 9 | 0 | 0 |
| North Sannox | 14 | 12 | 2 | 14 | 0 | 0 |
| Sannox | 7 | 6 | 1 | 7 | 0 | 0 |
| *West* | | | | | | |
| Iorsa Water | 33 | 30 | 3 | 30 | 2 | 1 |
| Machrie Water | 12 | 12 | 0 | 12 | 0 | 0 |
| Black Water | 5 | 2 | 3 | 3 | 1 | 1 |
| Sliddery | 10 | 9 | 1 | 10 | 0 | 0 |
| *East* | | | | | | |
| Glen Rosa | 6 | 1 | 5 | 4 | 0 | 2 |
| Glen Shurig | 2 | 0 | 2 | 2 | 0 | 0 |
| Glencloy | 9 | 2 | 7 | 8 | 0 | 1 |
| Benlister | 8 | 1 | 7 | 8 | 0 | 0 |
| Glen Ashdale | 4 | 0 | 4 | 3 | 0 | 1 |
| Kilmory | 10 | 0 | 10 | 8 | 2 | 0 |
| **Total** | **134** | **84** | **50** | **122** | **5** | **7** |

3.2.1.1 Adult holding pools

A total of 21 significant adult fish holding pools was recorded during the surveys (Table 3.6). The number of pools recorded in each catchment range from 5 in the Benlister and Black Water to 50 in the Iorsa catchment. A total of 130 (59%) pools were identified as being sub-optimal with the remaining 89 (41%) as being optimal. The predominant type of cover available to fish was the depth of water and from boulders within pools. Overhanging tree canopy and bankside vegetation also provided significant cover for fish. The area of pool habitat potentially available ranged from 310m² in the Benlister to 43,000 in the Iorsa Water, which includes a loch in the catchment.

*Table 3.6 Adult holding pools results*

| Catchment | No. Pools | Sub optimal | Optimal | Primary cover | Secondary cover | Pool Area ($m^2$) |
|---|---|---|---|---|---|---|
| *North* | | | | | | |
| Abhainn Mor | 9 | 3 | 6 | Depth | Canopy | 574 |
| Chalmadale | 8 | 2 | 6 | Depth | Canopy | 620 |
| North Sannox | 13 | 7 | 6 | Depth | Canopy | 1086 |
| Sannox | 11 | 10 | 1 | Depth | Bank | 539 |
| *West* | | | | | | |
| Iorsa Water | 50 | 44 | 6 | Depth | | 43000 |
| Machrie Water | 26 | 19 | 7 | Depth | Canopy | 4435 |
| Black Water | 5 | 2 | 3 | Depth | Canopy | 545 |
| Sliddery | 22 | 7 | 15 | Depth | Canopy | 2557 |
| *East* | | | | | | |
| Glen Rosa | 22 | 10 | 12 | Depth | Bank | 2505 |
| Glen Shurig | 4 | 3 | 1 | Depth | Bank | 110 |
| Glencloy | 7 | 5 | 2 | Depth | Canopy | 366 |
| Benlister | 5 | 1 | 4 | Depth | Canopy | 310 |
| Glen Ashdale | 13 | 10 | 3 | Depth | Canopy | 615 |
| Kilmory | 24 | 7 | 17 | Depth | Canopy | 2432 |
| **Total** | **219** | **130** | **89** | | | **59694** |

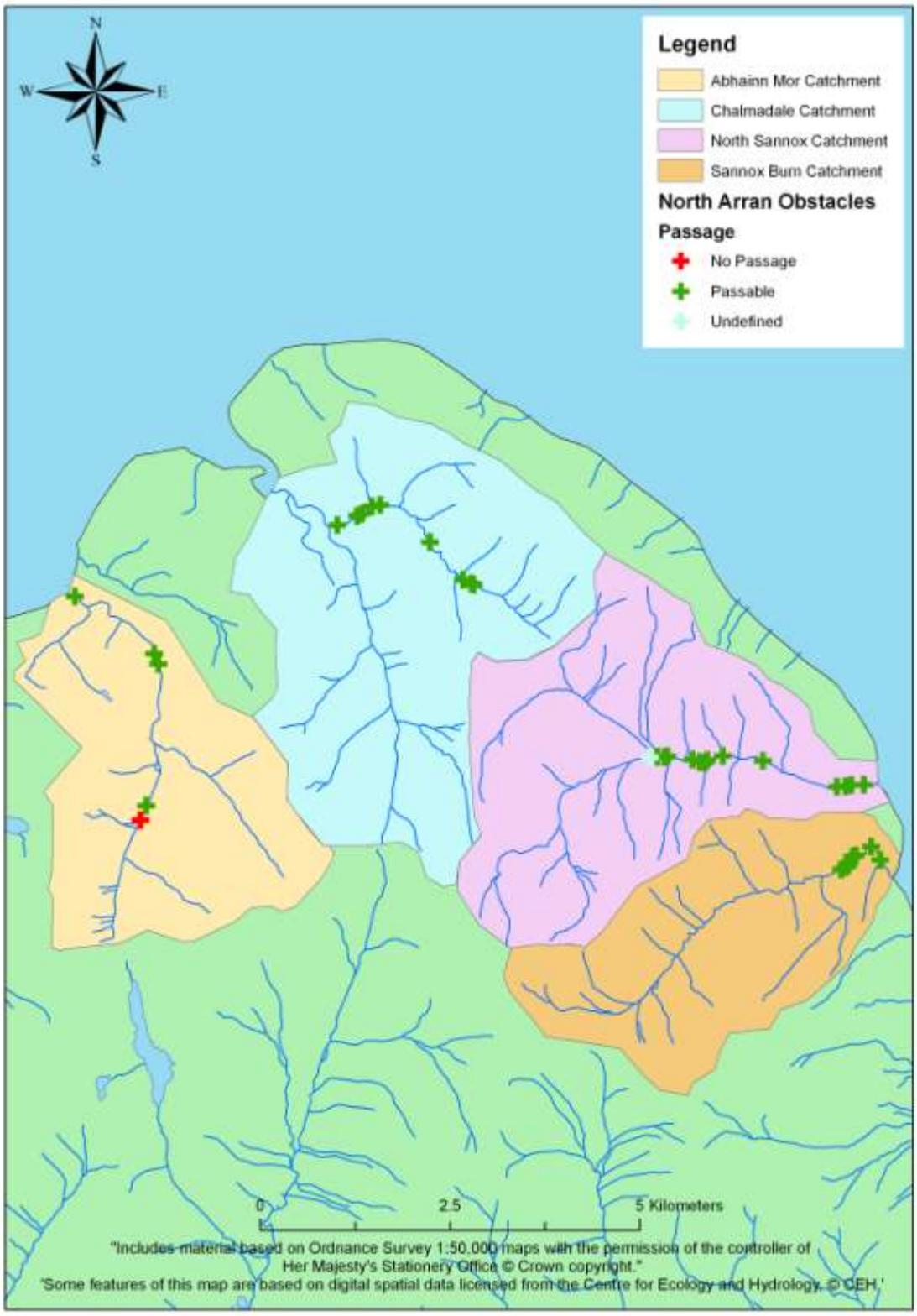



*Figure 3.14 Distribution of obstacles to salmonid fish passage in North Arran*

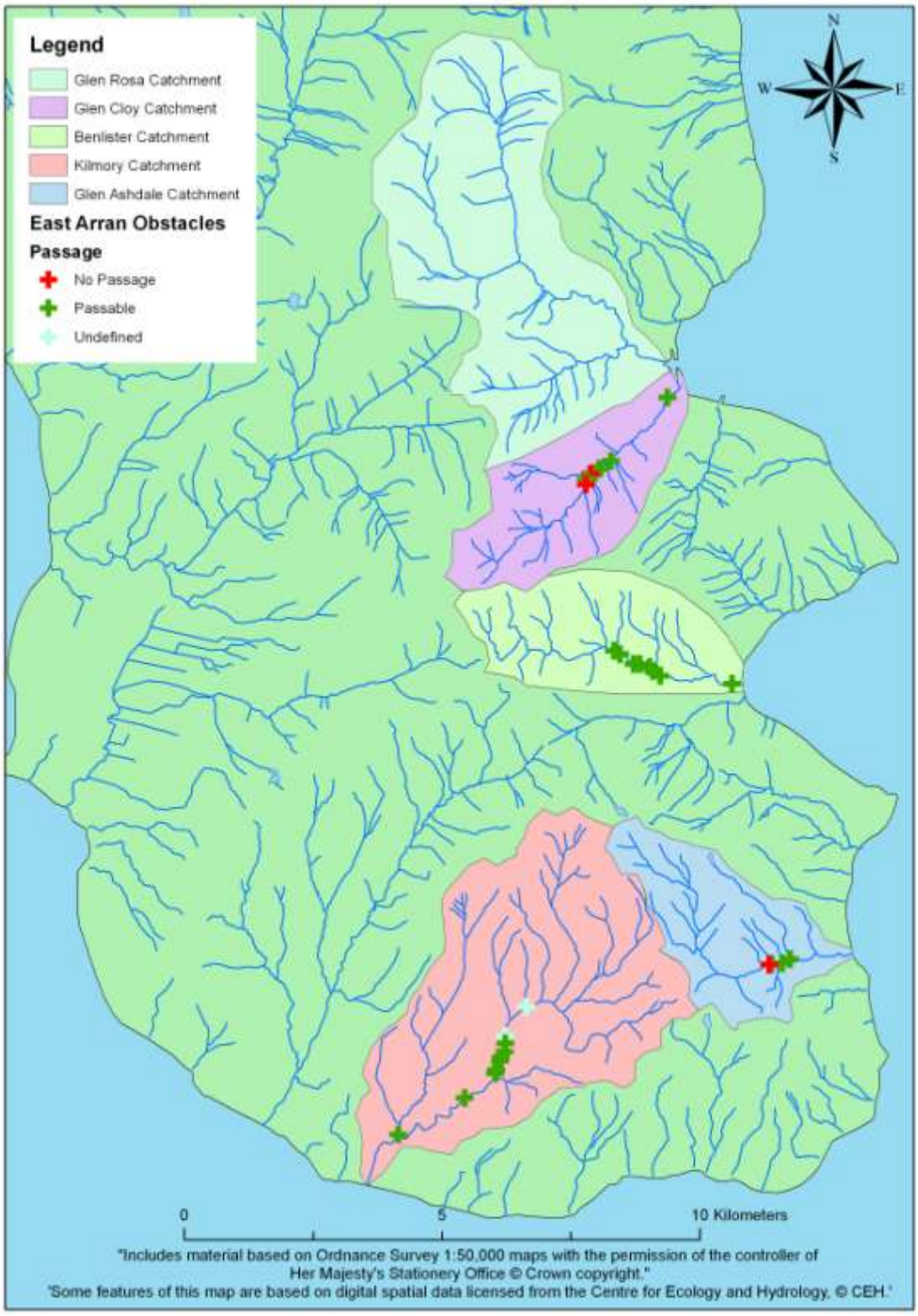



*Figure 3.15 Distribution of obstacles to salmonid fish passage in East Arran*

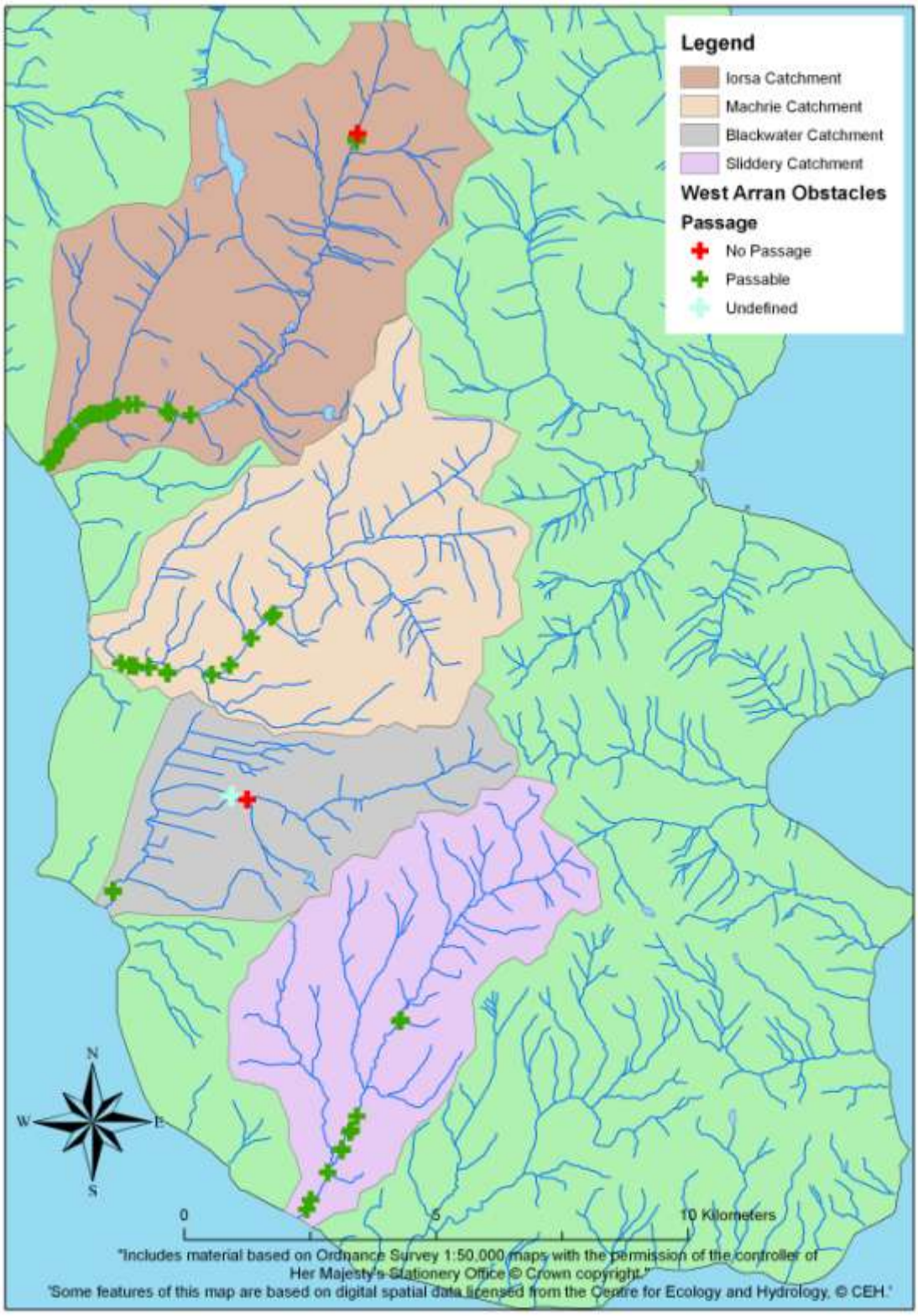



*Figure 3.16 Distribution of obstacles to salmonid fish passage in West Arran*

3.2.1.1 Spawning sites

A total of 132 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 North Sannox to 38 in the Glen Rosa catchment, including Glen Shurig. Of the 14 catchments surveyed, 8 (57%) had less than 80m$^2$ of potential spawning habitat: the greatest areas of potential spawning were found in the Machrie Water and Glen Rosa catchments, with 679m$^2$ and 701m$^2$ respectively. A total of 78 (59%) of sites were identified as being sub-optimal for salmonid spawning, with the remaining 52 (41%) having optimal conditions.

*Table 3.7 Spawning habitat survey results*

| Catchment | No. sites | Total area (m²) | Sub-optimal | Optimal | Predominant suitability | Predominant features |
|---|---|---|---|---|---|---|
| *North* | | | | | | |
| Abhainn Mor | 5 | 73 | 3 | 2 | Trout | Pool / Ford |
| Chalmadale | 5 | 35 | 0 | 5 | Salmon / trout | Pool / LWD* |
| North Sannox | 1 | 30 | 1 | 0 | Salmon | Pool |
| Sannox | 7 | 155 | 5 | 2 | Salmon | Pool |
| *West* | | | | | | |
| Iorsa Water | 20 | 422 | 10 | 10 | Salmon / trout | Pool / Braid |
| Machrie Water | 21 | 679 | 13 | 8 | Salmon | Pool |
| Black Water | 10 | 250 | 6 | 4 | Salmon | Ford |
| Sliddery | 4 | 41 | 4 | 0 | Salmon | Pool |
| *East* | | | | | | |
| Glen Rosa | 29 | 671 | 13 | 14 | Salmon | Ford / Pool |
| Glen Shurig | 9 | 30 | 8 | 1 | Trout | Pool / Braid |
| Glencloy | 6 | 48 | 4 | 2 | Salmon | Pool |
| Benlister | 3 | 38 | 2 | 1 | Salmon | Pool / Braid |
| Glen Ashdale | 7 | 52 | 6 | 1 | Trout | Pool / LWD* |
| Kilmory | 5 | 65 | 3 | 2 | Salmon | Pool / LWD* |
| **Total** | **132** | **2589** | **78** | **52** | | |

In the northern catchments, the predominant suitability of spawning habitat available was for salmon (larger substrates) even though no salmon were found to be present in these catchments (see table 3.2, figure3.1). In eastern catchments, the predominant type of spawning habitat available in the Glen Rosa, Kilmory, Benlister and Glen Cloy catchments was for salmon (larger substrates) and for trout (smaller substrates) in the Glenshurig and Glenashdale catchments. Habitat features associated with spawning sites were mostly pools and other features such as fords, braided channels and large woody debris (LWD). In western catchments, the predominant suitability was for salmon, with pools frequently associated with the spawning areas. The relative distributions of pools to spawning areas are demonstrated in figures 3.17, 3.18 and 3.19.

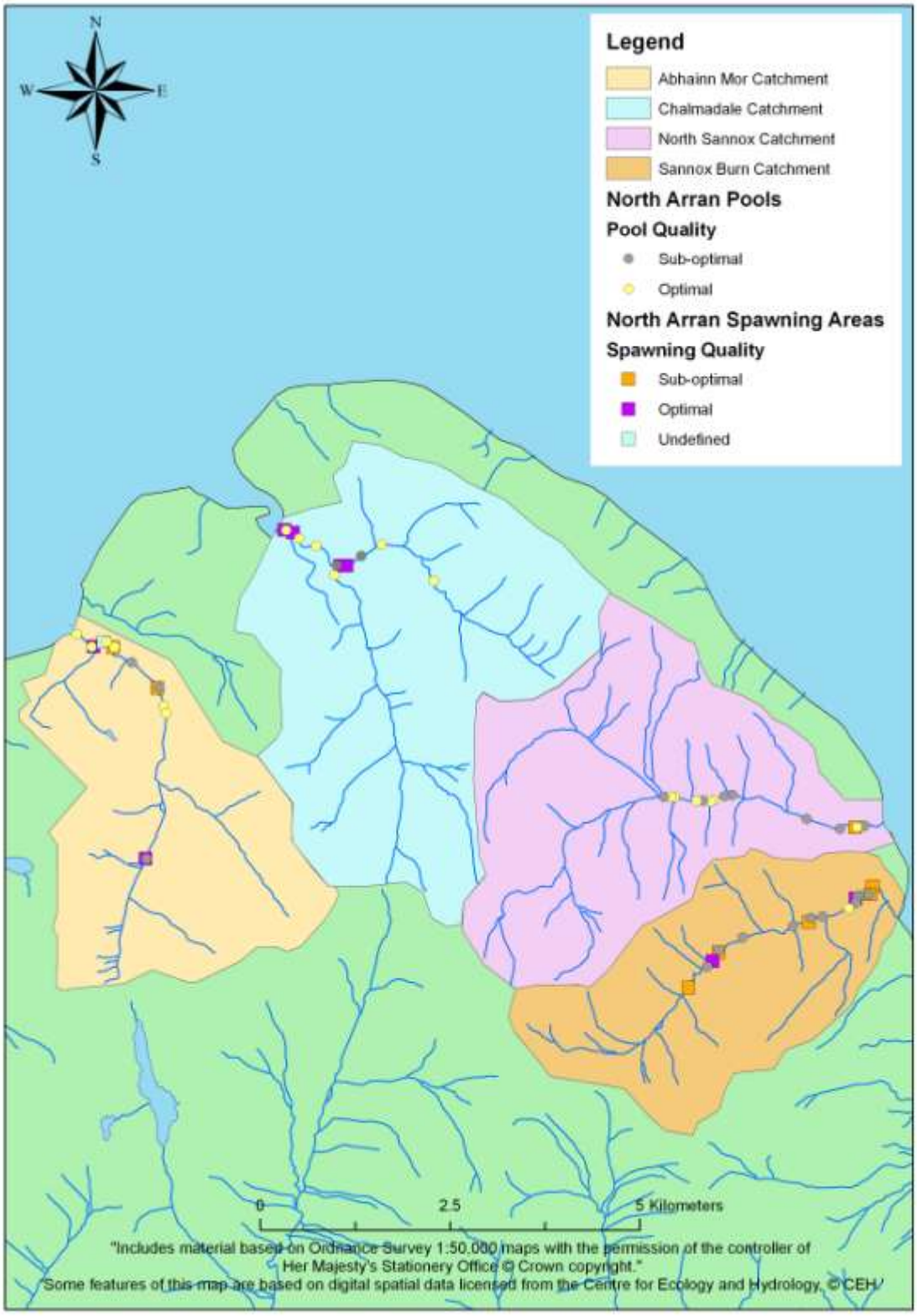



*Figure 3.17 Distribution of spawning areas and pools in North Arran*

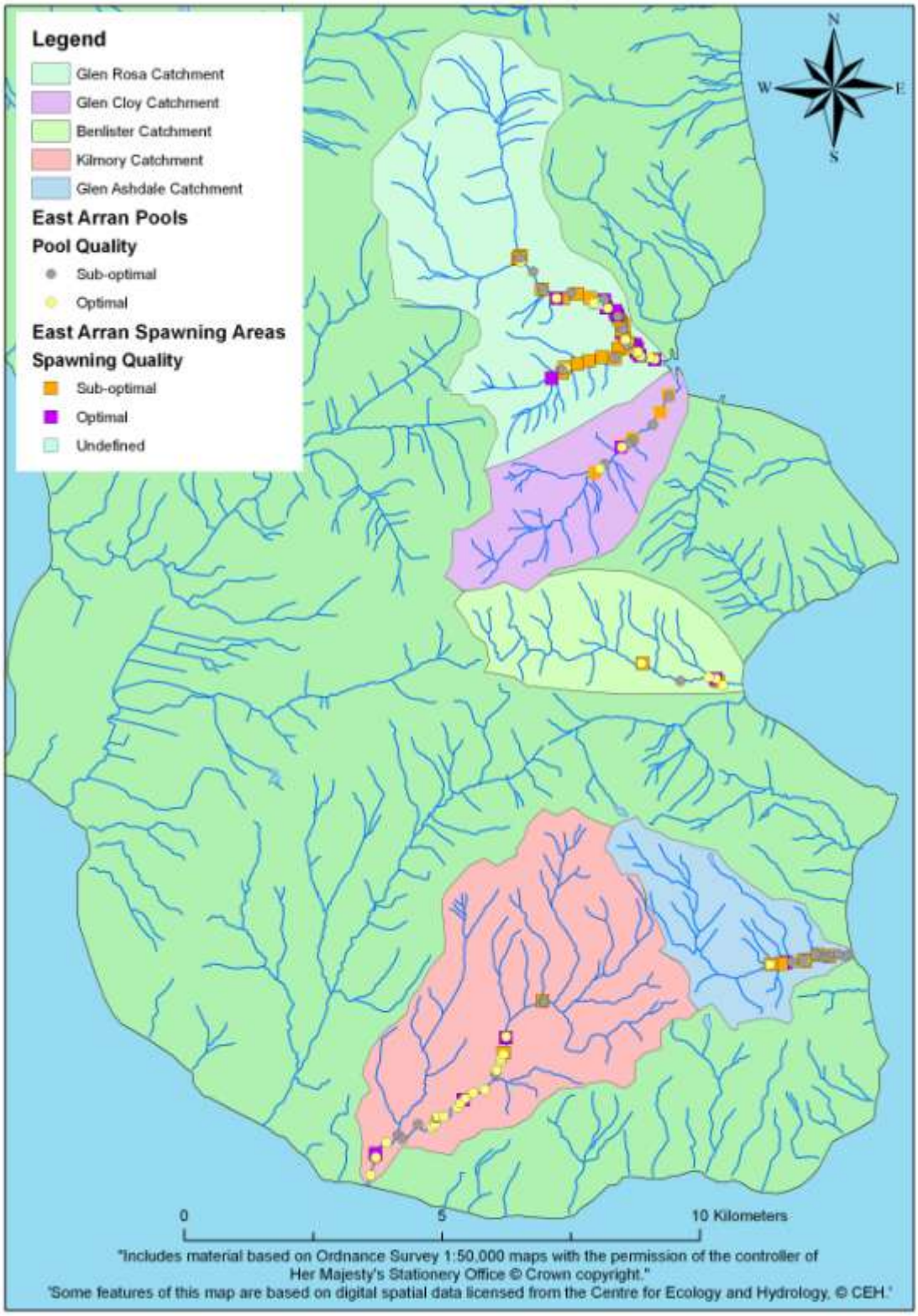



*Figure 3.18 Distribution of spawning areas and pools in East Arran*

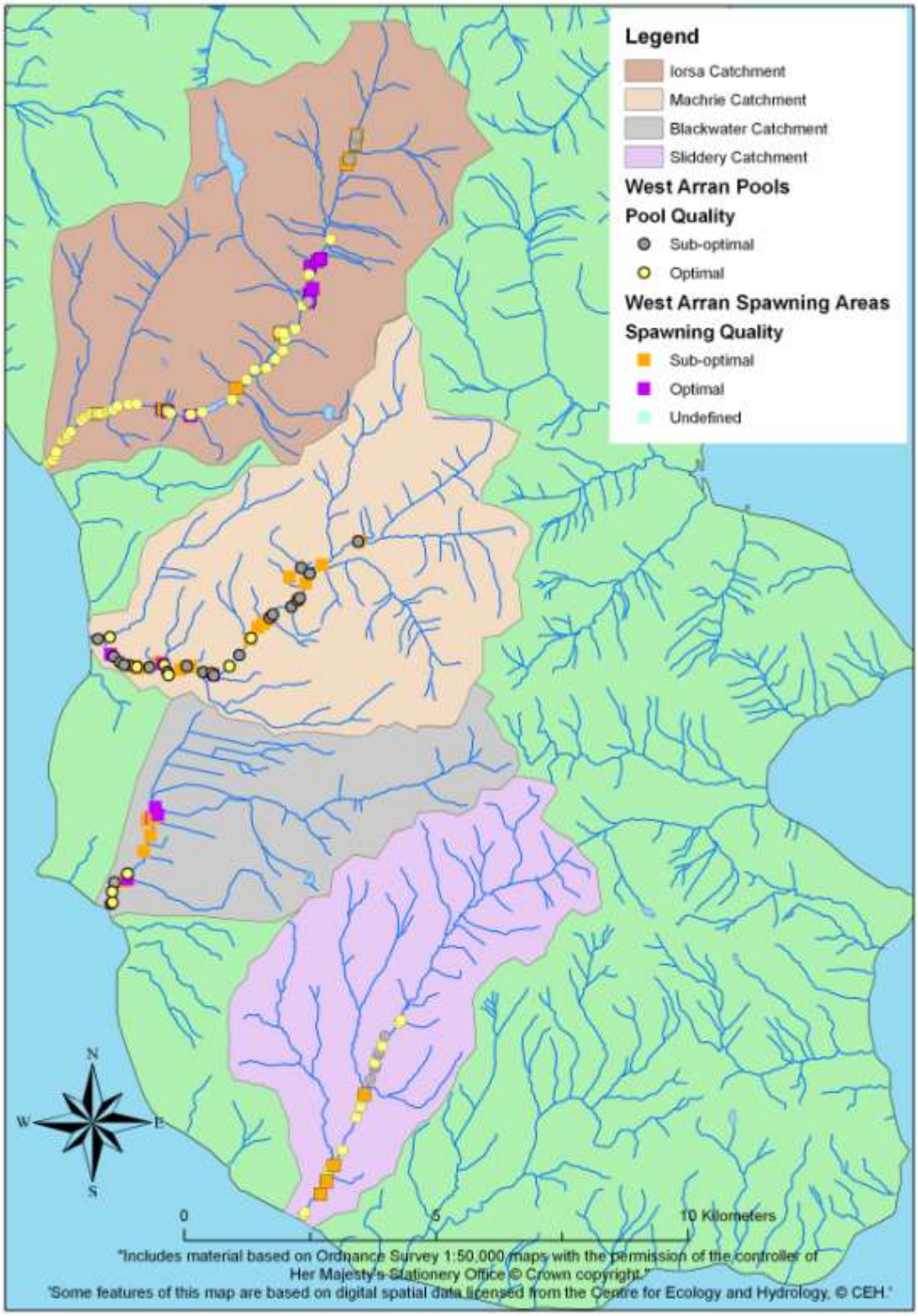



*Figure 3.19 Distribution of spawning areas and pools in West Arran*

*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. Fry habitat was not well represented throughout Arran, with only 8.6% of all sections surveyed having habitat suitable only for fry. No fry habitat was present in the northern catchments. Mixed juvenile habitats were recorded in all catchments, with 87% of all sections having mixed habitat, and scores of predominantly moderate to good (scores 3 to 4). Deep juvenile habitat was recorded in 26% of sections surveyed with scores of predominantly poor to moderate (2 to 3).

*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 |
| *North* | | | | | | | |
| Abhainn Mor | 16 | 0 | | 15 | 3 | 0 | |
| Chalmadale | 15 | 0 | | 15 | 4 | 2 | 1 |
| North Sannox | 12 | 0 | | 11 | 2 | 1 | 2 |
| Sannox | 17 | 0 | | 17 | 3 | 8 | 2 |
| *West* | | | | | | | |
| Iorsa Water | 45 | 12 | 3 | 28 | 4 | 27 | 4 |
| Machrie Water | 27 | 2 | 0 | 21 | 3 | 7 | 2 |
| Black Water | 19 | 2 | 3.5 | 17 | 3 | 6 | 2 |
| Sliddery | 34 | 0 | | 34 | 3 | 0 | |
| *East* | | | | | | | |
| Glen Rosa | 18 | 5 | 3 | 15 | 3 | 15 | 3 |
| Glen Shurig | 7 | 1 | 2 | 7 | 4 | 1 | 3 |
| Glencloy | 12 | 0 | | 10 | 4 | 0 | |
| Benlister | 12 | 0 | | 12 | 3 | 1 | 3 |
| Glen Ashdale | 7 | 0 | | 7 | 4 | 0 | |
| Kilmory | 26 | 1 | 3 | 23 | 4 | 2 | 2 |
| **Total** | **267** | **23** | | **232** | | **70** | |

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 2.9 on the Glenashdale to 9.7 on the North Sannox and averaged 4.9 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 |
|---|---|---|---|---|---|---|
| *North* | | | | | | |
| Abhainn Mor | 5.8 | 0.0 | 1.3 | 0.0 | 3.4 | 1.0 |
| Chalmadale | 3.1 | 0.0 | 1.0 | 0.0 | 0.0 | 2.1 |
| North Sannox | 9.7 | 2.0 | 3.7 | 0.0 | 2.3 | 1.7 |
| Sannox | 6.1 | 3.1 | 2.4 | 0.0 | 0.5 | 0.2 |
| *West* | | | | | | |
| Iorsa Water | 3.3 | 1.4 | 0.1 | 1.2 | 0.2 | 0.4 |
| Machrie Water | 4.6 | 0.1 | 1.4 | 0.6 | 2.3 | 0.2 |
| Black Water | 5.3 | 2.5 | 0.8 | 0.0 | 2.0 | 0.0 |
| Sliddery | 5.8 | 0.0 | 2.2 | 0.0 | 3.2 | 0.4 |
| *East* | | | | | | |
| Glen Rosa | 5.7 | 2.7 | 0.2 | 1.9 | 0.4 | 0.4 |
| Glen Shurig | 3.7 | 0.3 | 1 | 0 | 0.3 | 2 |
| Glencloy | 4.7 | 1.7 | 1 | 0.3 | 0.3 | 1.3 |
| Benlister | 5 | 0.9 | 1.9 | 0.3 | 0.3 | 1.6 |
| Glen Ashdale | 2.9 | 1.1 | 1.1 | 0 | 0.6 | 0 |
| Kilmory | 3.5 | 0.3 | 2.2 | 0 | 0 | 1.1 |
| **Average** | **4.9** | **1.1** | **1.4** | **0.3** | **1.1** | **0.9** |

Downgrades identified during the surveys were mostly attributed to bedrock substrates (1.4 per km), fine sediments in the substrate matrix (1.1 per km) and unstable substrates (1.1 per km). Lower numbers of downgrades were attributed to high or low gradient (0.9 per km) and lack of in-stream cover (0.3 per km). The number of riparian downgrades identified per km of survey varied between 2.0 on the Glenshurig to 5.3 on the Benlister and averaged 3.3 per km for all catchments surveyed.

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

| Catchment | Total No. | No Shade | Over Shade | Bank Cover | Predominant Land use |
|---|---|---|---|---|---|
| *North* | | | | | |
| Abhainn Mor | 3.7 | 3.7 | 0.0 | 0.0 | Moorland heath |
| Chalmadale | 2.6 | 0.3 | 1.8 | 0.5 | Rough pasture / Broadleaf trees |
| North Sannox | 2.7 | 2.3 | 0.3 | 0.0 | Broadleaf trees / Moorland heath |
| Sannox | 3.8 | 2.8 | 0.5 | 0.5 | Broadleaf trees / Moorland heath |
| *West* | | | | | |
| Iorsa Water | 4.2 | 4.0 | 0.0 | 0.2 | Moorland heath |
| Machrie Water | 3.0 | 0.8 | 0.9 | 1.4 | Rough pasture |
| Black Water | 2.3 | 0.0 | 2.3 | 0.0 | Improved grazing |
| Sliddery | 4.8 | 1.6 | 1.2 | 2.0 | Mixed (broadleaf trees / grazing / moorland heath) |
| *East* | | | | | |
| Glen Rosa | 3.6 | 2.3 | 1.3 | 0 | Rough Pasture |
| Glen Shurig | 2 | 0 | 2 | 0 | Broadleaf Trees |
| Glencloy | 2.7 | 0 | 2 | 0.7 | Broadleaf Trees |
| Benlister | 5.3 | 0 | 3.1 | 2.2 | Broadleaf Trees |
| Glen Ashdale | 3.4 | 0 | 1.1 | 2.3 | Broadleaf Trees |
| Kilmory | 2.8 | 0.6 | 1.5 | 0.6 | Conifer plantation |
| **Average** | **3.3** | **1.3** | **1.3** | **0.7** | |

Downgrades identified during the surveys were mostly attributed to over-shading of the channel from a dense canopy of trees (1.3 per km), a lack of shade from trees (1.3 per km) and a low provision of bank-side cover (0.7 per km).

3.2.2.3 Invasive Non-Native Species (INNS)

The presence of invasive non-native plant species were recorded during habitat surveys (table 3.11). The catchment with the greatest number of recorded sections with INNS was Glencloy, with 6 sections with Japanese knotweed and 6 sections with *Rhododendron ponticum*. No INNS were recorded in the northern catchments and no Himalayan balsam was recorded on any catchment surveyed. Japanese knotweed was recorded in 30 (11%) of sections surveyed and was the most common INNS found. *Rhododendron ponticum* was found in 24 (9%) of sections surveyed.

*Table 3.11Catchments with Invasive Non-Native Species.*

| Catchment | No. of Survey Sections | INNS - no. of sections where present | | |
|---|---|---|---|---|
| | | Japanese Knotweed | *Rhododendron ponticum* | Himalayan balsam |
| *North* | | | | |
| Abhainn Mor | 16 | 0 | 0 | 0 |
| Chalmadale | 15 | 0 | 0 | 0 |
| North Sannox | 12 | 0 | 0 | 0 |
| Sannox | 17 | 0 | 0 | 0 |
| *West* | | | | |
| Iorsa Water | 45 | 0 | 0 | 0 |
| Machrie Water | 27 | 0 | 9 | 0 |
| Black Water | 19 | 7 | 0 | 0 |
| Sliddery | 34 | 2 | 0 | 0 |
| *East* | | | | |
| Glen Rosa | 18 | 1 | 3 | 0 |
| Glen Shurig | 7 | 1 | 2 | 0 |
| Glencloy | 12 | 6 | 6 | 0 |
| Benlister | 12 | 6 | 3 | 0 |
| Glen Ashdale | 7 | 3 | 0 | 0 |
| Kilmory | 26 | 4 | 1 | 0 |

3.3 Other results

During the habitat surveys, a range of other data was collected on in-stream and riparian issues that we have not reported here. This detailed information, in conjunction with the electrofishing data, can be utilised to develop catchment management plans for individual catchments.

# 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

The distribution of juvenile salmon and trout are discussed below.

### *4.1.1 Atlantic salmon*

In healthy populations of Atlantic salmon, natural impassable barriers or large areas of unsuitable habitat such as bedrock substrates or smaller tributaries are likely to limit the distribution of juveniles within a catchment. Additionally, relatively small catchments may not be able to support sufficient numbers of smolts to sustain a population over the long-term. The data collected indicate that 11 of the 20 catchments surveyed as part of this study do not currently support salmon populations even though there appears sufficient habitat in some of them. This is particularly apparent in the north of Arran where no salmon were found in all six catchments surveyed. Although, these are not particularly large catchments, the habitat available for salmon appear favourable, although it is noted that these are possibly less productive generally for fish due to the base-poor geology of the area.

In catchments where salmon were found, distribution of juveniles was fragmented and they appear to be absent in the upper reaches of catchments where suitable habitats 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. The patchy distribution of age classes also indicates that spawning activity may be infrequent and not currently 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 habitat issues and similarly reflected in the distribution of trout. This survey indicates that the poor distribution of salmon even in larger catchments is widespread and therefore is likely to be primarily attributable to low numbers of sea returns. Although most naturally available habitats of salmon appear accessible, the habitat survey found two man-made obstacles in the Blackwater catchment, a bridge apron and a dam that appear to restrict the distribution of salmon at this time.

### *4.1.2 Brown trout*

Unlike salmon, juvenile brown trout were widely distributed and populations consisted of a range of age groups. This is likely to be due to a higher abundance of adult spawners that are able to recruit more frequently. It may also 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.

### *4.1.3 Non-salmonid species*

Although not sampled in all sites the distribution of European eel was also 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 one site this does not accurately reflect the distribution of potential lamprey. Habitat survey data indicate that potential habitat for juvenile lamprey (ammocoetes) may be limited to a small number of catchments, but further sampling will be required to establish their distribution. Flounder were sampled in the lower reaches of two 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. There were no three-spine stickleback sampled during the study, but this 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

The relative abundance of fish sampled during the survey is discussed below in relation to factors potentially affecting the productivity of fish populations.

### *4.2.1 Atlantic salmon*

Where present the relatively low abundance of salmon fry and parr sampled 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 relatively low, further inhibiting the maintenance and recovery of

salmon populations. The relatively low abundance found in most sites indicate that there may be a potential threat of local extinctions in some catchments, but time series data will be required to understand trends over time.

The relatively higher abundance of trout sampled in these catchments indicate that freshwater habitat condition is likely to be sufficient to support relatively healthy populations of salmonid fish, but further investigation of water chemistry and invertebrate populations will be required to fully substantiate this. Therefore the primary factors affecting salmon populations are likely to be marine-based. International, national and local fishery research implicates a number of known and unknown factors affecting marine survival of salmon, reducing adult sea returns and recruitment in freshwater. 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 historical data to suggest that there is significant recovery in the rivers sampled as part of this survey.

#### 4.2.2 Brown and sea-run trout

The relatively moderate-to-good abundance of trout fry and parr 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 in the middle and lower reaches 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 local marine survival of sea trout is relatively good or at least better than that of salmon in the oceanic habitats of the North Atlantic.

### 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 over-wintering of older juveniles in relation to the limited availability of resources (suitable habitats or food) to support them.

The condition of freshwater habitats observed during the study indicates that despites some unfavourable elements, habitats were generally favourable for salmonid fish (depth variation, stable flow and coarse in-stream substrates). Therefore, the low level of salmon abundance 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 is associated with other factors not related to competition between

individuals. These factors can be an artefact of extreme weather events such as high flows that mobilise significant amounts of bed materials (redd wash-out) or drought conditions that reduces habitat availability. Other independent factors related to water chemistry and low pH events that can potentially cause significant mortality of ova and early fry stages in catchments with base-poor geology. The susceptibility of some catchments on the Isle of Arran may be a factor potentially affecting productivity, but there are no robust data to evaluate this potential at this time.

*4.3.1 River morphology*

Historical channel re-alignment (straightening) was found to be restricted to relatively small areas in the lower reaches of a number of catchments, particularly in relation to urban development and infrastructure development. it is likely that such morphological alterations have reduced productivity of habitats to the detriment of fish populations, but the relatively small areas affected in most catchments is not likely to explain the low abundance of fish found at most sites. However, two catchments had more widespread changes to morphology; the Blackwater and lower reaches of the Iorsa. The Blackwater has been subject to significant re-alignment throughout much of the mainstem and also appears to have some recent localised disturbance of habitats from channel maintenance works, which are likely to affect productivity on an on-going basis if continued. The Iorsa has boulder weirs placed at a relatively high frequency in the lower reaches, which are likely to increase the abundance of deeper water habitats suitable for adult fish.

*4.3.2 In-river substrates*

Habitat survey data indicated that all catchments have substrates that are favourable for recruitment and nursery habitat for salmonid fish, although there appears to be some potential for instability of in-stream substrates in some catchments that may potentially affect salmonid fish recruitment. Intensive grazing of livestock and subsequent loss of tree cover in riparian zones in some areas of some catchments are likely to exacerbate over-supply and instability of substrates and over-widening of the channel. Land drainage associated with the two main land uses; livestock farming and forestry has potential to increase peak flows and reduce base summer flows which may reduce productivity of fish habitats.

4.3.3 Riparian habitats

The existing and historical land-use of Arran strongly influences the condition of riparian habitats found in the survey. Most catchments were found to have a high abundance of improved and rough grazing land adjacent to river banks. Typically this was reflected in the survey as a lack of shading of the river channel, but is also likely to reduce productivity for fish in other ways such as the reduction of leaf litter entering the aquatic ecosystem, large woody debris that increase habitat complexity and tree roots that stabilise banks and provide cover for fish. Forestry activity is limited to fewer of

the catchments surveyed, but where present did not appear to conform to Forest and Water Guidelines, probably because much of the planting appeared to have been undertaken prior to the guidelines being implemented. Where present, broadleaf woodland habitats were found to be fragmented by other land uses and increasing the quality and distribution of this habitat type is likely to have long-term benefit for fish populations.

Invasive non-native plants were found in a number of catchments, particularly on the east of the Island where Japanese knotweed is common in the lower reaches of rivers close to urban developments. Their current influence on the productivity of habitats is not likely to be significant, but control and preferably eradication will be required at an early stage to ensure further habitat is not affected. More widespread is Rhododendron ponticum which also has potential to reduce productivity of freshwater habitats and fish populations.

### 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 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 and interaction with farmed escapee salmon may have an influence on the current status of migratory salmonid fish. Some data is now being collected on sea lice burdens of sea trout as part of the Area Management Agreement process, but there is insufficient locally derived time-series data to fully evaluate the relative significance of aquaculture activity on migratory fish at this time.

### 4.5 Factors affecting survey results and interpretation of data

The stocking of juvenile salmon and trout into freshwater habitats has been undertaken by a number of fishery managers and angling clubs on the isle of Arran. It is possible that some juvenile fish sampled in the Glen Rosa, Machrie and Iorsa catchments during this survey are of hatchery origin and therefore the results given may not be fully representative of the distribution and abundance of wild spawned fish. Further evaluation of stocking records and collection of juvenile fish data will be required to fully evaluate any benefits attained by stocking, but the results of this survey indicate that stocking activity does not appear to be attaining optimal population levels for salmon.

It is likely that the abundance of the species found in the survey are likely to be somewhat higher than recorded as one-run sampling does not usually catch all the fish present at a survey site. However, the classification scheme used to assess juvenile salmonid fish abundance may be somewhat biased toward higher classes as the quintile ranges utilised in the SFCC scheme are collected from fish populations that have undergone 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.

# 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 Island of Arran.

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 trout indicate that there is significant potential for sustainable fisheries for sea trout in the catchments surveyed at this time, although it is important to effectively control such fisheries to ensure that sufficient spawning escapement and recruitment of smolts is maintained over time.

Conversely, the current status of salmon populations in all catchments indicate that they are not able to support exploitative fisheries at this time and further exploitation is likely to decrease potential for future restoration and increase the potential for local extinctions.

### *5.1.1 Maximise spawning escapement*

The apparent low numbers of sea returns of salmon and consequent poor 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.

## 5.3 Aquaculture management

Changes to the management of marine salmon fish farm production as part of the Firth of Clyde Area Management Agreement are likely 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 been sufficient in recent times to maintain juvenile populations, but further information on older adolescent and mature age classes are required to fully evaluate the current status. Maintaining high efficiency in lice control will also be required in combination with on-going development of effective sea lice treatments and implementation of production strategies to minimise potential impact of sea lice on wild fish recruitment.

Containment of farm stock is also a priority for both the aquaculture and fisheries sectors. 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. Any significant loss and subsequent interaction of farm stock with wild fish has potential to undermine the fitness of wild salmon populations and therefore it is important to have effective containment and in the event of an escape of farm fish an adequate recapture plan.

# 6 CONCLUSIONS

Interpretation of the data collected by fish and habitat surveys in 2008 and 2009 provides a number of conclusions at this time.

## 6.1 Fish distribution

Fish surveys undertaken sampled four native fish species; Atlantic salmon, brown trout, European eel, and flounder. The distribution of juvenile salmon was patchy, but juvenile trout were sampled at all sites surveyed. The limited distribution of salmon is likely to be an artefact of populations decline.

## 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 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. Time constraints and weather conditions meant that the number of sites sampled for lamprey was minimal in this survey. Further assessment of lamprey will be required to fully evaluate their status on the Island.

## 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 on the Isle of Arran 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 useful 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 diversity within the salmon population is to be maintained.

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