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SURVEY REPORT

Improving Management of Fish Habitats in the Lower Firth of Lorn, Argyll 2010: Summary Report

This report should be quoted as:

Argyll Fisheries Trust (2011). Improving Management of Fish Habitats in the Lower Firth of Lorn, Argyll 2010: Summary report. Argyll Fisheries Trust, Inveraray, Argyll

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Summary

Improving Management of Fish Habitats in the Lower Firth of Lorn, Argyll 2010: Summary Report.

Background

Argyll Fisheries Trust undertook habitat surveys of six river catchments; the Nell, Euchar, Oude, Abhainn na Cille, Barbreck and Add in the lower Firth of Lorn in 2010. The aims of the surveys were 1) to provide a baseline survey so that future comparison studies can assess the health of the fisheries and the benefits secured from any habitat works, and 2) to enable land managers and landowners to identify riparian works which will enhance biodiversity and the fishery and potential sources of grant aid to help fund that work.

The surveys also sought to provide a context to better interpret existing fish population data collected during fish surveys undertaken in 2006-08. This report summarises the findings of the surveys and provides management advice for fisheries and habitat improvement. Catchment specific reports of the study findings provide have been produced that provide detailed information and management prescriptions under sections headed “Habitat Management” that may be used to further develop and improve catchment management plans.

Main findings

Habitat surveys were undertaken on over 84km of main channels in six catchments. The location and assessment of 81 obstacles to fish passage, 353 significant adult holding pools and 340 spawning locations was recorded.

The connectivity of habitats to fish from the sea were mostly influenced by naturally occurring high gradient features such as waterfalls and cascades, but there are fish passes on two hydro-electric dams on the river Add a weir on a tributary of the River Euchar where there are no current passage for migratory fish. The use of water resources on the river Oude may also influence the passage of fish upstream.

The condition of juvenile salmonid fish habitat was mostly of moderate status, but was poor in one catchment (Oude) due to use of water resources and more commonly in all catchments due to changes to river morphology and riparian habitat due to land use influences. The most abundant type of juvenile habitat found was suited to a range of age

classes (mixed), while habitat specific to fry (young of the year) and deep juvenile (older parr and sub-adults) were also present, but were not abundant in any one reach of any catchment.

The factors affecting productivity of juvenile habitats were identified for in-stream conditions including modification of river channels, bedrock, fine sediments and lack of large woody debris which are likely to reduce fish cover. Factors affecting riparian habitats were widespread due to lack of bank cover for fish and low diversity of riparian vegetation. Over-shading or 'tunnelling' of the stream channel was found at few locations in areas which were fenced from livestock or natural gorges. One section surveyed in afforested reaches of the River Add did not appear to meet current Forestry and Water guidelines, but most other sections had been recently felled or restructured.

Data collected on fish and water conductivity between 2006 and 2008 indicate that water chemistry is relatively productive compared to other areas of Argyll. Juvenile salmon were widespread in the Nell, Euchar, Barbreck and Add catchments and of relatively moderate-to-good abundance at most sites surveyed. Salmon parr were found some sites in the Oude catchment, but no fry were recorded. Juvenile trout were less well distributed compared to salmon, which may have been due to poor marine survival of post-smolt sea trout or an artifact of the poor condition of smaller tributary streams preferred for recruitment by trout.

The following conclusions were reached:

The provision of a fish pass or weir removal is required to restore the connectivity of fish habitats in the Euchar catchment (Abhainn Bragleenbeg). Regular inspection of the fish pass facilities at the dams on the Add catchment and monitoring of salmonid fish upstream will be required to ensure fish passage is maintained (as there are no fish counter information). There may be potential to improve recruitment of salmonid fish in the River Oude with changes to the regulation of flow, but this will require further study and assessment to inform future management options.

The restoration of natural river morphology in significant reaches of the River Add (Kilmartin Burn), Barbreck, Abhainn na Cille and the Nell (Feochan Bheag and River Lonan) are likely to have significant long-term benefit for fish populations and wider biodiversity. However, there are significant resource, technical and land use considerations to be better understood and overcome if ecological status is to be improved.

Agriculture is the most significant land use affecting riparian habitats, which are mostly open to grazing and in places, poaching by livestock. Localised fencing of stream banks affected by grazing may improve the diversity of riparian vegetation, but may prevent or impair natural recovery of morphology where river channels have been modified. An integrated approach to control of grazing and restoration of stream morphology is likely to be required to achieve widespread and significant improvement. The planting of or regenerating of existing native trees in riparian zones in combination with effective fencing is likely to have longer-term benefit for management of water temperature, which may be a limiting factor for salmonid fish in the future depending on the localised effects of future climate change. Forestation of the upper Add catchment has a significant influence on riparian habitat, which is currently being re-structured to achieve standards outlined in the Forest and Water Guidelines. Further work may be necessary post-felling to restore native broadleaf woodland on a significant scale in riparian zones, particularly where deer numbers may influence regeneration of existing trees.

Timely measures for control and eradication of Japanese Knotweed on the Nell and Euchar catchments are required to prevent further spread. Measures for prevention of introduction and spread of all priority invasive non-native species such as knotweed, *R. ponticum* (Feochan Bheag and Abhainn na Cille) and Himalayan Balsam (Nell) are likely to have longer-term benefits in protecting against new threats to biodiversity. The minnows found in fish surveys are widespread, but further translocation must be avoided to prevent competition and biosecurity risks to native fish. Biosecurity and other threats to native fish resources are also posed by aquaculture activity in freshwater catchment of the Oude where fish data indicate that the local salmon populations are vulnerable to competition and inter-breeding with escapee farm salmon. Freshwater escapes of smolts from Loch an Losgainn Mhor in the Abhainn na Cille catchment may also contribute to competition and pose genetic risks to wild populations. Analysis of genetic samples (Nell and Euchar) indicate that salmon populations are genetically diverse, which is a priority for the management and maintenance of wild fish resources, particularly where stocking may be undertaken or there are potential for fish farm escapes to be or have been significant.

The data collected on fish indicate that salmon and particularly sea trout populations are not likely to support exploitation by fisheries at this time, but operating fisheries on conservation-minded principles of catch and release will maximise spawning escapement of sea run adult fish and stimulate restoration of the fishery resource. Management and regulation of the use of local marine resources, principally the coastal net fishery, aquaculture and future development of marine renewable will have a significant influence on the health and survival

of migratory species during the marine phase of their life-cycle over and above other wider issues related to climate change.

Acknowledgements

Argyll Fisheries Trust thanks the project partners, Scottish Natural Heritage (SNH) and Scottish & Southern Energy for their support. 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 habitat surveys on six catchments in the lower Firth of Lorn in 2010 (Figure 1.1). The aims of the surveys were to establish baseline data on the accessibility and quality of fish habitats; to better interpret existing fish survey data and provide as basis for improvement in the productivity of fish populations and the performance of fisheries; to generate catchment-based reports to inform fishery management plan objectives; to better inform management of the use of land and water resources. Information for land managers interested in carrying out habitat improvements is found in section 5.2 of this report, in appendices II and II and in the catchment specific reports.

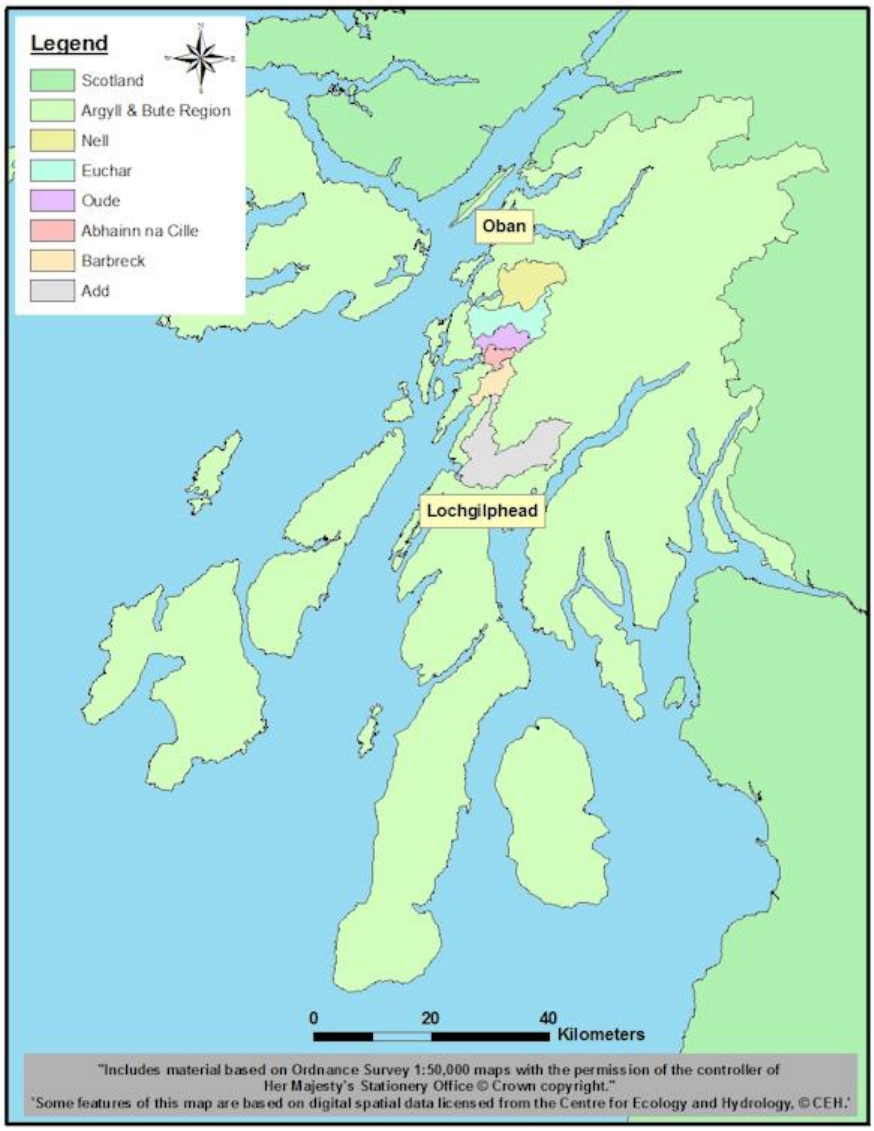

Figure 1.1 Lower Firth of Lorn catchments surveyed in 2010

The information on fish populations and their habitats is required to inform a wide range of stakeholders of the status of the resource; and to enable responsible authorities to consult effectively with potential development of renewable energy schemes.

This report summarises the findings of the surveys undertaken in 2010 and compares fish data collected in 2006-08 (AFT, 2009). The 2009 fish surveys report is provided as an appendix (appendix IV) to this report, and the main results of those surveys are reproduced in this report. Catchment specific reports that provide more detailed information on the study findings are also available.

1.1 The catchments surveyed

There are a number of characteristics of geology, topography and human induced pressures that may influence the distribution and status of fish populations and the productivity of freshwater habitats.

1.1.1 *Geology and use of land and water resources*

The catchments surveyed in the Lower Firth of Lorn are primarily influenced by base geology (figure 1.2). In the northern catchments of the Nell, the Euchar and the Oude, the geology is dominated by igneous extrusive rock with strata of igneous intrusive rock types. More central and southern catchments are dominated by metamorphic rock again interlaced with igneous intrusive rocks.

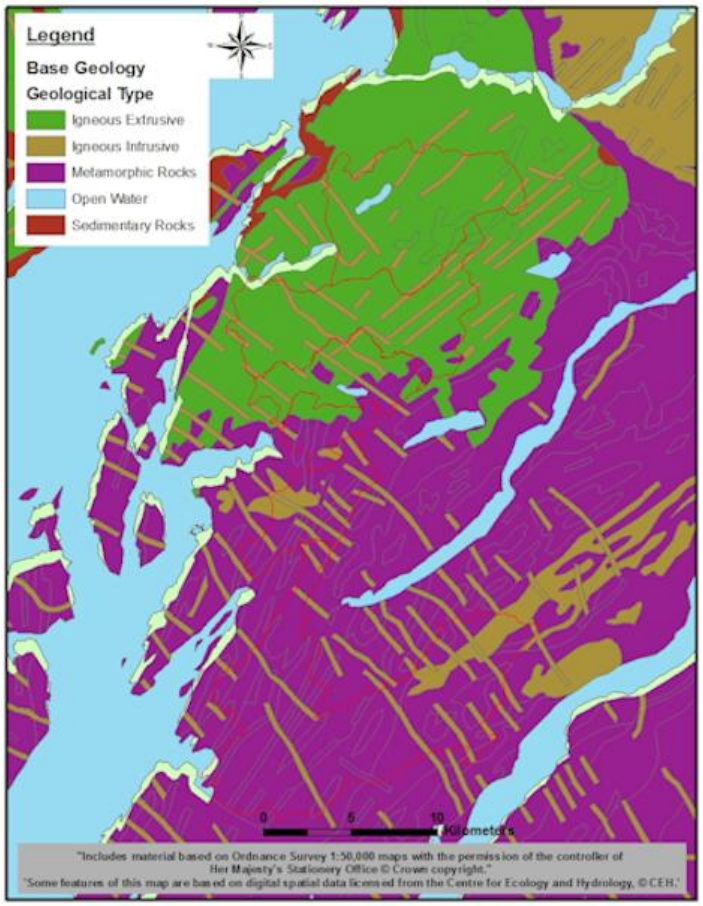

Figure 1.2 Base geology of the Lower Firth of Lorn

1.1.2 Ecological status of freshwater catchments

The 2010 survey included eight catchments which have been assessed by the Scottish Environment Protection Agency (SEPA) as part of the Argyll and Lochaber River Basin Plan (http://www.sepa.org.uk/water/river_basin_planning/area_advisory_groups/argyll.aspx). As part of this process, the ecological status of all catchments have been categorised (Table 1.1).

Table 1.1 Ecological status of catchments surveyed in (SEPA) 2010

Catchment	Waterbody	ID	Ecological status	Identified pressure
Loch Feochan				
Nell	River Nell	10302	Good	Abstraction for drinking water
	River Lonan	10303	Good	None
	Feochan Bheag	10299	Good	None
Euchar	River Euchar (d/s Loch Scammadale)	10296	Moderate	Abstraction for renewable energy
	River Euchar/Abhainn Braglenmore (u/s Loch Scammadale)	10297	Moderate	Abstraction for renewable energy
Loch Melfort				
Oude	River Oude (d/s Loch Tralaig)	10294	Poor (HMWB)	Abstraction for renewable energy Morphological alterations
Abhainn na Cille	Abhainn na Cille	10293	High	None
Loch Craignish				
Barbreck	Barbreck River	10269	Good	None
Loch Crinan				
Add	River Add (d/s Kilmartin Burn)	10264	High	None
	Kilmartin Burn	10265	Good	None
	River Add (u/s Kilmartin Burn)	10266	Bad (HMWB)	Storage / abstraction for renewable energy
	Rhudil Burn	10267	Good	None
	River Add (u/s Abhainn Bheag an Tunns)	10268	Bad (HMWB)	Forestry, Abstraction for renewable energy

The ecological potential of the freshwater catchments within the survey area varies from bad ecological potential in the heavily modified water bodies (HMWB) in the Add catchment, to poor status in the Oude catchment, moderate in the Euchar catchment and good or high ecological status in the other catchments.

1.2 Fish populations and fisheries

The freshwater habitats of the Lower Firth of Lorn consist of a number of relatively small (Abhainn na Cille), moderate-sized (Nell, Euchar, Oude and Barbreck) and large (Add) river catchments and a number of lochs and coastal streams. Fish fauna are mostly species including that migrate between freshwater and marine habitats such as Atlantic salmon (*Salmo salar*) and the migratory form of brown trout; the sea trout (*Salmo trutta*). Other native fish fauna that are typically found to utilise freshwaters during their life-cycle in the west coast region of Scotland are understood to be European eel (*Anguilla anguilla*), river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*), three spine stickleback (*Gasterosteus aculeatus*) and flounder (*Platichthys flesus*). Brook lamprey (*Lampetra planeri*) and some individual brown trout may spend their whole life in freshwater. This study was mainly focused on salmonid fish, but also collected data on other species sampled at survey sites.

1.2.1 Salmonid fish life-cycle

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

1.2.2 Fisheries for salmon and trout

This resource supports rod & line fisheries for Atlantic salmon and sea trout in most of the catchments surveyed that are of importance to the local economy. The resource has been managed on a regional scale by the Argyll District Salmon fishery Board and at a local level by the Nell & Euchar River Improvement Association and the Add & Barbreck River Improvement Association. There is also a net and coble fishery for salmon in Loch Feochan that operates during August each year.

Historically, fishery catch data has been collected for three fishery districts; The Nell district

in the north which also includes the Euchar and the net fisheries, the Awe district which includes the Oude (although there is little fishery activity) and the Add district, which also includes the Barbreck fishery. There are no reported stocking of salmon or trout in the area, although there has been a ‘put and take’ fishery for stocked rainbow trout on Loch Oude in recent years.

2 METHODS

To assess the condition of the aquatic habitat for fish populations, walk-over surveys were conducted. Methods for collection of fish data in 2006-08 are reported separately (AFT, 2008)

2.1 Habitat surveys

Walk over habitat surveys were undertaken on main channels of six catchments (figure 2.1). The aim of the surveys was to quantify and evaluate the condition of freshwater habitats utilised for recruitment by salmonid fish.

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 surveys were divided up into 500m sections and location of survey start and end points were recorded using a six figure grid reference by hand-held GPS. During the course of the surveys 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.

2.1.1 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 2.1.

Table 2.1 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

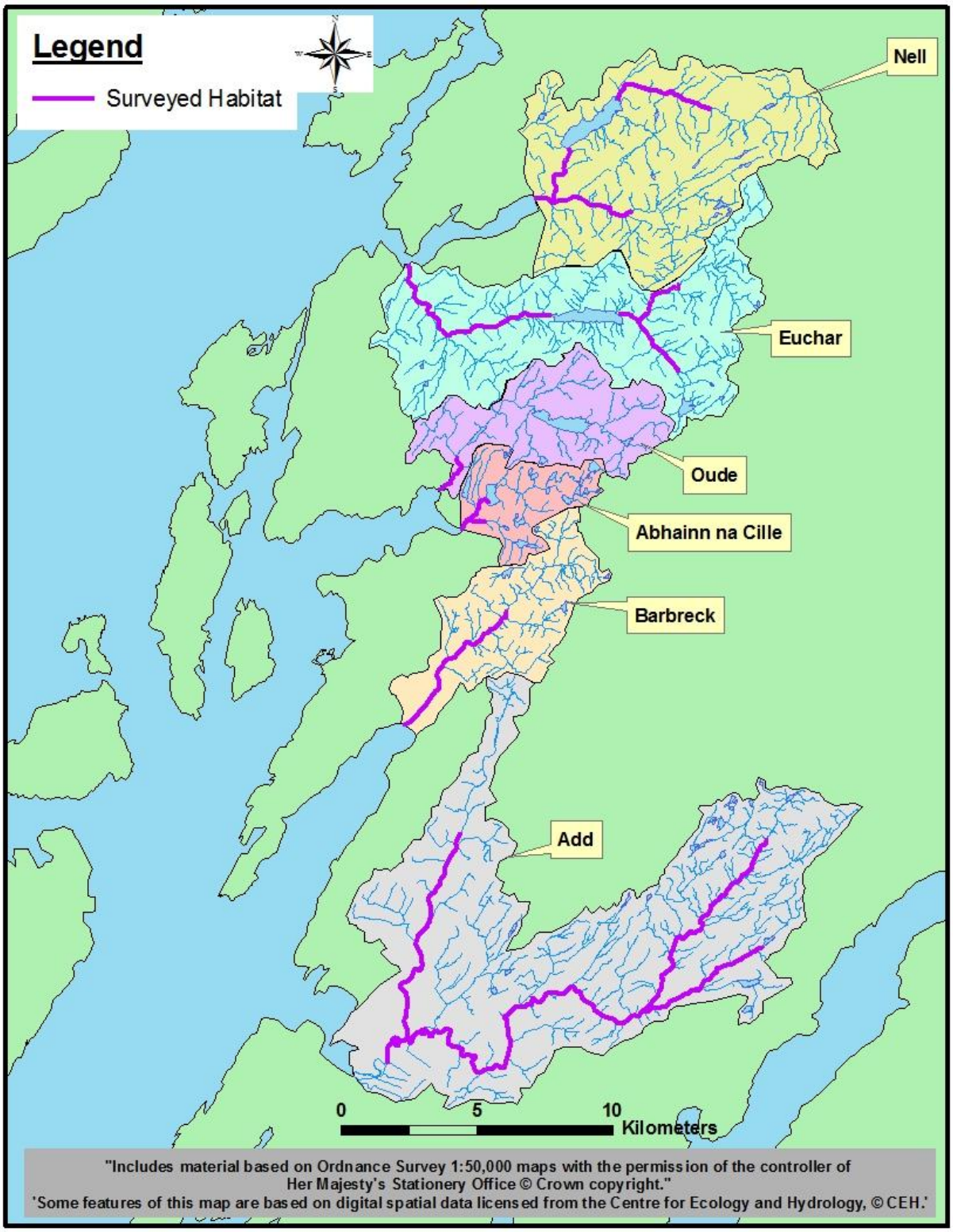

Figure 2.1. Habitat surveyed in the six catchments of the Lower Firth of Lorn.

2.1.2 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 2.2).

Table 2.2 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 2.3).

Table 2.3 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

2.1.3 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 9.3.1).

2.1.3.1 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 2.4).

Table 2.4 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

2.1.3.2 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 2.5). 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 2.5 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 (>50m²), deep (>2m), In-stream boulders, overhanging vegetation Sub-optimal; Small size (<50m²), shallow (<2m), Lower availability of in-stream and bank cover
Notes	Other information such as features creating or sustaining the pool habitat

2.1.3.3 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 2.6).

Table 2.6 Spawning site assessment

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

2.1.3.4 Channel and bank modifications

The location of modifications to the bank and channel was recorded and length of channel affected was assessed (Table 2.7). Notes on potential affects on fish habitat were also recorded.

Table 2.7 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

2.1.4 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), specifically *Rhododendron ponticum*, Japanese Knotweed and Himalayan balsam, were also recorded.

3 RESULTS

3.1 Distribution of Key habitats

Approximately 84.65km of stream were surveyed in 170 survey sections (of 500m) in eight catchments (Table 3.1).

Table 3.1 Habitat survey coverage

Catchment	Catchment Size (km^2)	No. of sections	Length Surveyed (km)	Area Surveyed (m^2)
Loch Feochan				
Nell / Lonan	41	25	12.3	80200
Feochan Bheag	24	7	3.5	34000
Euchar	62	29	14.25	114500
Loch Melfort				
Oude	28	4	2	13500
Abhainn na Cille	14	6	2.6	13200
Loch Craignish				
Barbreck	27	13	6.5	69500
Loch Crinan				
Add	128	86	43.5	517500
Totals	**324**	**170**	**84.65**	**842400**

3.1.1 Distribution and status of key habitats

The location and status of 81 significant obstacles, 353 adult fish holding pools and 340 spawning sites recorded in the surveys are described below.

3.1.1.1 Obstacles to fish passage

A total of 81 significant obstacles to fish passage was recorded during the surveys (Table 3.2). The frequency of obstacles recorded in each catchment ranged from 0.6 per km in the Add and Barbreck rivers to 3.8 per km in the Abhainn na Cille. Natural bedrock waterfalls or cascades were the most common type of the 68 (84%) natural obstacles identified. The surveys also identified 13 (16%) man-made obstacles that were mostly weirs and bridge aprons. A total of 64 (79%) of the obstacles recorded were adjudged to be potentially passable and 14 (17%) to be impassable to migratory salmonids. The potential passage of salmonid fish past a further three obstacles by could not be confidently assigned. The

distribution of obstacles is illustrated in figures 3.1, 3.2

Table 3.2 Obstacles to upstream passage of salmonid fish

Catchment	No. of Obstacles	Man-made	Natural	Passable	Unsure	Not passable
Loch Feochan						
Nell / Lonan	13	3	10	13	0	0
Feochan Bheag	4	0	4	3	0	1
Euchar	18	2	16	14	0	4
Loch Melfort						
Oude	7	1	6	6	0	1
Abhainn na Cille	10	5	5	7	0	3
Loch Craignish						
Barbreck	4	0	4	2	1	1
Loch Crinan						
Add	25	2	23	19	2	4
Totals	**81**	**13**	**68**	**64**	**3**	**14**

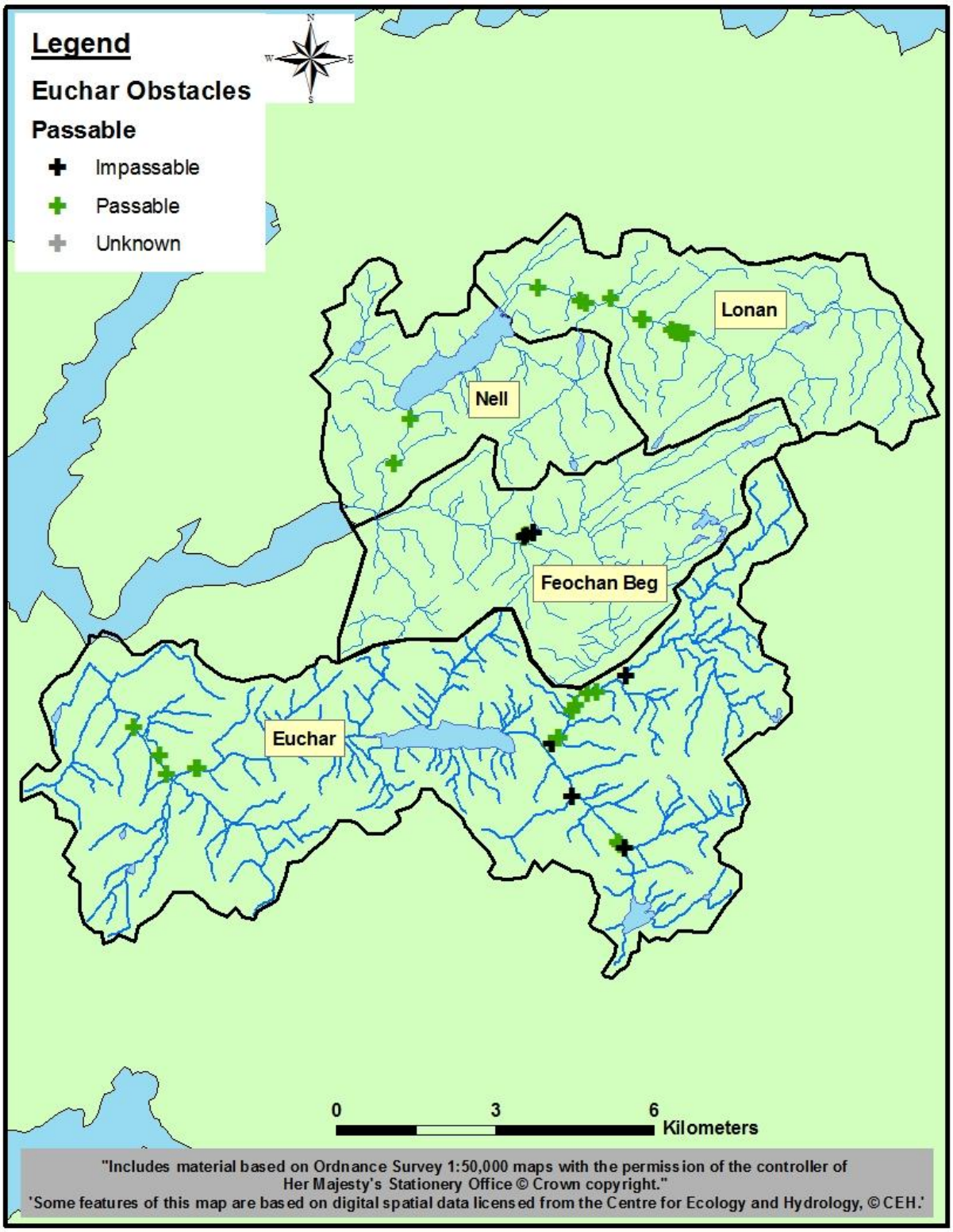

Figure 3.1. Distribution of obstacles in the Nell and Euchar catchments.

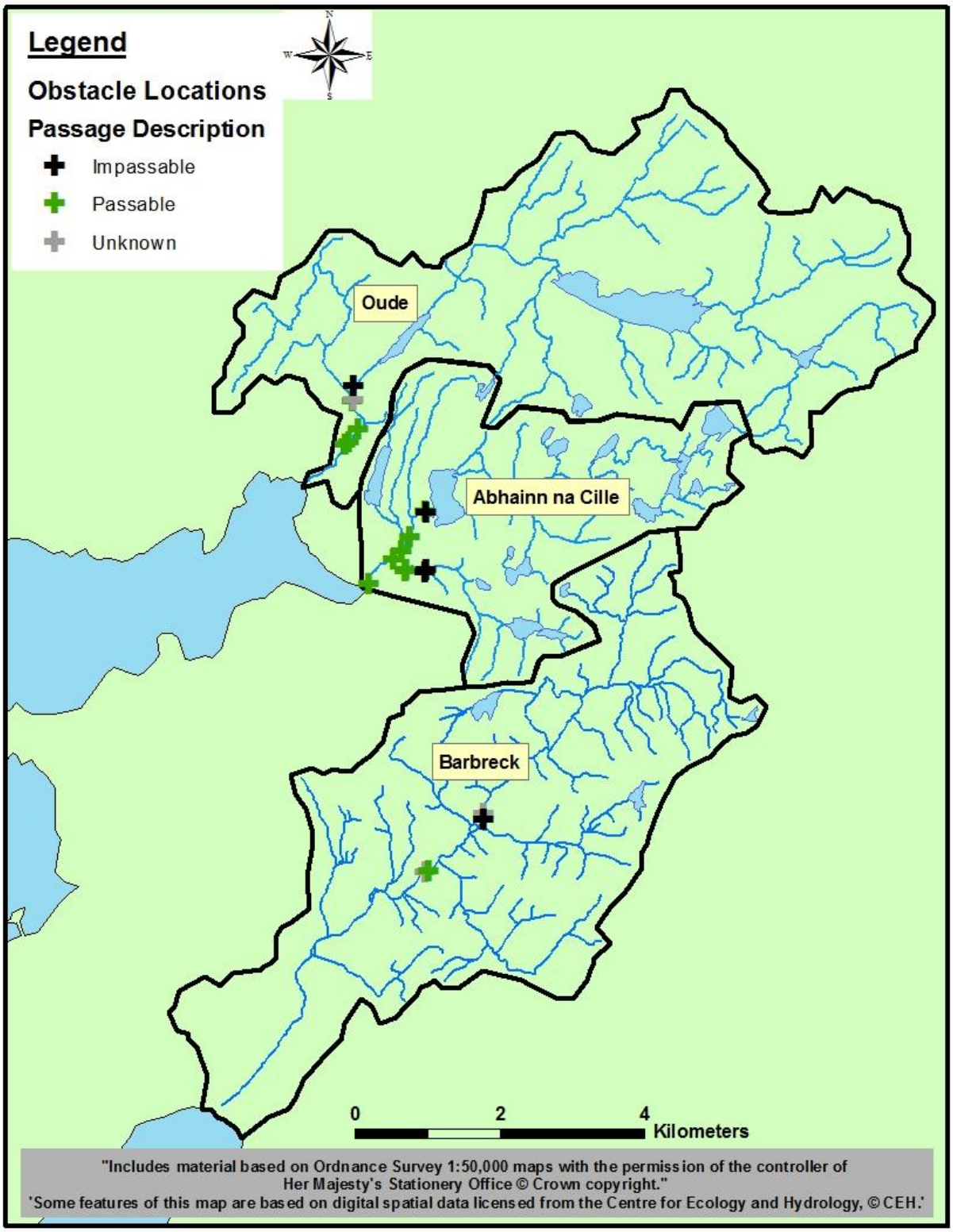

Figure 3.2. Distribution of obstacles in the Oude, Abhainn na Cille and Barbreck catchments.

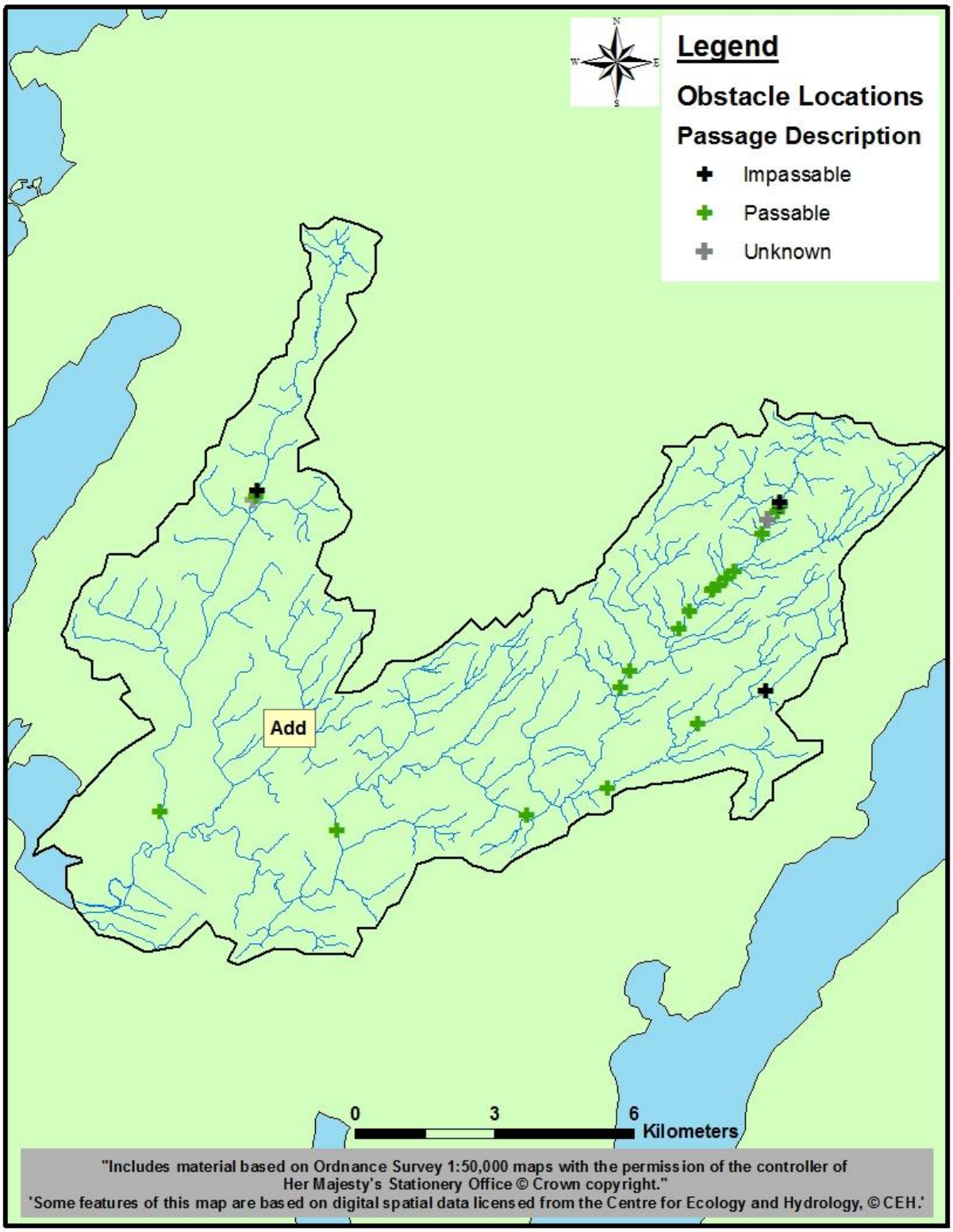

Figure 3.3. Distribution of obstacles in the Add catchment.

3.1.1.2 Adult holding pools

A total of 353 significant adult fish holding pools was recorded during the surveys (Table 3.3).

Table 3.3 Adult holding pools results

Catchment	No. of pools	Optimal	Sub-optimal	Primary Cover	Secondary Cover	Pool Area (m^2)
Loch Feochan						
Nell / Lonan	67	30	37	Depth	Canopy	55402
Feochan Bheag	30	17	13	Depth	Canopy	4720
Euchar	65	43	22	Depth	Canopy	15445
Loch Melfort						
Oude	8	0	8	Depth	Canopy	1105
Abhainn na Cille	9	2	7	Depth	Canopy / Bank	714
Loch Craignish						
Barbreck	27	20	7	Depth	Canopy	7115
Loch Crinan						
Add	147	67	80	Depth	Canopy	94220
Totals	**353**	**179**	**174**			**178721**

* Excludes Loch Nell **Excludes Loch Scammadale

The frequency of pools found in each catchment range from 3.4 per km in the Add to 8.6 per km in the Feochan Bheag catchment. A total of 174 (49%) pools were identified as being sub-optimal with the remaining 176 (51%) as being optimal. The predominant type of cover available to fish was the depth of water and from canopy cover from trees. The area of pool habitat potentially available ranged from 714m² in the Abhainn na Cille to 94,220m^2 in the Add catchment. Loch Nell (1.23km^2) and Loch Scammadale (0.96km^2) provide large holding areas for adult and juvenile fish, however were not included in the above analysis to avoid disorting the results. A total of 179 (51%) pools were identified as optimal fish holding pools, with 174 (40%) of pools assessed as sub-optimal (see table 2.7 for a definition of optimal and sub-optimal holding pools).

3.1.1.3 Spawning sites

A total of 527 significant salmonid fish spawning sites was recorded at 340 locations during the surveys (Table 3.4). The frequency of sites recorded in each catchment range from 1.9 per km in the Abhainn na Cille to 7.4 per km in the Feochan Bheag, part of the Nell catchment. Of the six catchments surveyed, the Oude and the Abhainn na Cille had less

than 100m^2 of potential spawning habitat: the greatest areas of potential spawning were found in the Add catchment, with 4,189m^2. A total of 175 (51%) of sites were identified as being optimal for salmonid spawning, with the remaining 165 (49%) having sub-optimal conditions (see table 2.8 for a definition of optimal and sub-optimal conditions).

Table 3.4 Spawning habitat survey results

Catchment	No. of Locations	No. of Sites	Total Area (m^2)	Optimal	Sub-optimal	No. per km
Loch Feochan						
Nell / Lonan	86	67	2,948	47	20	5.4
Feochan Bheag	29	26	1,464	12	14	7.4
Euchar	50	48	1,760	26	22	3.4
Loch Melfort						
Oude	8	8	60	0	8	4.0
Abhainn na Cille	5	5	28	1	4	1.9
Loch Craignish						
Barbreck	30	24	601	10	14	3.7
Loch Crinan						
Add	319	162	4,189	79	83	3.7
Totals	**527**	**340**	**11,050**	**175**	**165**	**4.0**

Habitat features associated with spawning sites were mostly morphological features of the river channel including glides at the outflow of pools and other features such as braided channels and islands. The relative distributions of pools to spawning areas are demonstrated in figures 3.4, 3.5, 3.6.

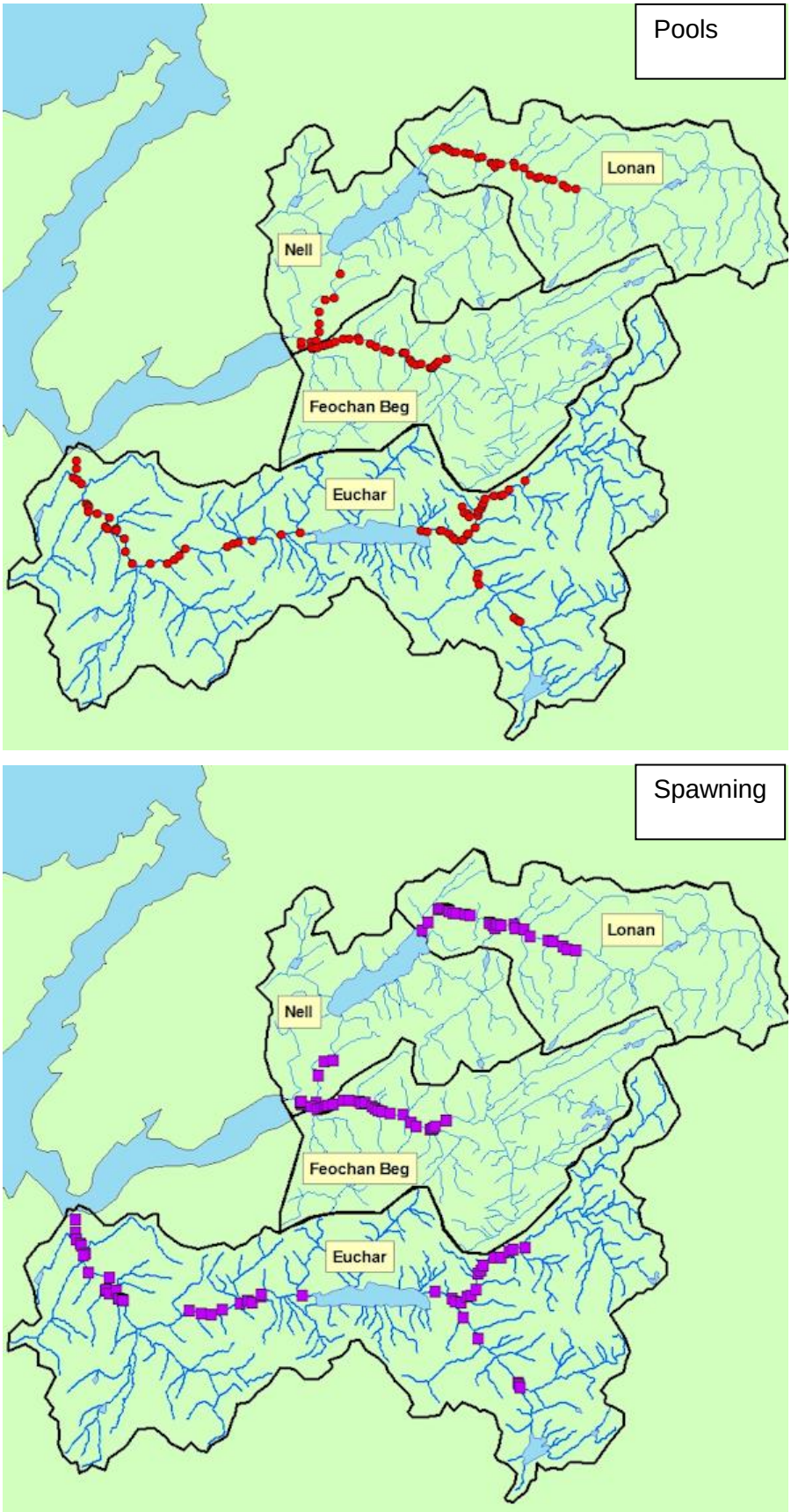

Figure 3.4. Distribution of spawning and pool habitat in the Nell and Euchar catchments

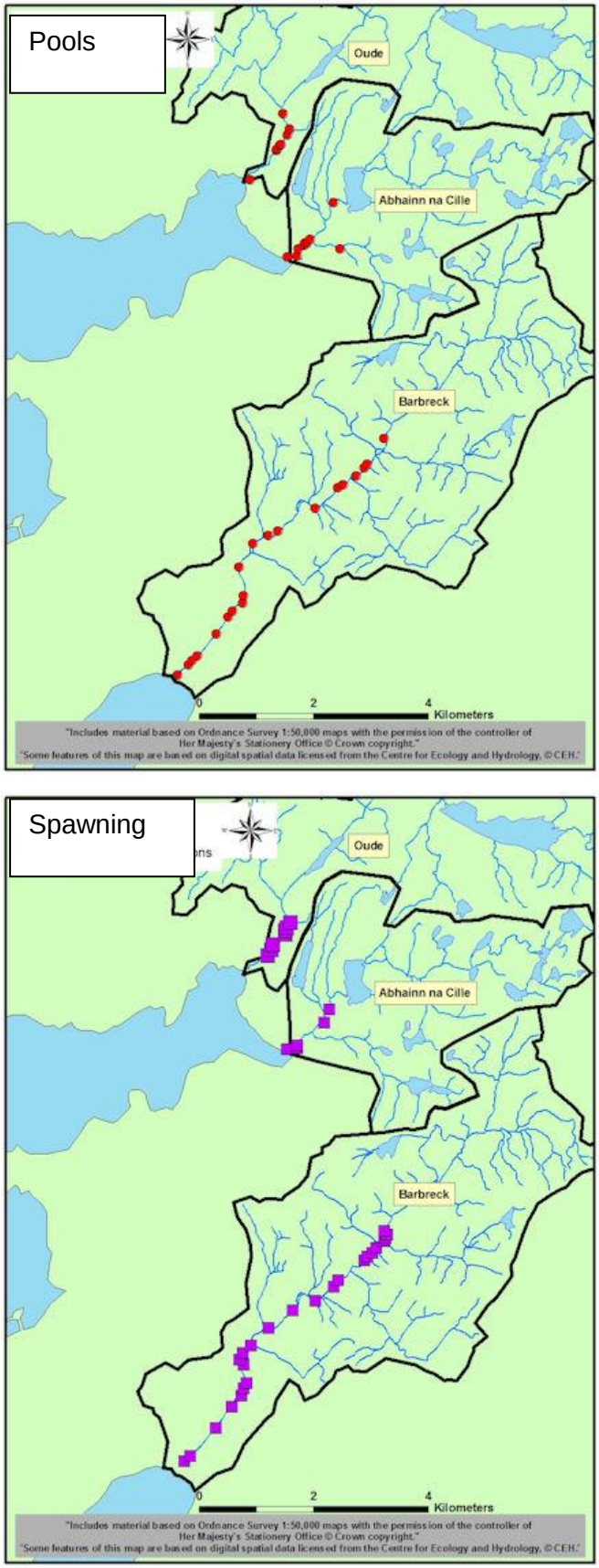

Figure 3.5 Distribution of spawning and pool habitat in the Oude, Abhainn na Cille and Barbreck catchments.

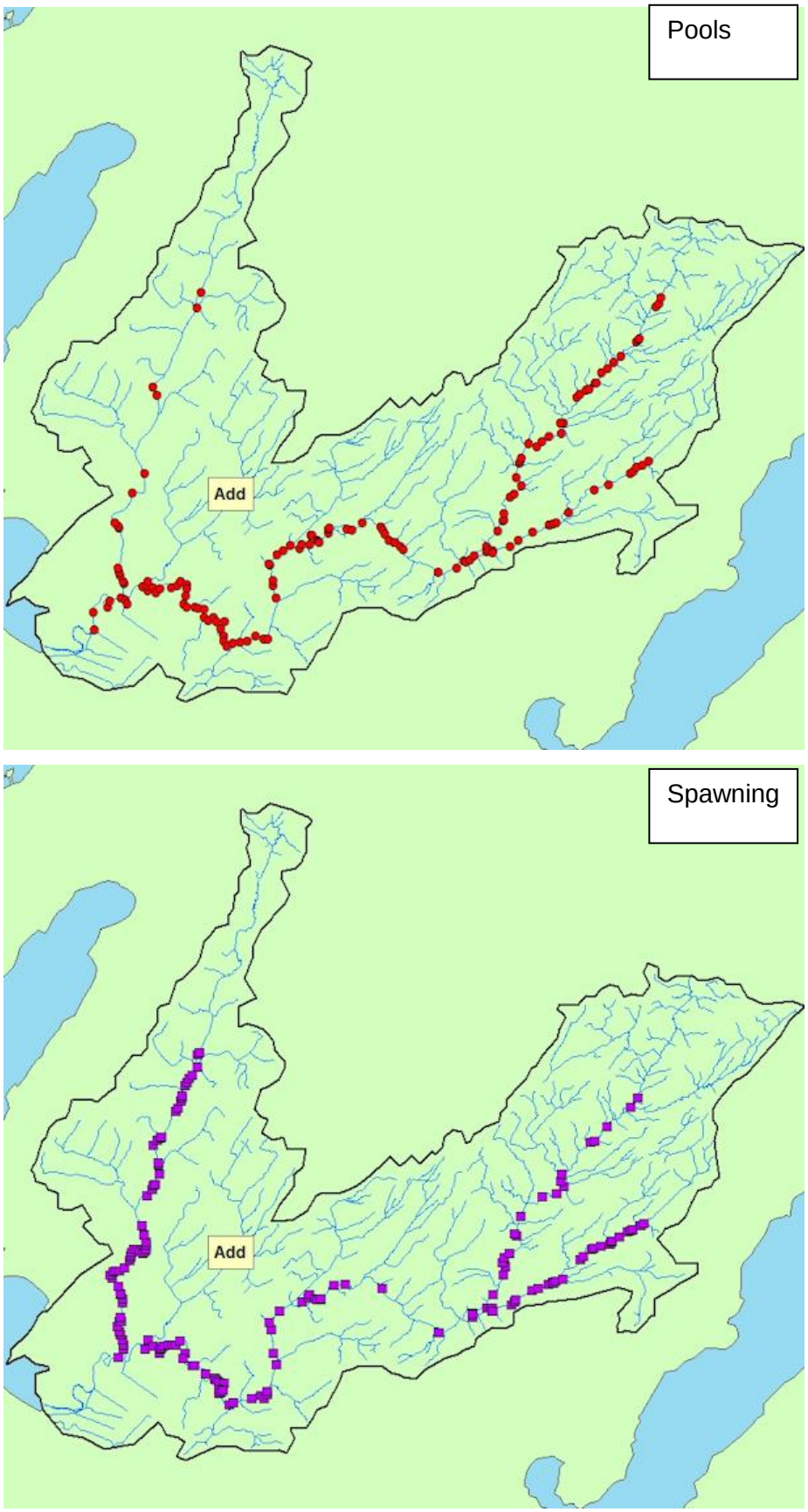

Figure 3.6. Distribution of spawning and pool habitat in the Add catchment.

3.2. 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.

3.2.1 Habitat suitability for juvenile salmonid fish

The juvenile salmonid fish habitats recorded (Table 3.5) consisted of shallow, mixed and deep habitats. Large areas of fry habitat were present in 22% of all sections surveyed, and were less abundant than mixed or deep juvenile habitats. The median scores suitability of fry habitats ranged from 2.5 out of a possible 5.0 in the Barbreck to 3.5 in the Add, with a median of 3.0 for all sections. Mixed juvenile habitats (which including smaller areas of fry and deep juvenile habitat) were most abundant being recorded in 82% of all sections and in all catchments. Suitability scores for mixed juvenile habitat ranged from 2.5 in the Oude and Abhainn na Cille to 3.5 in the Feochan Bheag, with a median value across all sections of 3.0.

Table 3.5 Habitat abundance and suitability scores for juvenile salmonid fish

Catchment	No. of Sections	Fry		Mixed Juvenile		Deep Juvenile	
		Sections present	Score	Sections present	Score	Sections present	Score
Loch Feochan							
Nell / Lonan	25	6	3	18	3	7	3
Feochan Bheag	7	0		6	3.5	0	
Euchar	29	0		29	3	14	3
Loch Melfort							
Oude	4	0		4	2.5	0	
Abhainn na Cille	6	0		6	2.5	1	3
Loch Craignish							
Barbreck	13	4	2.5	13	3	6	3
Loch Crinan							
Add	86	27	3.5	64	3	39	2
Totals / Median	**170**	**37**	**3**	**140**	**3**	**67**	**3**

Deep juvenile habitats were relatively abundant being recorded in 39% of all . Suitability scores for deed juvenile habitat ranged from 2 in the Add to 3 in the other catchments, where present.

3.2.2 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 3.6) and riparian (Table 3.7) habitats. The total number of in-stream downgrades identified per km of survey varied between 2.9 on the Feochan Bheag to 5.1 on the Add and averaged 3.5 per km for all catchments surveyed.

Table 3.6 Downgrades of in-stream habitat condition (No. per km)

Catchment	Total No.	Fines	Bedrock	Cover	Compaction	Unstable	Grad	Large Woody Debris	No Spawn
Loch Feochan									
Nell / Lonan	3.2	0.0	0.6	0.3	0.2	0.2	0.4	1.1	0.3
Feochan									
Bheag	2.9	0.3	0.0	0.0	0.0	0.9	0.0	1.7	0.0
Euchar	3.3	0.1	0.9	0.0	0.0	0.0	0.6	1.1	0.6
Loch Melfort									
Oude	3.5	0.5	1.0	0.0	0.5	0.0	0.0	0.5	1.0
Abhainn na									
Cille	3.5	0.0	0.0	0.8	1.2	0.0	0.4	0.0	1.2
Loch Craignish									
Barbreck	3.4	0.0	0.2	0.8	0.5	0.9	0.2	0.6	0.3
Loch Crinan									
Add	5.1	0.9	0.7	0.7	0.6	0.0	0.4	1.3	0.6
Totals	**24.8**	**1.8**	**3.3**	**2.6**	**2.8**	**2.0**	**2.0**	**6.4**	**3.9**

Downgrades identified during the surveys were mostly attributed to factors related to in-stream cover for young fish (2.8 per km average), such as bedrock substrates, fine sediments in the substrate matrix, a lack of cover and a lack of large woody debris in the river channel. More moderate average scores were also recorded for compacted substrates, unstable substrates in four of the six catchments surveyed, high or low gradient and lack of spawning sites.

Table 3.7 Downgrades of riparian habitat condition (No. per km)

Catchment	Total No.	No Shade	Over Shade	Bank Cover	Land use
Loch Feochan					
Nell / Lonan	1.5	0.8	0.3	0.4	Broadleaf Woodland / Improved Grazing / Rough Pasture
Feochan Bheag	1.7	0.6	0.6	0.6	Broadleaf Woodland / Improved Grazing
Euchar	1.5	0.6	0.2	0.8	Broadleaf Woodland / Improved Grazing
Loch Melfort					
Oude	0.5	0.0	0.0	0.5	Gardens / Broadleaf Woodland
Abhainn na Cille	1.2	0.0	1.2	0.0	Broadleaf Woodland /Scrub
Loch Craignish					
Barbreck	1.5	0.8	0.6	0.2	Broadleaf Woodland / Improved Grazing
Loch Crinan					
Add	1.1	0.8	0.3	0.0	Broadleaf Woodland / Improved Grazing / Conifer Plantation
Totals	**1.3**	**0.7**	**0.4**	**0.2**	

The number of riparian downgrades identified per km of survey varied between 0.5 per km on the Oude to 1.7 on the Feochan Bheag and averaged 1.3 per km for all catchments surveyed. Downgrades identified during the surveys were mostly attributed to lack of shading of the river channel (0.7 per km), a lack of bank-side cover for fish in five catchments (average 0.2 per km). Over-shading from trees was identified in all catchments with an average of 0.4 per km.

3.2.3 Invasive Non-Native Species (INNS)

Invasive non-native plant species were recorded in three catchments during habitat surveys (table 3.8). Japanese knotweed was found at six locations in Loch Feochan catchments only. *Rhododendron ponticum* was identified in two catchments; the Euchar amd the Abhainn na Cille. Himalayan balsam was found on one section of the Nell catchment.

Table 3.8 Distribution of invasive non-native plants (no. sections where present).

Catchment	No. of Sections	Japanese Knotweed	Rhododendron Ponticum	Himalayan balsam
Loch Feochan				
Nell / Lonan	5	5	0	1
Feochan Bheag	0	0	0	0
Euchar	4	1	3	0
Loch Melfort				
Oude	0	0	0	0
Abhainn na Cille	2	0	2	0
Loch Craignish				
Barbreck	0	0	0	0
Loch Crinan				
Add	0*	0	0	0
Totals	**11**	**6**	**5**	**1**

* Japanese Knotweed fd on forestry track in catchment

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. A full photographic record of each catchment was also collected and is available for viewing upon application.

3.4 Fish Population Data

The fish population results from the electrofishing surveys of 2006-08 are illustrated in table 3.9 and figures 3.7, 3.8, 3.9, 3.10. A full description of the method and a discussion of the results can be found in the Argyll Fisheries Trust report (AFT, 2009) provided as appendix IV to this report.

Table 3.9 Summary of electrofishing results from 2007 survey

Catchment	Salmon Fry		Salmon Parr		Trout Fry		Trout Parr	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Loch Feochan								
Nell	D	A	D	A	E	A	D	C
Euchar	C	A	B	A	E	A	E	C
Loch Melfort								
Oude*	F		E		B	A	E	
Abhainn na Cille	F		F		E	A	C	A
Loch Craignish								
Barbreck	D	A	D	A	D	B	E	A
Loch Crinan								
Add	E	A	D	A	E	A	E	A

** Oude surveyed in 2008*

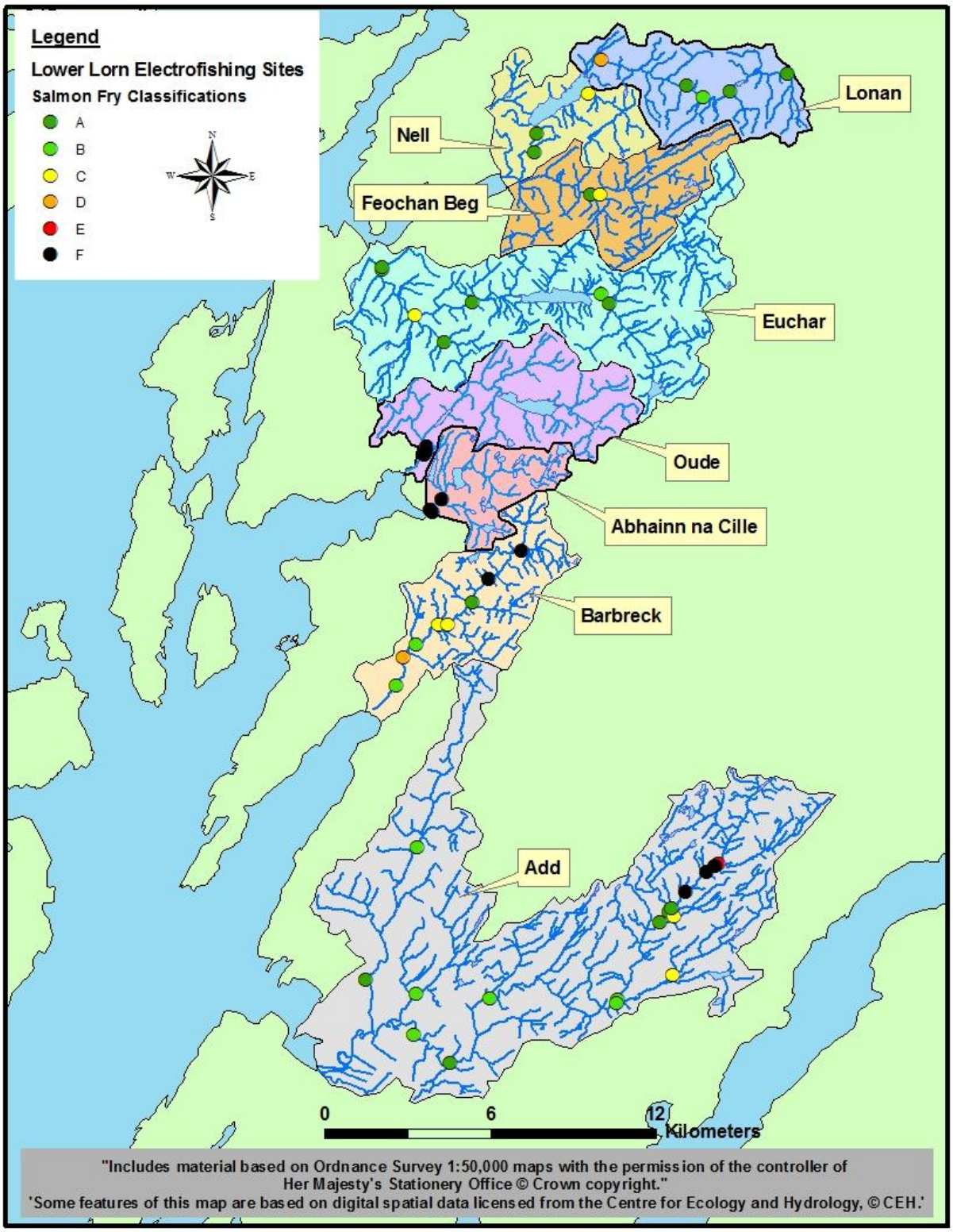

Figure 3.7 Electrofishing results for Atlantic salmon fry in the Lower Firth of Lorn.

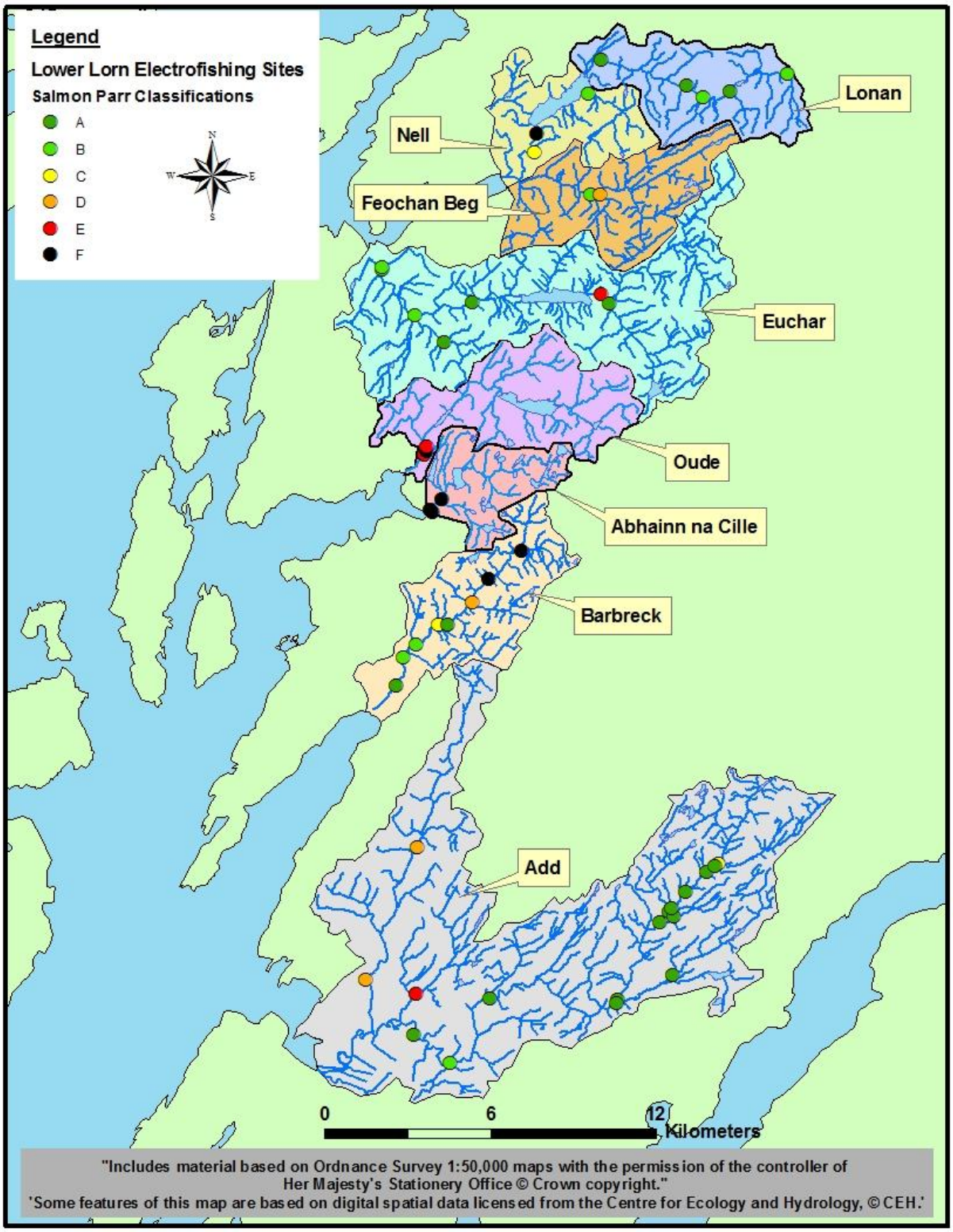

Figure 3.8 Electrofishing results for Atlantic salmon parr in the Lower Firth of Lorn.

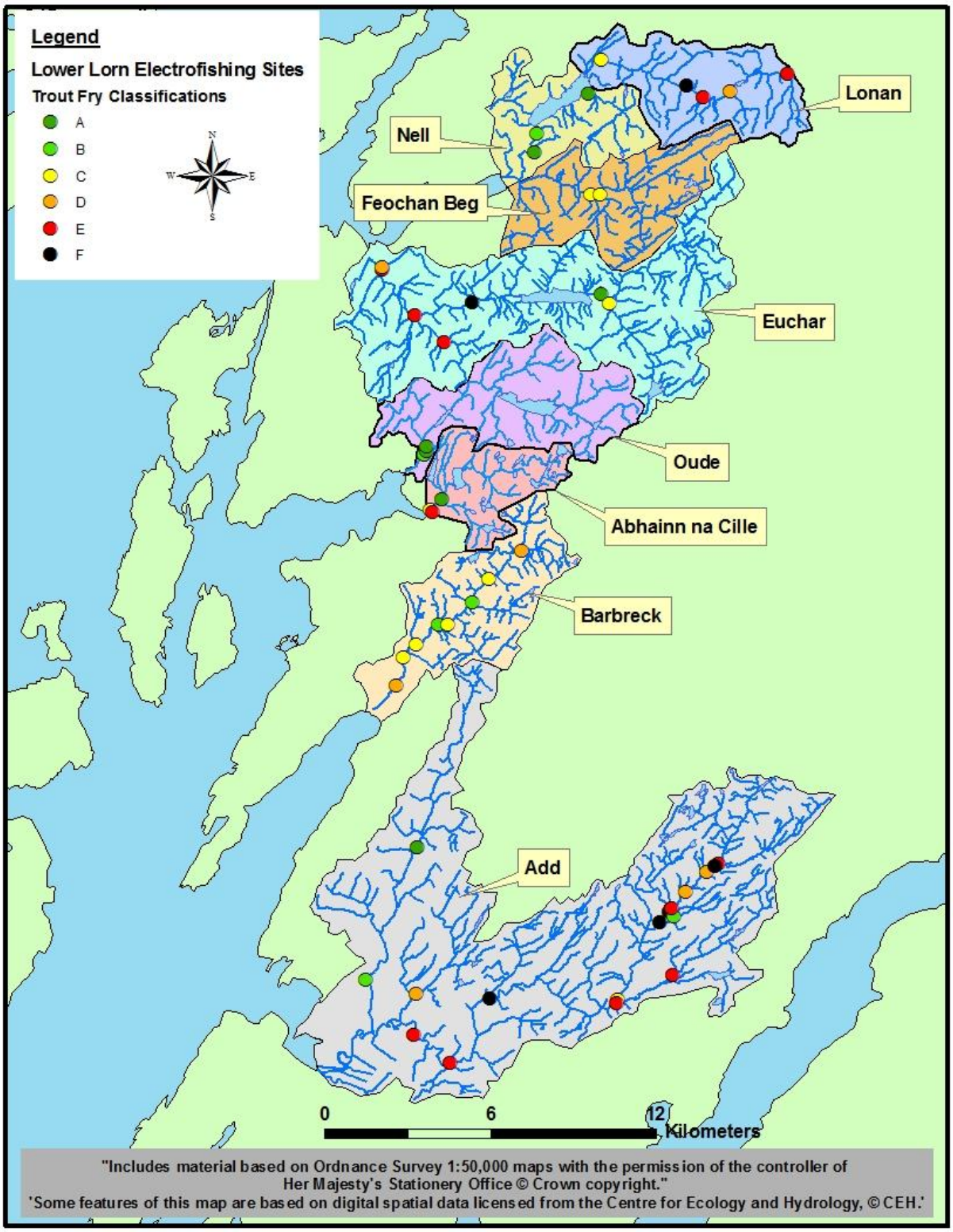

Figure 3.9 Electrofishing results for brown trout fry in the Lower Firth of Lorn.

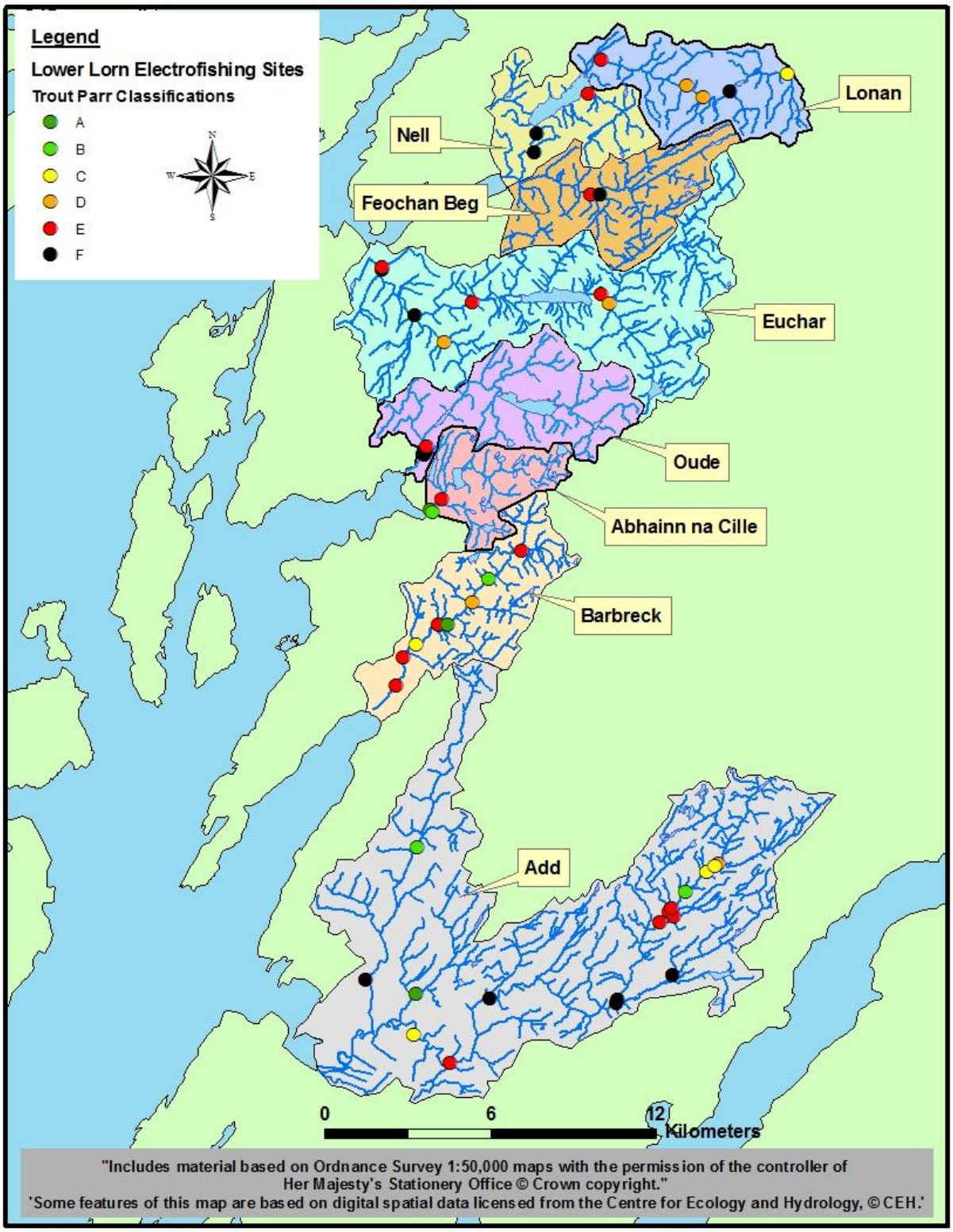

Figure 3.10 Electrofishing results for brown trout parr in the Lower Firth of Lorn.

4 DISCUSSION

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

4.1 Fish distribution and abundance

4.1.1 Atlantic salmon

The data collected indicate four of the six catchments surveyed; Nell, Euchar, Barbreck and Add are currently able to support salmon populations throughout the currently accessible habitat. However, there is currently a barrier to salmon migration on a tributary of the upper Euchar catchment (Abhainn Coromaig), which has prevented access to suitable habitat for recruitment (approximately 2.5 km of stream) of juveniles.

Fish data for the Add catchment indicate that migratory fish are able to utilise the fish passes on the main Add barrage and the dam on the Tunns tributary that are associated with the diversion of water to the Glashan hydroelectric scheme. However, patchy salmon fry distribution and low abundance upstream of a natural waterfall barrier on the upper River Add indicate salmon and trout may pass in some years when flow (and possibly water temperature) is suitable in the autumn spawning period.

There is potential for flow regulation to influence fish distribution in the Nell catchment from the regulation of flow into the River Nell (Feochan Mor) by abstraction of water from Loch Nell. Anecdotal information from local fishery interests indicates that flow in the river has been very low at times during low rainfall, which may impair fish movement into the catchment from Loch Feochan over and above that which may occur naturally. Subsequently, there is potential for spawning escapement to be reduced by the affects of predation by seals and catches of salmon by net fishery on Loch Feochan during low flow periods.

Flow regulation may also influence the distribution of migratory fish in the Oude catchment, where no salmon fry were found, but low numbers of parr were recorded. The status of the salmon population and consequently the fish survey data in the Oude may also be affected by escapees from the smolt farm in the upper catchment and reports of farmed adults entering the catchment from Loch Melfort.

The relatively small accessible catchment area in the Abhainn na Cille catchment appear to have limited habitat to be able to support sufficient numbers of smolts to sustain a population over the long-term. It is possible that salmon may have been present in times of high population abundance, but current marine survival of post-smolts at sea may inhibit re-colonisation at this time.

Where found in the Nell, Euchar, Barbreck and Add catchments, the relative abundance of salmon fry and parr were mostly moderate, good or high compared to classification of other west coast populations. It is likely that the underlying geology, reflected by the relatively high levels of dissolved minerals in the water during sampling, may have an influence of in-stream productivity. Although not undertaken as part of this study, it is possible that invertebrate and other life in relatively base-rich systems may influence juvenile fish abundance. Even with relatively high productivity, only moderate juvenile salmon parr abundance was found in the Kilmartin Burn and low-to-moderate fry numbers at some sites in the Barbreck. Habitat modification (stream morphology) and possibly additional pressures from gravel abstraction in the Barbreck may influence juvenile abundance at some sites.

4.1.2 Brown trout

The fish data collected indicate that all six catchments surveyed as part of this study are currently able to support trout populations even though both fry and parr were not sampled at all survey sites in all catchments and relative abundance was highly variable.

The relatively limited distribution and low abundance of trout found in the main river channels of the Lonan (upper Nell), Lower Euchar and Add catchments indicate that there may be limitations on in-stream habitat suitability for this species where high flows better suit salmon than trout. The lower proportion of sites where trout were found compared to salmon in this survey may also be an artefact of sampling error, as few small tributaries were surveyed that are more commonly used for trout recruitment compared to main river habitats.

Where surveys were undertaken in smaller channels of the main river (Barbreck, Oude and Abhainn na Cille) and tributaries (Add and upper Euchar), trout fry were relatively common and were of moderate or high abundance. The exception to this was the Lonan, where lack of vegetation on river banks may impair habitat use by trout and the Tunns tributary of the Add, where very few trout were found. These data also suggest that trout parr distribution and abundance was lower than that of fry, which may be an artefact of older trout utilising loch or deeper pool and glide habitat, which are not possible to assess by electrofishing.

Patchiness and changes recorded in trout distribution of different age classes also indicates that spawning activity may be infrequent in some populations which may be as a result of poor adult sea returns. The relatively moderate-to-good abundance of trout fry and parr sampled at some sites 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 may be less than optimal.

4.1.3 Non-salmonid species

Although not sampled in all sites the distribution of European eel was also relatively wide in all catchments surveyed in the 2006-08 survey (61 % of sites) compared to other non-salmonid fish. 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 modest 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.

Flounder were found at a small number of sites (3% of sites surveyed) in the lower reaches of two catchments (Oude and Abhainn na Cille) and are 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. Hence their distribution may be wider than described here. Three-spine stickleback were found at 8% of sites surveyed in three catchments (Add, Nell and Barbreck), but are likely to be more widespread in loch and slower flowing habitat types that were not surveyed as part of the 2006-08 study.

Although lamprey ammocoetes (*Lampetra spp.)* were not found at any survey sites this may 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 sites in a few catchments, much of which was in shallow loch habitats that could not be surveyed by the electrofishing technique. Therefore, further site specific sampling would be required to establish their distribution.

Minnow are understood to be a translocated species in west-flowing Scottish Waters and are therefore unlikely to be native to the Lower Lorn Rivers. Their current distribution in 31% of

sites surveyed in the larger catchments of the Add, Euchar, Nell and Barbreck is likely to be as a result of them being discarded by anglers after they have been used as bait for trout. Consequences for native species resulting from introduction of minnow are not well understood in the Scottish context, but where studied in Scandinavia (Borgstrom *et. al.,* 2010), reduced recruitment and annual growth rate of brown trout as well as changes in diet were most likely related to the introduction of European minnow.

4.2 Factors affecting productivity in freshwater habitats

The assessment of habitat condition on the Lower Firth of Lorn rivers provided as part of the Argyll and Lochaber River Basin Plan suggest that most catchments are of high or good ecological status, but are moderate in much of the Euchar and heavily modified and of bad ecological potential in the Oude catchment and parts of the Add due to abstraction. However, this survey found some aspects of the habitat to differ from these classifications in respect to suitability for salmonid fish recruitment.

4.2.1 River morphology and channel characteristics

The morphology of river channels surveyed was thought to be natural in most survey sections, but it is possible that historical channel re-alignment (straightening) has been undertaken in some catchments, which can both reduce stream length, sinuosity and habitat diversity. A significant number of straightened reaches of the lower-middle Add and its tributaries; the Kilmartin and the Abhainn Tunns were observed during the survey. The lower reach of the Barbreck River has also been straightened and has a number of weir structures and bank hardening features that reduce sinuosity and river processes. Smaller sections of the Nell, Feochan Bheag and the Lonan also appear to have been modified, the most recent of which is in the lower Feochan Bheag where weirs have been constructed to deepen pool habitats within a straightened section of the channel. These alterations are likely to be primarily aimed at enhancement of the fishery. Despite the high ecological status of the Abhainn na Cille, some sections also appear to have been straightened, while despite only a moderate status, the main channel of the Euchar appeared to have relatively minor channel modifications. Generally, the older and more extensive alterations to river channels were found on the lower gradient reaches, possibly as a means to aid land drainage for farming and forestry.

The gradient of fall of the river habitat has an influence on stream morphology (and bed substrate composition). The alterations to habitat were all found in relatively low gradient habitats, which are also potentially the most sinuous with meanders and pool riffle flow sequences. The relative affect on fish populations of the loss of lower gradient habitat cannot

be quantified here, but typically a lower diversity of habitat and fewer locations suitable for recruitment were present in these modified reaches compared with natural reaches.

4.2.2 Connectivity of habitats

Obstacles to fish migration were more frequent in higher gradient habitat in the upper reaches of most catchments, with the exception of the Oude, which appears to have a relatively short access for migratory fish, but it is unclear if the high gradient boulder steps are impassable or the combination of the dam and flow regulation make the steps impassable. The Euchar has a natural waterfall obstacle in the lower reaches that is likely to restrict the distribution of some migratory species, such as lamprey and stickleback, which are less well adapted to passing significant obstacles. Eels may be less affected if there is sufficient moist substrate at the edges of obstacles over which they may pass and were also found upstream of obstacles, which salmonids cannot pass (upper Barbreck).

Typically obstacles were natural bedrock outcrops or boulder-pool steps, most of which are passable to salmonid fish in favourable flow conditions, with the exception of 'Leuinn na Lic' waterfalls on the Barbreck River, which appear to be a complete barrier to migration and 'Creag an Fhithich' on the main River Add and others on the Kilmartin and Abhainn Tunns tributaries. There was however a partial barrier at the water intake for the fish farm in the upper Kilmartin Burn, although there was little useful habitat upstream of this weir and a dam at the head of the Tunns tributary, built on a natural bedrock feature that was likely to be a complete barrier to fish prior to construction. With the exception of the Oude, the most significant man-made obstacles found were the dams in the Add catchment which have fish passes incorporated into their structure. Fish data suggest that these are effective is passing salmon and trout and eels. The dam found on the Abhainn a Coromaig tributary of the Euchar catchment at Bragleenbeg House, limits the distribution of salmonids some 2.5 km below their likely natural range. Local information indicates that salmon once utilised this tributary for recruitment before the dam was built and this survey suggest that the habitat upstream of the dam is of relatively good condition with frequent pool, spawning and mixed juvenile habitat. Therefore it is likely that restoration of habitat connectivity for salmonids (and possibly eels) could make a significant difference to fish recruitment in the upper Euchar, where genetic studies have shown that multi sea-winter salmon stock components are present.

4.2.3 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 significant areas of some catchments that are less suitable. Fine substrates and bed compaction is

likely to reduce in-stream cover for juvenile salmonids and may subsequently reduce survival as shelter from high flows and predators is less abundant. Notably the Kilmartin Burn has a high proportion of finer substrates in a significant proportion of the habitat which is likely to be a consequence of the modification of the channel morphology. Straightening and over-widening of the channel may reduce stream force and increase fine sediment deposition (exacerbated by erosion of exposed and poached soils), which subsequently is less suited as cover for salmonids. However, fish survey data suggest that fish density is relatively good in much of the Kilmartin Burn which may be as a result of cover provided by the aquatic vegetation growth in fine sediment. Although aquatic vegetation may provide cover for juvenile fish during the summer months, it is not available to fish in the winter after the vegetation has declined and may contribute to juvenile mortality at this time.

Relatively unstable bed materials were found in some sections of the Barbreck River and Feochan Bheag (tributary of the Nell). The middle reach of the Barbreck may be affected by drainage connected to forestry in the upper catchment, but there are other riparian contributory factors resulting from livestock grazing that leave banks exposed to erosion. The influence of subsequent channel widening and reduction in flow depth are likely to have consequences for fish habitat at these sites (particularly in low flow periods) and may also contribute to the oversupply of substrates downstream. The Feochan Bheag appeared to have similar influences of loss of vegetation on banksides affecting in-stream stability that has affecting channel morphology and sediment supply.

The habitat where most frequent optimal spawning locations were found were in the low gradient areas, although smaller ‘spots’ were present throughout most moderate gradient habitats. The changes to channel morphology in low gradient habitats is likely to have reduced the occurrence of both pool and spawning habitat frequency as found in some unaffected sections of the Lonan where highly sinuous morphology included frequent deep pools and spawning substrates.

4.2.4 Riparian habitats

The existing and historical land-use of Lower Firth of Lorn rivers 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 and a low diversity of riparian vegetation. In places, such as the Kilmartin Burn, parts of the Barbreck, Glen Lonan and Euchar catchments, grazing and poaching of banks were a more significant factor affecting bank-side cover for fish and the condition of in-stream substrates. Secondary

aspects of lack of shading of the channel may be affecting control of water temperature, which is known to affect salmonid feeding and growth toward the upper range of tolerance. Concerns over the increasing water temperature affects on salmonid fish populations due to future climate change are not yet clearly defined, but is likely that increasing broadleaf cover on bank-sides will play an increasingly significant role in management over time. Lack of broadleaf trees on stream banks are 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 in riparian zones is limited to a smaller number of sections surveyed in most catchments with the exception of the River Add where much of the middle and upper catchment is afforested. Wider influences from forestry on hillsides are common to the catchments surveyed, where land drainage issues may influence flow conditions and substrate dynamics in the main river habitats surveyed and many of the tributary streams (favoured as habitat by trout) that were not surveyed. Where present in riparian zones, some existing mature plantations 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. Much of the upper Add has been clear-felled in recent years, opening up much of the channel to sunlight, which may improve in-stream productivity, but there are few broadleaf trees to regulate temperature or provide leaf litter. Replanting may be necessary along with deer control to allow regeneration of native trees. The Abhainn Tunns tributary was found to be mostly afforested and restructuring of plantations to benefit to the longer-term health of the aquatic environment

Where present, broadleaf woodland habitats in riparian zones were found to be fragmented by other land uses and constrained to a narrow band inside fencing where present. Fencing and presence of broadleaf trees were common in straightened sections of habitat, and although beneficial to the aquatic environment, they are primarily maintained to prevent erosion of banks, which are likely to impair the natural restoration of channel morphology in combination with flood embankments.

Invasive non-native plants were found in a number of catchments, particularly in the areas close to roads or downstream of urban development in the Nell catchment where both Japanese knotweed and Himalayan Balsam were present. Knotweed was also found in the Abhainn na Cille and the Add catchment on a forestry track, but not along the river bank. Although not a priority non-native, skunk cabbage was also found in the lower Add catchment in several spots, but was not identified to species level. 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. *Rhododendron ponticum* which also has potential to reduce productivity of freshwater habitats and fish populations was found at a small number of sites in only two catchments and early control is likely to prevent further spread.

4.3 Factors affecting productivity in marine habitats

There is potential that aquaculture related factors such as sea lice (*Lepeophtheirus salmonis*) burdens affecting survival and growth of salmonid post-smolts and interaction with farmed escapee salmon (McGinnity et. al, 2004) may have an influence on the current status of migratory salmonid fish. Existing data has been collected on sea lice burdens of sea trout as part of the Area Management Agreement process (Tripartite Working Group, 2011, in preparation) in Loch Feochan, but there is little or no data from Lochs Melfort, Craignish or Crinan.

Other studies have found a relationship between lice burdens on sea trout and the distance of the nearest fish farm and also on increased lice burdens when farms are in the second year of production (Butler & Watt, 2002), probably due to the higher biomass of fish in the second year pre-harvest and higher lice levels found on most farms in most production cycles (Penston & Davies, 2009). The fish data collected in the survey indicate that salmon may not be significantly impacted by aquaculture at the time of survey. However, the relatively low densities and more patchy distribution of trout may be influenced by aquaculture activity, but the sampling strategy employed may not be so representative of trout populations as it is for salmon.

New information on the influence of salmon farm location, wind and tidal movements on sea lice larvae distribution and potential effects on wild fish is currently being collected in Loch Linnhe to the north and Loch Fyne further south in Argyll. This approach, previously used in Loch Torridon (Penston & Davies, 2009) may better inform management of aquaculture and wild fish interaction if it is employed in the Lower Firth of Lorn also.

Initial studies into population genetics of salmon in the Nell and Euchar catchments found no evidence of farm fish cross-breeding interaction with wild fish, but the techniques used in this work may not be sufficient to identify influence form farm fish. New techniques currently being developed may provide further important information in future as a small number of escapee farm fish were found in the net fishery in Loch Feochan.

4.4 Factors affecting survey results and interpretation of data

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

4.4.1 Survey design, technique and environmental conditions

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

The environmental conditions at the time of survey were relatively favourable for efficient sampling. The conductivity of the water in all catchments surveyed was relatively high and favours effective sampling of fish. The relatively low number of smaller tributary streams sampled is likely to have meant that there is comparatively less information on the status of juvenile trout compared to salmon that are usually more abundant in main river habitats.

The survey technique used is designed to sample relatively shallow water in streams and hence less is known of the relatively deeper areas of habitat including lochs, which are likely to be favoured habitats of trout parr and other non-salmonid fish. Subsequently the actual distribution and abundance of fish maybe somewhat higher in deep juvenile and still water habitats than was measured as part of this survey.

4.4.2 Fishery intervention

The stocking of juvenile salmon and trout into freshwater habitats has potential to skew the results of fish survey data, but there has been no known stocking of trout or salmon by fishery managers on any of the catchments studied.

5 IMPLICATIONS FOR MANAGEMENT

The data on fish (2006-08) and their habitats (2010) collected in the survey provide an indication of the implications for the management of fish populations on Lower Firth of Lorn Rivers. The fish species sampled in the survey; Atlantic salmon, brown trout, European eel flounder and three-spine stickleback have value as part of local biodiversity, however migratory salmonids also have potential to support fisheries that are important to local recreation and economy.

5.1 Fishery management

The data on juvenile salmon indicate that there is significant potential for sustainable fisheries for these species in the catchments surveyed at this time. However, it is important maximising spawning escapement of adult fish by effective control such fisheries to ensure that sufficient spawning escapement and recruitment of smolts is improved over time. Conversely, the current status of salmon populations in the Oude catchment indicate that they are not able to support exploitative fisheries at this time and exploitation is likely to decrease potential for local extinction.

5.1.1 Maximise spawning escapement

Genetic studies of salmon caught in the net fishery at Dunach in Loch Feochan has been found to exploit stocks from both the Nell and Euchar, therefore it is important to control exploitation of stocks, particularly multi sea-winter salmon in this fishery. The stock status of trout is less clear than for salmon and the pressures on sea trout in local marine waters indicate that they are unlikely to sustain significant exploitation at this time.

Allowing sea trout, often females, to escape the fishery is likely to provide significant benefit to future stock status as individual female sea trout, unlike salmon are able to spawn repeatedly over a number of years. 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 data suggest that there is unlikely to be a requirement for stocking of salmon to enhance fishery performance as juvenile populations are relatively good in most rivers and there is little or no habitat where juvenile numbers are sufficiently low that they may benefit from hatchery-based support. Stocking initiatives are also unlikely to overcome the causes of

the decline of catches, which are currently thought to be most significant in the marine environment. Similarly, there is unlikely to be benefit from hatchery intervention with trout populations due to marine influences and unlike salmon they are able to reproduce without going to sea and as a species they are likely to be maintained over the longer-term until such time that marine survival improves. There may be some potential for hatchery-based salmon restoration activities in the Oude catchment, but there is little fishery-based activity in the catchment to support this work at this time. Longer-term management of habitat issues and improved management of land and water resources are more likely to derive a sustained improvement in fish health and abundance (Webb et. al, 2009).

Local management 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 the genetic samples collected as part of this study may be used to better inform management of populations, particularly in larger populations where stock structuring may be more complex.

5.1.3 Biosecurity of fish and fisheries

It will be important for fishery managers to raise local awareness of biosecurity issues and engage a wide range of stakeholders active in the catchment. Guidance for the management of biosecurity issues are identified in the Argyll & The Islands Fisheries Biosecurity Plan (AFT, 2009). The establishment of surveillance, control and eradication programmes are required to manage existing and future threats including health checks of fish from Marine Scotland Fish Health Inspectorate.

Although not yet present in the UK, the introduction of the *Gyrodactylus salaris* parasite is a significant threat to the future of fisheries in Scotland. If and when it is introduced to the British Isles it may be spread through the movement of fish (prior to being diagnosed) and therefore the risks associated with movement and stocking of fish reared in commercial facilities for aquaculture and fisheries need to be assessed. American mink are likely to be present in the catchments surveyed and a co-ordinated approach by land managers to control is likely to bring benefit to fish populations and biodiversity more widely.

The control of Japanese knotweed and other priority non-native plant species found at several locations, which if tackled in the short-term may be eradicated from the catchments and avoid the spread and significant associated management costs in the future. It is unlikely that minnow, found in four of the six catchments surveyed can be eradicated, but their distribution may be controlled to reduce risk of further competition with native species

such as trout for limited resources. Ensuring that minnow are not translocated into other catchments will ensure that the productivity of these species is not affected on a wider scale. There is now legislation in place that prohibit the use of live vertebrates as bait and therefore raising local awareness of the issues related to competition and introduction of parasites and other pathogens may prevent further spread of the species.

5.2 Habitat management

Longer term aspects of promoting recovery and maintenance of fish populations will be to deliver improvement in the ecological status and productivity of freshwater habitats. Despite the River Basin Plan (RBP) assessment of good or high ecological status of most of the rivers surveyed, this survey found a number of aspects of land management that may be changed for the benefit of freshwater resources.

The long-term historical grazing of habitats by livestock (and possibly deer) has left few broadleaf woodland riparian habitats in the riparian zones of river channels. Regulation of water temperature and delivery of leaf litter, large woody debris, and terrestrial food sources are likely to be important aspects of the management of salmonid fish, biodiversity and fisheries in the future. This may not be as important for invertebrates and other food sources in these relatively base-rich rivers as for fish in particularly low productivity rivers, but in-stream food production will be naturally improved over existing levels, with additional benefit of improved cover for fish from tree roots and large woody debris.

Restoration of river morphology is also likely to significantly benefit fish populations and subsequently fisheries, but modified habitats identified by this survey were not recognised by the current river Basin Plan as being significant. It will be important to review current status of morphology in future phases of the RBP 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.

Landowners are able to tackle land use issues with financial assistance available under the Scottish Rural Development Programme . This programme of economic, environmental and social measures can help individuals or groups deliver the Government's strategic objectives

in rural Scotland. The rural priorities for Argyll include areas such as biodiversity, landscape, water and soils and adaptations to mitigate climate change which are relevant aquatic habitats. Attaching to these priorities are packages that can help deliver the desired improvements. For example, forest management or habitat improvements to address morphological pressures are driven by the Waters and Soils priorities (regional code ARG18 and packages 27-30). Support to remove invasive non-native species, or improve freshwater habitats supporting salmonids or freshwater pearl mussels is driven by relevant packages under the Biodiversity priority.

The contact for SRDP in Argyll is:-
SGRPID
Cameron House
Albany Street
Oban
PA34 4AE
Tel: 0300 244 9340
Fax: 0300 244 9331
Email: SGRPID.Oban@scotland.gsi.gov.uk

Alternatively, a land agent can assist with an application. Further guidance on specific management activities is provided in Appendices II and III together with the individual catchment reports.

Longer term aspects of promoting recovery and maintenance of fish populations will be requierd 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 in the Lower Firth of Lorn are since 2006 as part of the Area Management Agreement (AMA) and the Aquaculture code of good practice are likely to have improved containment and sea lice management on local salmon farms. These changes to management are likely to have improved the health of both farmed and wild fish. However, since the changes in management associated with the AMA, new challenges have arisen in regard to the efficacy of sea lice treatments and increases in biomass of farm fish in the area. Area-based management agreements between wild and farm fish interests are not currently active and on-going expansion of the aquaculture sector is likely to maintain pressures on wild fish resources in the future.

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 of sea-run trout. 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 surveys (2006-08) and habitat surveys (2010) of six catchments in the Lower Firth of Lorn in Argyll, Scotland provides a number of conclusions that relate to management of land and water resources in the Nell, Euchar, Oude, Abhainn na Cille, Barbreck and Add catchments.

6.1 Fish distribution

Fish surveys undertaken sampled five native fish species; Atlantic salmon, brown trout, European eel, stickleback and flounder. Non-native minnow were found in four of the six catchments surveyed. Juvenile salmon and trout were found in all large catchments, but salmon fry distribution was limited in the Oude and no fry were found in the Abhainn na Cille. Within catchments, fish distribution was restricted on a tributary of the Euchar catchment by a weir and may also be affected in the Oude catchment by a combination of flow regulation, natural and man-made obstacles. Similarly, abstraction of flow from Loch Nell may exacerbate flow related effects on fish migration in the out-flowing River Nell during periods of low rainfall. Fish data also suggest that fish passes on two hydroelectric dams on the Add catchment are effective.

6.2 Juvenile salmonid fish abundance

Where present the abundance of juvenile salmon was relatively moderate or good in the Nell, Euchar, Barbreck and Add catchments and low in the Oude compared to data from other rivers in the west coast region. Juvenile trout abundance varied between sites, but unlike salmon, trout abundance was generally higher in smaller streams compared to larger main river habitats.

6.3 Factors affecting productivity

The principle factors affecting productivity of migratory salmonid fish are currently 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 modification of channel features and use of land and water resources.

Grazing of livestock in un-fenced riparian zones of streams was the most widespread land use affecting the diversity of vegetation on stream banks that is likely to influence availability of cover for juvenile trout and terrestrial food sources, leaf litter and large woody debris

entering stream habitats. Diffuse pollution derived from trampling of banks by livestock and erosion of soils from unprotected banks were also found to influence in-stream habitat condition in some areas. Forestry plantations were found to influence riparian habitat, some of which is currently being restructured to conform to current guidelines for management practice.

The relatively base-rich geology of the catchments surveyed compared to other areas of Argyll are likely to influence in-stream productivity for fish, and the relatively good densities of juvenile salmonid fish found in the fish survey confirm this. Although not surveyed as part of this study, the condition and use of local inshore marine habitats are also likely to influence the status of juvenile salmonids and subsequently the performance of fisheries.

6.4 Fishery and catchment management

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. This is likely to be particularly relevant to sea trout at this time to protect older repeat spawning females that are important to the restoration of juvenile trout stocks and future smolt production. Relatively high juvenile salmon abundance found in catchments where fisheries are currently operating indicate that stocking is not likely to benefit fisheries at this time and trout numbers are likely to improve if potential influences of aquaculture are minimised.

Juvenile fish distribution may be restored to their natural range in the Euchar catchment by removal of the dam at Bragleenbeg or installation of an effective fish pass, which may be supported by funding from the SEPA Restoration Fund (SRF). More widespread factors of habitat condition and productivity related to historical modifications to stream morphology may also be addressed through affecting SRF or possibly the SRDP. Similarly improvement in the condition of riparian habitats may be undertaken through SRDP and drivers identified in the Argyll and Lochaber River Basin Plan.

7 APPRAISAL OF METHODOLOGY AND FUTURE PROGRAMME OF WORK

The methodology utilised in the survey; walkover habitat surveys, is appraised and the suitability discussed.

7.1. 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 further develop the catchment management phase of the River Basin Planning (RBP) process and 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.

7.2. 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 useful to assess changes in juvenile abundance over time to inform progress of management initiatives and longer-term changes in the status of migratory fish stocks. Better interpretation of juvenile fish abundance may also be attained if the classification scheme is reviewed to include more recent data on the relative density of fish populations. Additional information on adult fish spawning (redd counts) may also be useful to further interpret the findings of this study. Genetic data will also be required to inform future management of diversity within the salmon and trout populations.

Consultation with centres of expertise will provide useful information to further assess the habitat data and implications for the ecological status of catchments in the RBP.

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