SURVEY REPORT

Loch Fyne Rivers Project: Summary of 2011 Fish Populations, Fish Habitat and Potential Habitat Management Initiatives

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SURVEY REPORT

Summary

Loch Fyne Rivers Project: Summary of 2011 Fish Populations, Habitat Surveys and Potential Habitat Improvement Initiatives.

Background

Argyll Fisheries Trust undertook electrofishing and habitat surveys of 14 river catchments draining into Loch Fyne in 2011. The aim of the surveys was to assess fish species distribution and their relative abundance compared to a previous surveys. New data were collected on fish habitats.

This report has two main purposes:

1. To enable land managers and landowners to identify riparian improvement works that will enhance biodiversity and the fishery resource. Potential sources of grant aid to fund improvement work are highlighted in section 5.2 of this document.

2. 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.

This report summarises the findings of the survey and provides management advice for fisheries and habitat improvement. Catchment specific reports of the study provide detailed information and management prescriptions.

Main findings

Electrofishing surveys were undertaken at 92 sites in 14 catchments including 61 sites in seven catchments in upper Loch Fyne and 31 sites in seven catchments in lower Loch Fyne. The surveys found six native species; Atlantic salmon (*Salmo salar*), Brown trout (*Salmo trutta*), European eel (*Anguilla anguilla*), flounder (*Platichthys flesus*), three-spine stickleback (*Gasterosteus aculeatus*) and lamprey (*Lampetra spp.*). One translocated species; minnow (*Phoxinus phoxinus*) was also found.

Juvenile Atlantic salmon were found in eight of the catchments surveyed in 2011; Aray, Douglas, Fyne, Eas Dubh, Kilfinan, Kinglas, Leacann and Shira. Salmon fry were sampled at 51 % of sites in five of the seven catchments (Aray, Douglas, Fyne, Kilfinan, Kinglas and Shira) surveyed in upper Loch Fyne and 3 % of sites in one of the seven catchments (Kilfinan) in lower Loch Fyne. Salmon parr were found at 72 % of sites in all seven

catchments in upper Loch Fyne and 3 % of sites in one catchment (Kilfinan) in lower Loch Fyne.

Where found the relative abundance of juvenile salmon was variable when compared to a classification scheme for rivers on the west of Scotland. A relatively low abundance of juvenile salmon was found more frequently in all catchments with the exception of the River Aray where moderate abundance of fry and high abundance of parr were most frequently found.

Juvenile brown trout were found in all of the 14 catchments surveyed in 2011. Trout fry were found at 80 % of sites in all catchments in upper Loch Fyne and 65 % of sites of in all catchments except one (Largiemore) in lower Loch Fyne. Trout parr were found at 89 % of sites in all catchments in upper Loch Fyne and 84 % of sites in all catchments in lower Loch Fyne.

Where found the relative abundance of juvenile trout was variable when compared to a classification scheme for rivers on the west of Scotland. A relatively low abundance of trout fry was found more frequently in all seven catchments in Lower Loch Fyne and three catchments in upper Loch Fyne. Moderate abundance was more commonly found in the Leacann and Eas Dubh and high abundance in the Shira and Aray. A relatively low abundance of trout parr was found more frequently in seven catchments, moderate in three (Aray, Douglas and Cuilarstich) and high abundance in the Eas Dubh, Skipness and Auchalick River.

Comparisons with the juvenile salmonid fish abundance found in 441 surveys undertaken between 1985 and 2011 indicate that in general, salmon abundance decreased between 1993 and 2001, but has increased to a lesser extent between 2002 and 2011. Similar comparisons indicate that juvenile trout abundance has slightly increased slightly over this period.

Non-salmonid fish were found at fewer sites in 2011 compared to salmon and trout. European eel were found at 20 % of sites surveyed in nine catchments, but have been found in surveys of three others (Shira, Douglas and Kinglas) in previous surveys. Flounder were found at 4 % of sites in the lower reaches of four catchments in lower Loch Fyne in 2011, but have also been found in two others (Shira and Kinglas) in previous surveys. Lampreys were also found in 4 % of all sites surveyed in the Shira, Strathlachlan, Cuilarstich and Kilfinan catchments. Sticklebacks were found in the Shira and Strathlachlan catchments (2 % of sites), while minnow were found only in the Auchalick in 2011, but have also been found in the River Aray in previous surveys.

Habitat surveys were undertaken on 67.9 km of main channels in 14 catchments, covering

some 536,842 m² of river habitat where a total of 200 separate sub-units of habitat were identified. On average, 94 % of habitat area surveyed was suitable for juvenile fish (< 1 m depth), 5% for adult fish (> 1 m depth) and 1 % was suitable for salmonid fish spawning.

Of the habitat surveyed, 10 % was of **high gradient** (4-8 m/100m slope) with an entrenched channel, low sinuosity and substrates dominated by bedrock and large boulder, which are less suitable for juvenile salmonids, but host some important adult fish habitats (pools). Relatively **moderate gradient** (2-4 m/100m slope) habitat with moderately entrenched channel, sinuosity and substrates dominated by boulders and cobbles were found in 42 % of the habitat, which are suitable for fry and parr life-stages of juvenile salmonids. Entrenched river channels of moderate gradient (that are less able to access the flood-plane) were found in 9 % of habitat, which are generally sub-optimal for juvenile salmonids, but also host pool habitats for adult fish. Three types of **low gradient** (0-4 m/100m slope) habitat were found; two types are slightly entrenched with moderate-to-high sinuosity and potential for lateral migration across the flood-plane, which are optimal for juvenile salmonids and have a moderate proportion of spawning habitat and larger pools. One other low gradient habitat type which have been **realigned and straightened** with moderate sinuosity or low sinuosity (less able to access the flood-plain due to down-cutting of the bed), were found in 15 % of the habitat. The substrates found in low gradient habitat were mostly cobble (type 3) and gravel (type 4), which are important to fry and younger parr life-stages and have a high proportion of spawning habitat and larger pools.

An average of 64 % of river channel length was found to be confined (unable to migrate laterally across the valley floor), 22 % of which was constrained by **bank revetment and embankments**.

The survey also found 216 **obstacles to upstream fish passage**, 61 (28 %) of which were man-made structures, most of which were weirs. Eighteen obstacles (8 %) were thought to be impassable (or access was not fully determined) to migratory salmonid fish, while 183 (85 %) obstacles were thought to be obstacles to upstream migration of poorer swimming species such as lamprey.

In-stream cover for juvenile fish was found to be impaired in an average of 31 % of the habitat area by bedrock substrate (24 % average) and a combination of small substrates, compaction of the bed by silt and fine sediments (7 % average). A total of 309 pieces of **large woody debris** (LWD) was found at 133 sites in 80 of the 200 habitat units surveyed. Where present the associated features of the debris were assessed as providing bank protection (19% of sites), bank erosion (14 %) or bed scour (28 %). Smaller debris trapped by larger pieces also provided additional cover fish (78 % of sites) and created or retained

spawning habitat (28 % of sites). LWD features were assessed as being stable at 45 % of sites and were of sufficient size to have potential for preventing upstream migration of fish at 20 % of sites, two of which were thought to be currently forming an upstream barrier in the Eas Dubh and Skipness catchments.

A total of 594 salmonid fish **spawning sites** were found with a total of 4,250 m² of spawning habitat, 70 % of which were assessed as being in optimal condition. **Pool habitats**, suitable for adult salmonid fish were found at 330 sites, with a total area of 35,154 m², 74 % of which were assessed as being suitable for longer-term habitat for adult migratory salmonids.

The range of **juvenile habitat** found was suitable for different age classes of fish; 10 % was suitable for fry (<0.15 m depth), 56 % for a mixed age classes of juveniles (fry and parr), 20% deeper habitat (>0.4 m depth) suitable for older parr and 10 % was bedrock habitat that is less suitable for juvenile fish.

The major land use types found within 10 m of the river channels surveyed were mostly semi-natural broadleaf woodland (average of 46 % of bank length for all catchments), improved grazing (34 % in 10 catchments), rough grazing (14 % in eight catchments) and conifer plantation (17 % in six catchments). The **bank cover for juvenile fish** from a combination of tree roots, draped vegetation and undercut banks was less than optimal on an average of 57% of bank length surveyed, a lack of canopy cover on an average of 23 % and over-shading by dense canopy in 2 %.

Grazing livestock were estimated to be excluded from an average of 72 % of bank length and where present the impact on riparian vegetation was assessed as being not detectable on 9 % of bank length, slight on 13 % and significant on 7 % of bank length.

Invasive non-native plant species were found at a total of 84 sites in 10 catchments covering an area of 16,111 m². Japanese Knotweed (*Fallopia japonica*) was found at 48 sites in five catchments covering 9,776 m², Himalayan Balsam (*Impatiens glandulifera*) was found at five locations in the Cuilarstich catchment (531 m²) and Rhododendron (*R. ponticum*) was found at 31 locations in nine catchments covering an estimated area of 5,805 m².

The following conclusions were reached:

The patchy distribution and low abundance (in most sites surveyed) of juvenile salmon in upper Loch Fyne catchments; Aray, Shira, Fyne, Kinglass, Douglas, Leacann and Eas Dubh found in 2011 indicate that while these are key habitats for **Atlantic salmon**, the status of these populations is currently sub-optimal and are not able to support exploitative fisheries. Fishery catch data show a significant decline in the salmon catch during the 1990s and

subsequent closure of rod and net fisheries in the early 2000's. Comparison of data collected on juvenile salmon in these catchments data collected prior to 2003 indicate that juvenile salmon abundance also decreased before increasing in distribution and abundance post 2003. Reasons for the decline in salmon abundance is related to marine survival of post-smolts and reduced numbers of adult sea returns.

Similarly, fishery catch data of **sea trout** (the migratory form of brown trout), have also shown a decline in the population, but these have been longer-term compared to salmon prior to the 1990's before collapsing in a similar manner post 1990. The longer-term decline of sea trout in Loch Fyne indicate that habitats specific to this species; smaller tributary streams used for recruitment in freshwater and in-shore coastal water used for growth may have been impaired over a longer time-scale compared to those habitats preferred by salmon; larger main rivers for recruitment and the wider Atlantic ocean for growth.

The halt of decline of both species in **Upper Loch Fyne** has been achieved through a combination of initiatives; closure of exploitative fisheries, re-organisation of aquaculture activity and subsequent stock restoration programme. The initial data collected on fish populations in the seven smaller catchments in **lower Loch Fyne** in 2011 show that juvenile salmon are at a very low abundance in one catchment (Kilfinan) and were not found in other (Skipness and Auchalick) where modest salmon fisheries are known to have operated in the past. Juvenile trout abundance was also generally patchier compared to upper Loch Fyne.

To continue the recovery of salmon and trout stocks in Loch Fyne, bottlenecks acting on smolt production in the freshwater habitats need to be addressed as well as ensuring that use of local marine resources are not detrimental to the health of migratory salmonids and their habitats.

This survey found a wide range of natural geologic and topographic features affecting the productivity of freshwater habitats for salmonid and other native fish. However, the survey also found significant human derived influence from **use of land and water resources** which are currently affecting recruitment of juveniles and subsequent smolt production.

Although outside the remit of this survey, the long-term **use of water resources** in the Shira, Kinglas and Fyne catchments and newer developments on the Douglas and Kinglas for generation of hydro electric generation schemes, future investigation is required to better understand the effects on fish populations and their habitats. There are opportunities under the review of Controlled Activities Regulations (CAR) under the Water Framework Directive (WFD) to better utilise compensation and freshet flows for the benefit of fish and the wider ecology of these rivers.

This survey did however identify significant modification of natural river morphology in significant reaches of the **main channels** in some catchments. Where possible, restoration of habitats that have been straightened, realigned, embanked and constrained by revetments and weirs are likely to have significant long-term benefits for fish populations and wider biodiversity. However, there are significant hurdles to overcome in the availability of resources, technical know-how and land use considerations before this can be achieved. Therefore, these options for habitat restoration need to be considered in the medium to long-term in most cases.

This survey did not have sufficient resources to consider the many **tributary streams** that are important to sea trout recruitment. Anecdotal habitat information and fish survey data presented here suggest that a significant proportion of tributary stream habitat has been affected by channel straightening and constraining with a consequential loss of habitat features, particularly pool and spawning sites that are important to the early phases of salmonid fish recruitment. Further study and prescription of remedial activity is therefore required in the future if sea trout populations are to benefit.

While a significant proportion of river banks surveyed were found to host favourable semi-natural broadleaf woodland habitat, this **land use** was mostly restricted to higher gradient habitat (often sub-optimal for fish recruitment) or used to secure river banks in modified reaches of river. Expanding **riparian woodland** coverage into moderate and lower gradient habitats that are currently affected by grazing of livestock will have significant benefits for fish populations. These benefits include bank cover, large woody debris provision, food production and water temperature regulation which will have a positive long-term effect on the health of cold water fish in relation to **future climate change**.

Localised **fencing of stream banks** affected by grazing may improve the diversity of riparian vegetation, but a more significant scale of broadleaf tree planting and protective fencing are required in some upland areas to improve the diversity of vegetation. Additional control of deer numbers may also be required to reduce significant grazing pressure on stream banks. An integrated approach to control of grazing and restoration of stream morphology is likely to be required to achieve widespread and significant improvement as measures to regenerate bank vegetation may prevent or impair natural recovery of morphology where river channels have been modified.

Forestry activity in a number the catchments in Loch Fyne has a significant influence on riparian habitat, which will require re-structuring to achieve standards outlined in the Forest and Water Guidelines. Most of morphological impacts of conifer plantations are being addressed by the Forestry Commission under the Water Framework Directive over the next

two-to-three cycles of the Argyll and Lochaber River Basin Plan, but privately owned forests will also need to prioritise felling and subsequent restoration of broadleaf woodland if fish populations are to benefit.

Timely measure for control and eradication of **Invasive non-native plants** such as the Japanese Knotweed on the foreshore of Loch Fyne and a number of catchments including the Aray, Shira and Cuilarstich are likely to prevent further spread and impairment of local biodiversity. Measures for prevention of introduction and spread of all priority invasive non-native species are likely to have longer-term benefits in protecting against new threats to biodiversity. Two populations of **minnows** found by this and other surveys are not likely to be removed, but preventing further translocation must be a priority to prevent competition and biosecurity risks to native fish.

Much of the habitat management and improvement actions may be accomplished by land and fishery managers and owners. Guidance and sources of funding for this work can be found in the catchment specific reports generated as part of this study.

Acknowledgements

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Table of Contents **Page**

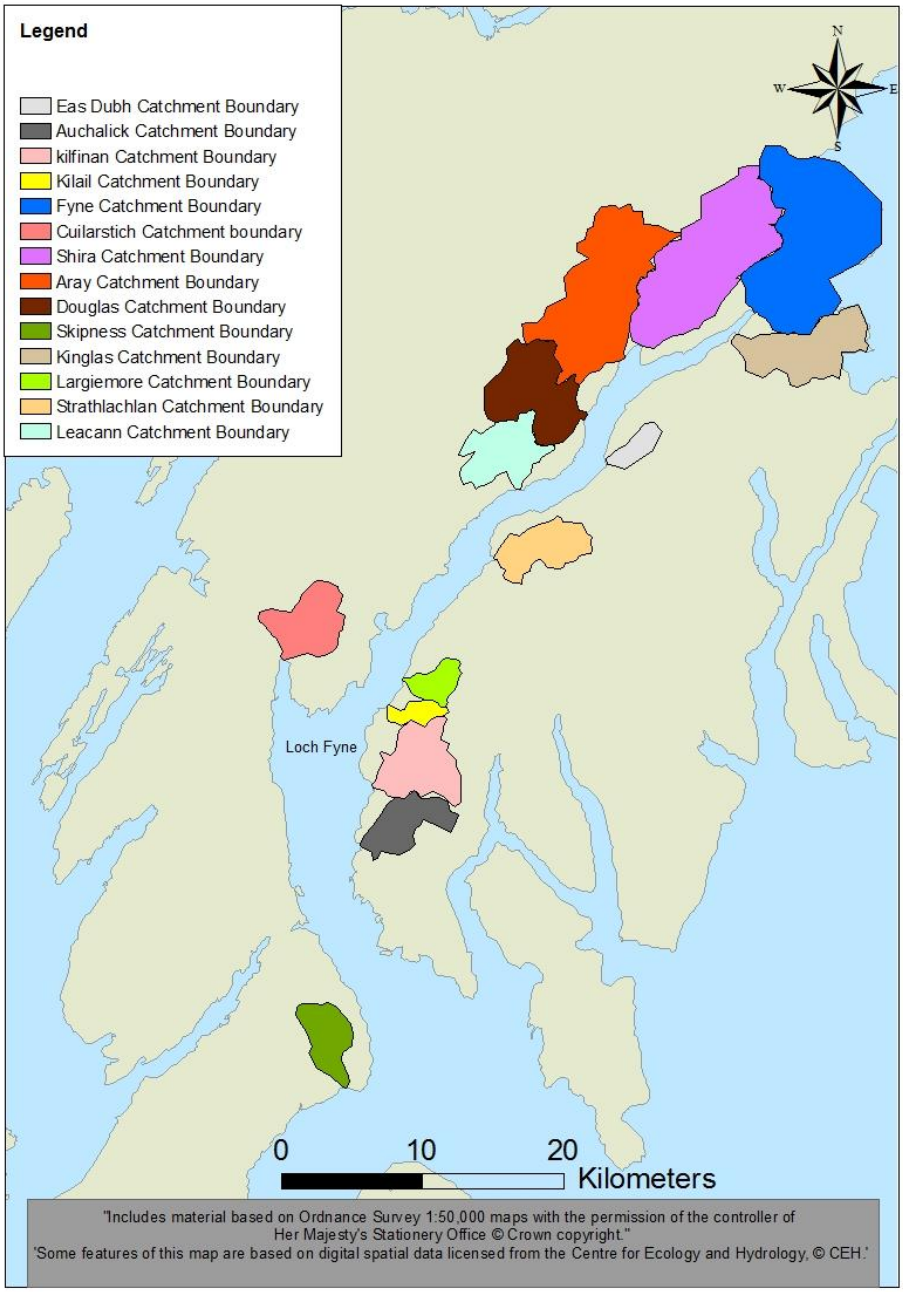
List of Figures **Page**

List of Tables **Page**

1 INTRODUCTION

Argyll Fisheries Trust undertook electrofishing surveys of fish population and habitat on 14 catchments around Loch Fyne in 2011 (Figure 1.1). The aim of the surveys was to collect information on fish species distribution; their relative abundance and the quality of habitats to establish the status of the freshwater resource. Additionally, guidance for habitat management and improvement initiatives are provided to enable land managers and landowners to identify riparian improvement works that will restore and enhance biodiversity and the fishery resource. Potential sources of grant aid to fund improvement work are highlighted in section 5.2 of this document.

Figure 1.1 Catchments surveyed in Loch Fyne, 2011



This report summarises the findings of the surveys undertaken in 2011 and makes comparison to fish data collected on some rivers where data was available. This report has two main purposes;

Firstly it will enable land managers and landowners to identify riparian works which will enhance biodiversity and fishery productivity and give guidance on potential sources of grant aid to help fund improvement work. Secondly, in addition to previous surveys in upper Loch Fyne, this survey provides further baseline data on fish populations which may contribute to time-series information so that future comparison studies can assess the health of the fisheries over time and quantify any benefits delivered by habitat improvement works in the future.

In addition to the survey findings, the implication for management is discussed and management actions that are likely to be beneficial to fish will also improve the aquatic environment and protect wider biodiversity. Potentially beneficial initiatives are linked to environmental measures in the Scottish Rural Development Programme (SRDP) in individual catchment specific reports (provided separately), which may be a useful resource for informing habitat improvements and identifying sources of funding to deliver improvement work.

A number of appendices to this report are provided to give general background information that is relevant to the wider understanding of the information given within the text of this report. Background information on the geology, use of land and water resources and the ecological status of the larger catchments provided for the Argyll and Lochaber River Basin Plan (SEPA, 2010) are summarised in Appendix I. A description of the management of fisheries and historical fishery catch statistics are summarised in Appendix II. The general trends in juvenile salmonid fish are reviewed in Appendix III for fish surveys undertaken in upper Loch Fyne. Maps of the distribution and abundance classification of juvenile salmonid and other fish for the 2011 survey are given in Appendix IV, while the result tables for both fish and habitat surveys are given in appendix V.

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. Survey site locations were chosen to represent the likely distribution of migratory fish and typical habitat condition within each catchment.

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

The electrofishing technique used to capture salmon and trout is also effective at capturing non-salmonid fish species. However, physiological differences between species means that the electrical output settings used to capture salmonids do not initiate the same level of response in other species. Additionally, the shallow water habitats targeted during salmon and trout surveys may not reflect the ecological requirements of other species due to seasonal or ontogenetic habitat preferences. Non-salmonid fish data is therefore less accurate and allows only for qualitative assessment of their distribution to be made.

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) (see Appendix V).

The classification scheme is based on statistical analysis of data from 185 sites in the west coast region of Scotland and places abundance into six quintile ranges (Class A to F) depending on stream width at a given survey site. Classes A (high) through to E (low) are assigned to abundance placed within a given quintile range, while Class F represents an absence of fish. The 100th percentile represents the highest density found at any one of the 185 sites compared. By comparing the class of abundance, rather than minimum density values, broad comparison of population status can be made. Localised changes at one or two survey sites may be expected as a part of natural variation, but widespread differences in abundance of a species or age class at a catchment or regional level may provide more reliable information on general trends in distribution and abundance.

2.1.4 Survey sites

A total of 92 fish survey sites were electro-fished between the 13th of July and the 13th of October 2011 (Table 2.2, and Figure 2.1). The surveys covered an area of 12,315 m² of habitat in 14 catchments that drain 401 of the 718 km² (56%) of catchment in the Loch Fyne region. The sampling effort was highest (61 sites) in the seven watercourses in upper Loch Fyne where the relative total size of catchments (total of 304 km²) and accessibility to migratory salmonids was higher than compared to watercourses in the lower loch. The seven catchments surveyed in lower Loch Fyne are one-third (total of 97 km²) that of the upper loch and proportionately approximately one-third of sampling effort was employed (31

of a total of 92 sites) in the lower loch. At the time of survey, the water conditions varied between favourable low and clear flow conditions at most sites. While medium flow and coloured (tainted) water conditions during surveys of the Largiemore, Skipness and Kilfinan catchment may have reduced sampling efficiency, conditions were sufficient to maintain effective and robust data collection. Average water conductivity measured at survey sites ranged between 17 (µs/cm^{-1}) in the Kinglas Water and 85 (µs/cm^{-1}) in the Largiemore and Cuilarstich Burns. Average water temperatures during the survey ranged from 10.0 to 13.6°C.

2.2 Habitat surveys

A walkover habitat survey was undertaken on main channels of 14 catchments with the aim of quantifying and evaluating 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 survey was divided up into 500m default sections to record riparian habitat characteristics, while in-stream characteristics were recorded according to changes in gradient and stream type. All survey start and end points (six figure grid reference) and photographs were recorded by a hand-held computer (Trimble TSC3). 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 bank-side habitat characteristics were recorded with the left and right banks orientation viewed downstream.

The type of river channel present in each survey section was categorized in relation to the fluvial geomorphological character as described by Rosgen (1998). The suitability of the habitat for different life-stages of salmonid fish was classified using definitions related to water depth adapted from Hendry and Cragg-Hine (1996) and assessment of habitat condition was scored (using a scale of 1 (poor) to 5 (excellent)) depending on the presence of habitat features likely to promote or reduce the productivity of the habitat for juvenile salmonid fish.

The location of obstacles and key habitats for salmonid fish; obstacles to migration, holding pools for adult fish, spawning sites and in-stream modifications to the habitat were recorded 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).

Land use, bank features and riparian habitat features were classified according to River Habitat Survey methodology (Environment Agency, 2003) and the presence of invasive non-native plants (INNS) were also recorded.

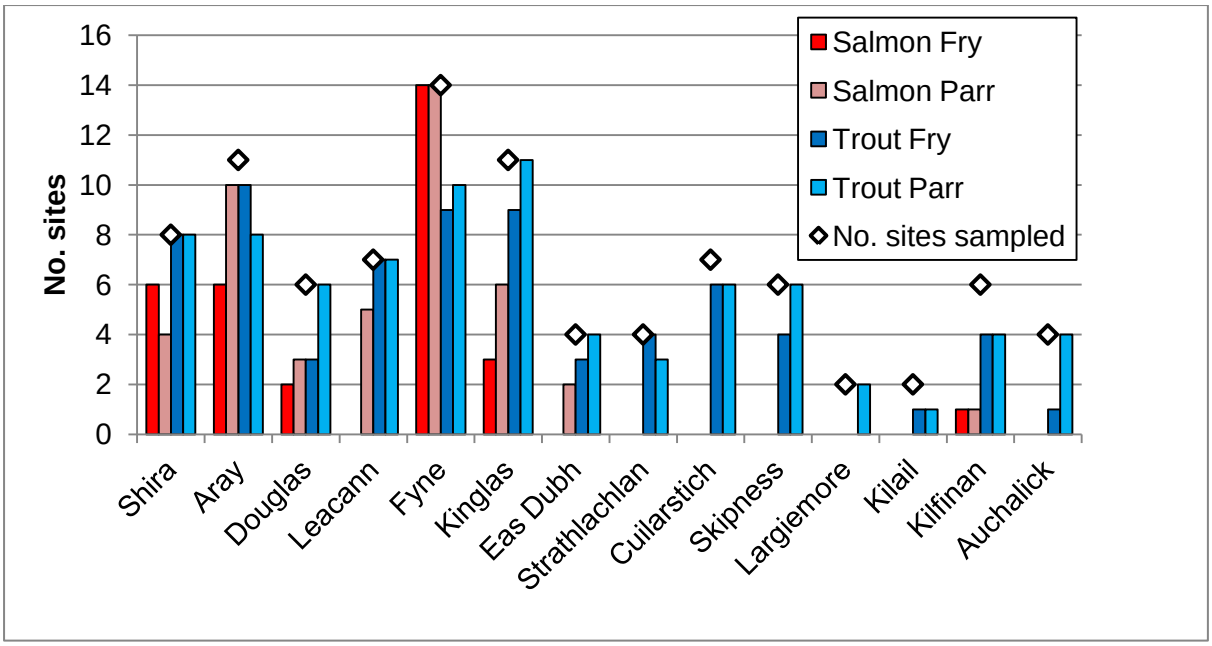
3 RESULTS

3.1 Electrofishing survey

3.1.1 Juvenile salmonid fish distribution 2011

Juvenile trout and salmon were sampled in all 14 catchments surveyed in 2011. Salmon fry were found at 32 (35 %) of the 92 sites sampled compared with salmon parr which were found at 45 (49 %) of sites. Trout fry were found at 69 (75 %) of the sites compared to trout parr which were found at 80 (87 %) of sites (Figure 3.1.1).

Figure 3.1.1 Distribution of juvenile salmonid fish (no. of sites) 2011



In the 61 sites (66 % of all sites) surveyed in the seven catchments of upper Loch Fyne (north of the upper-most sill in Loch Fyne), salmon fry (less than one year old) were found at 31 (51 %) of sites in five catchments. Salmon parr (more than one year old) were found at 44 (72 %) of sites in all seven catchments. Trout fry (less than one year old) were found at 49 (80 %) of sites and trout parr (more than one year old) were found at 54 (89 %) of sites in all seven catchments.

In the 31 sites (34 % of all sites) surveyed in the seven catchments of lower Loch Fyne (south of the upper-most sill in Loch Fyne), salmon fry were found at 1 (3 %) of site in the Kilfinan catchment as were salmon parr. Trout fry were found at 20 (65 %) sites in six catchments and trout parr were found at 26 (84 %) sites in all seven catchments.

3.1.2 Classification of salmonid fish abundance 2011

The classification of the minimum density of juvenile salmon sampled in the 2011 relative to river width ranged from grade F where no fish were found, classes D and E represent relatively low to very low abundance, classes C and B represent moderate to high abundance respectively and class A represents a very high abundance. The minimum, maximum and most frequent classifications (modal) for each catchment are given in Table 3.1.1).

Table 3.1.1 Classification of juvenile salmon abundance 2011

Catchment	Salmon Fry			Salmon Parr		
	Mod.	Min.	Max.	Mod.	Min.	Max.
Shira	D	D	A	F	D	A
Aray	C	D	B	A	D	A
Douglas	F	D		F	E	A
Leacann	F			D	E	B
Fyne	D	E	A	D	E	A
Kinglas	F	E	C	E	E	D
Eas Dubh	F			F	E	A
Strathlachlan	F			F		
Largiemore	F			F		
Cuilarstich	F			F		
Skipness	F			F		
Kilail	F			F		
Kilfinan	F	E		F	E	
Auchalick	F			F		

In the eight catchments where juvenile salmon were found in Loch Fyne, minimum values of fry abundance ranged from none (class F) in the Leacann Water and Eas Dubh to relatively low in the Fyne, Kinglas and Kilfinan (class E) and Shira, Aray and Douglas (class D). Maximum values found at sites where fry were present ranged from low abundance in the Kinglas Water (class D) and Kilfinan Burn (class E) to moderate abundance in the Kinglas Water (class C) and high or very high abundance in the Aray (class B), Shira and Fyne (class A). The most common (modal) class of fry abundance found at sites ranged from none (class F) in the Douglas, Kinglas Water and Kilfinan Burn or low abundance in the Rivers Fyne and Shira (class D) to moderate abundance in the River Aray (class C).

Minimum values of salmon parr abundance ranged from very low in the Kilfinan Burn, Eas Dubh, Leacann, Douglas and Fyne (class E) to low in the Shira and Aray (class D). Maximum values of parr abundance ranged from low abundance in the Kinglas Water (class D) and Kilfinan Burn (class E) to high abundance in the Leacann Water (class B) and very

high abundance in the Aray, Shira, Douglas, Eas Dubh and Fyne (class A). The most common (modal) class of parr abundance found at sites ranged from none (class F) in the Shira, Eas Dubh and Kilfinan or low abundance in the Leacann and Fyne (class D) or very low abundance in the Kinglas Water (class E). Very high abundance of salmon parr was commonly found in the River Aray (class A).

In the 14 catchments where juvenile trout were found in Loch Fyne (Table 3.1.2), minimum values of trout fry abundance ranged from none (class F) in the Largiemore, Kilail and Auchalick to relatively (class E) in all other catchments with the exception of the River Shira where high abundance (class B) was found to be the lowest abundance found at any site.

Table 3.4 Classification of juvenile trout abundance 2011

Catchment	Trout Fry			Trout Parr		
	Mod.	Min.	Max.	Mod.	Min.	Max.
Shira	A	B	A	E	E	A
Aray	A	E	A	C	E	A
Douglas	F	E	A	C	E	A
Leacann	C	E	B	D	D	A
Fyne	E	E	C	E	E	A
Kinglas	E	E	A	E	E	A
Eas Dubh	C	E	A	A	E	A
Strathlachlan	E	E	E	E	E	C
Largiemore	F			D	D	C
Cuilarstich	E	E	C	C	E	A
Skipness	F	E	A	B	E	A
Kilail	B	F	B	E	F	E
Kilfinan	D	E	A	F	A	
Auchalick	F	F	E	B	E	B

Maximum values found at sites where fry were present ranged from very low abundance in the Strathlachlan and Auchalick (class E) to moderate abundance in the Fyne and Cuilarstich (class C) and high or very high abundance in the Leacann, Kilail (class B), Shira, Aray, Douglas, Kinglas Eas Dubh, Skipness and Kilfinan (class A).

The most common (modal) class of trout fry abundance found at sites ranged from none (class F) in the Douglas, Skipness and Auchalick or low abundance in the Rivers Fyne, Kinglas, Strathlachlan, Cuilarstich (class E) and Kilfinan (class D) to moderate abundance in the Eas Dubh and Leacann (class C) and high abundance in the Shira and Aray (class A).

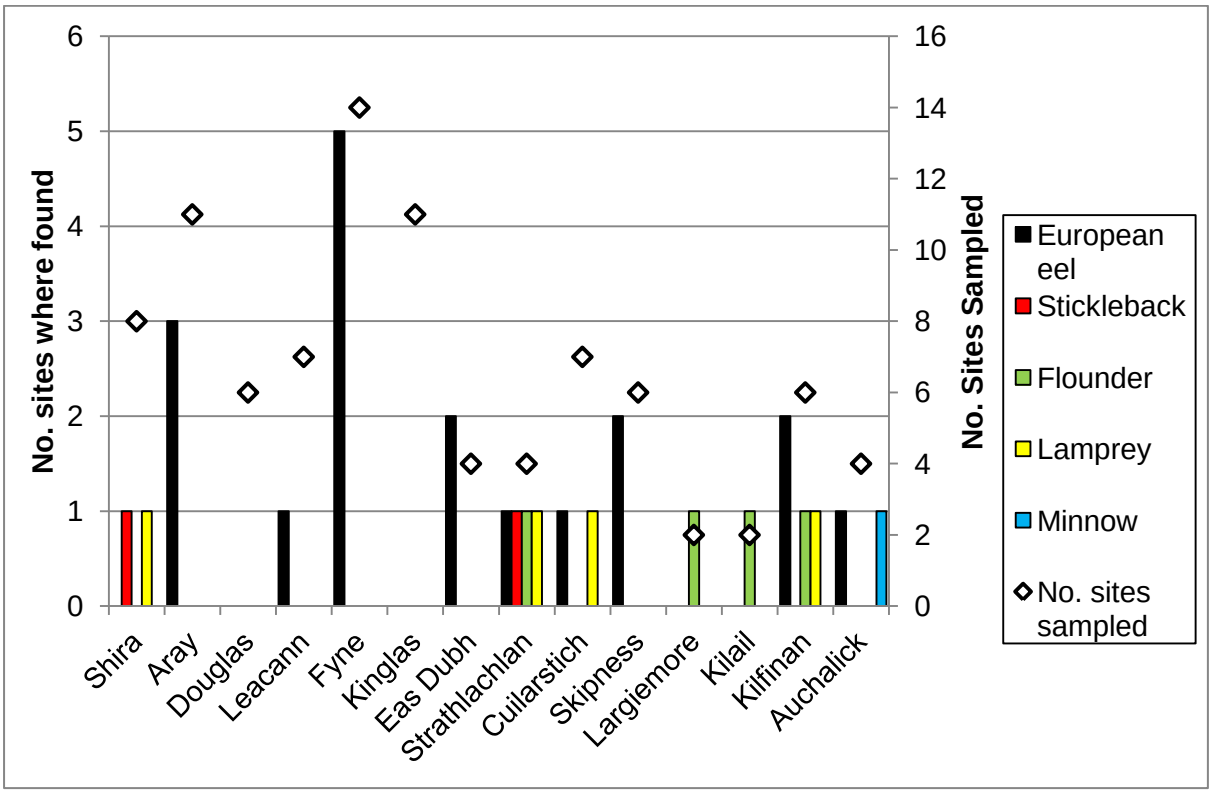
Minimum values of trout parr abundance ranged from none in the Kilail (class F), very low (classes E and D) in all other catchments with the exception of the Kilfinan Burn (class A).

Maximum values of parr abundance ranged from moderate abundance in the Strathlachlan and Largiemore (class C) to high or very high abundance in all other catchments. The most common (modal) class of parr abundance found at sites ranged from none (class F) in the Kilail and Kilfinan or low abundance in the Shira, Fyne, Kinglas Water, Strathlachlan (class E) and Leacann Water (class D). Moderate abundance of trout parr (class C) was most common in the Aray Douglas and Cuilarstich and high abundance (class B) in the Skipness and Auchalick and very high abundance of salmon parr was commonly found in the Eas Dubh (class A).

3.1.3 Non-salmonid fish distribution 2011

The electrofishing surveys found European eels at 18 (20 %) sites in nine catchments (Figure 3.1.2) in 2011; Aray, Leacann, Fyne, Eas Dubh Strathlachlan, Cuilarstich, Skipness, Kilfinan and Auchalick, but have also been found in four other catchments in previous surveys; Shira, Douglas and Kinglas. Stickleback were found at two sites in the Shira and Strathlachlan catchments in 2011, while flounder were found in four sites in four catchments; Strathlachlan Largiemore, Kilail and Kilfinan, but have also been found in two others; Shira and Kinglas in previous surveys. Lamprey were found in four sites in four catchments; Shira, Strathlachlan, Cuilarstich and Kilfinan. Minnow were found only in the Auchalick catchment in 2011, but have also been found in the Aray catchment in previous surveys.

Figure 3.1.2 Distribution of non-salmonid fish (no. of sites), 2011

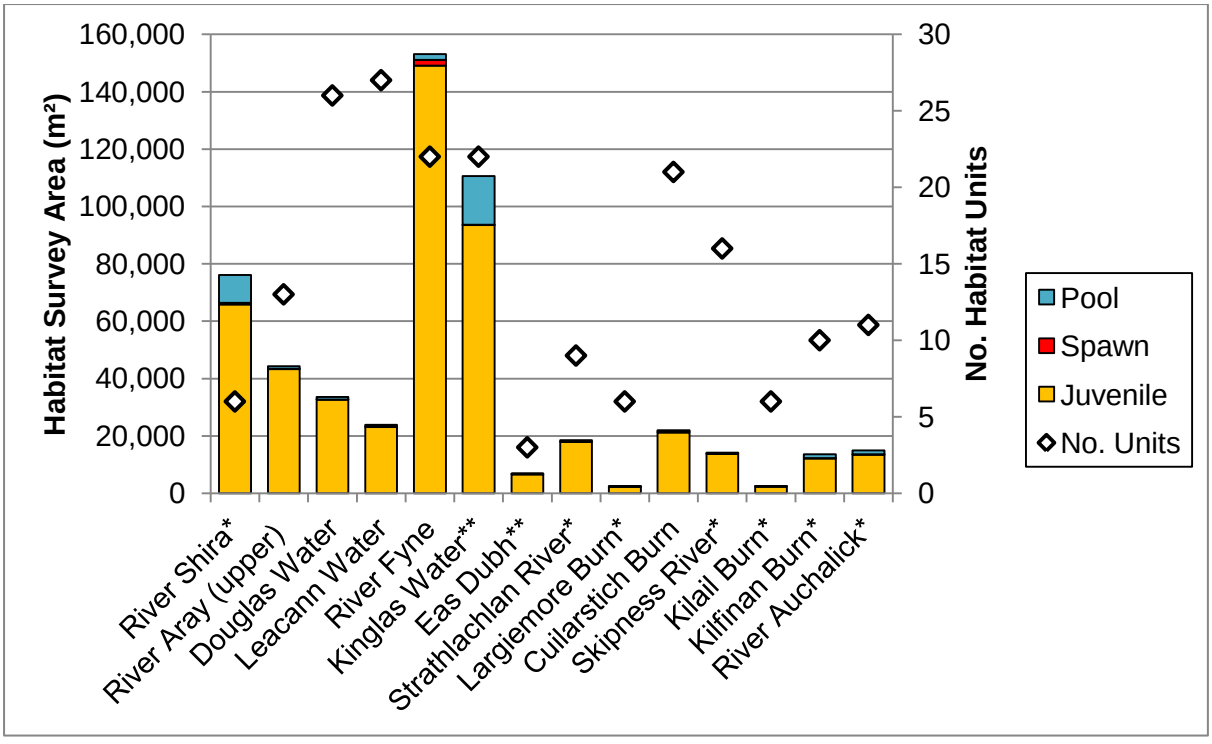


3.2 Habitat survey

An estimated total of 67.87 km of stream were surveyed in 14 catchments (Figure 3.2.1) covering 569,042 m² of fish habitat. On the western side of upper Loch Fyne, 22.7 km of river were surveyed in four catchments (Shira, Aray, Douglas and Leacann) with an estimated 196,804 m² of habitat (34% of all habitat surveyed). An estimated 5 km length of Survey data from the lower River Aray was corrupted, which will require re-survey. On the eastern side of upper Loch Fyne, 23.2 km of river were surveyed in three catchments (Fyne, Kinglas Water and Eas Dubh) with an estimated 281,453 m² of habitat (49 % of all habitat surveyed).

On the western side of lower Loch Fyne, 14.7 km of river were surveyed in four catchments (Strathlachlan, Largiemore, Cuilarstich and Skipness) with an estimated 58,722 m² of habitat (10 % of all habitat surveyed). On the eastern side of lower Loch Fyne, 7.4 km of river were surveyed in three catchments (Kilail, Kilfinan and Auchalick) with an estimated 32,063 m² of habitat (5 % of all habitat surveyed).

Figure 3.2.1 Habitat survey coverage



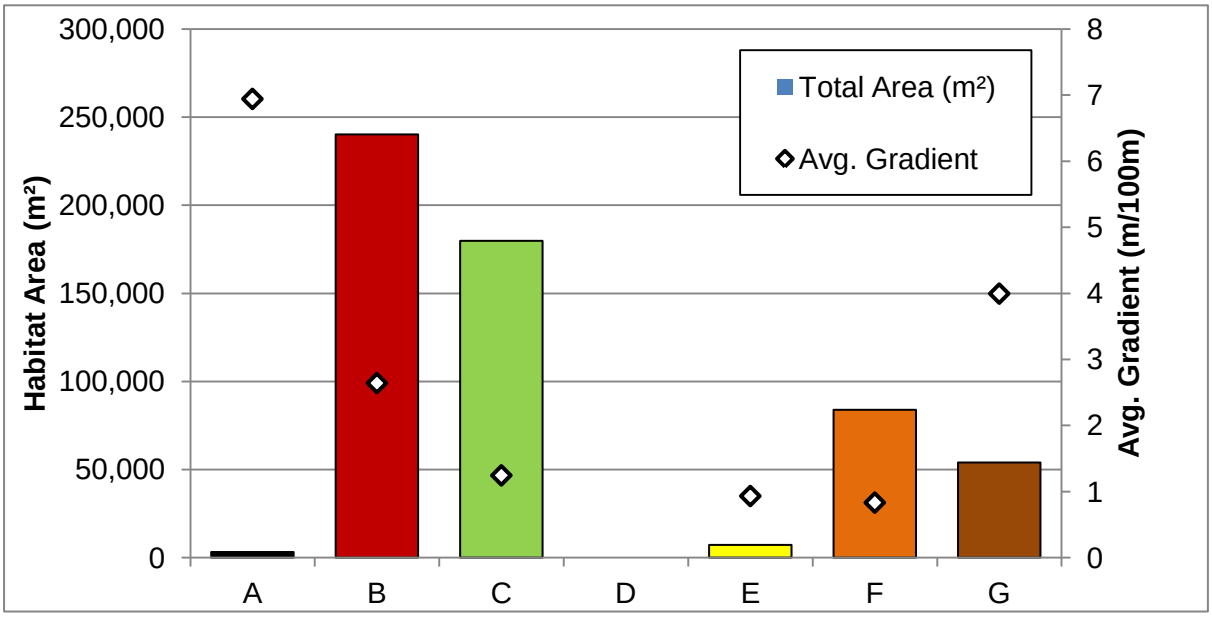
*Note; * Medium resolution survey, ** Low resolution survey*

3.2.1 Habitat types

The survey identified 200 separate habitat units with varying amounts of habitat suitable for salmonid fish recruitment. On average, approximately 5 % of habitat area was suitable for adult salmonids (deeper pools) and 94 % of habitat were suitable for juveniles (fry and parr), while only 1 % was assessed as being suitable for early stages of recruitment (spawning).

Of the habitat surveyed (Fig. 3.2.2), 10 % was of high gradient (4-8 m/100m slope) with an entrenched channel, low sinuosity (channel type A) and substrates dominated by bedrock and large boulder (substrate types 1 and 2). Relatively moderate gradient (2-4 m/100m slope) habitat with moderately entrenched channel (type B), moderate sinuosity and substrates dominated by boulders and cobbles (types 2 and 3) were found in 42 % of the habitat. Entrenched river channels of moderate gradient that are less able to access the flood-plane (type G) were found in 9 % of habitat. Three types of low gradient (0-4 m/100m slope) habitat were found; two types (C [32 %] and E [1 %]) are slightly entrenched with moderate-to-high sinuosity and potential for lateral migration across the flood-plane. One other (type F) are entrenched with moderate sinuosity, but are less able to access the flood-plane, were found in 15 % of the habitat. The substrates found in low gradient habitat were mostly cobble (type 3) and gravel (type 4).

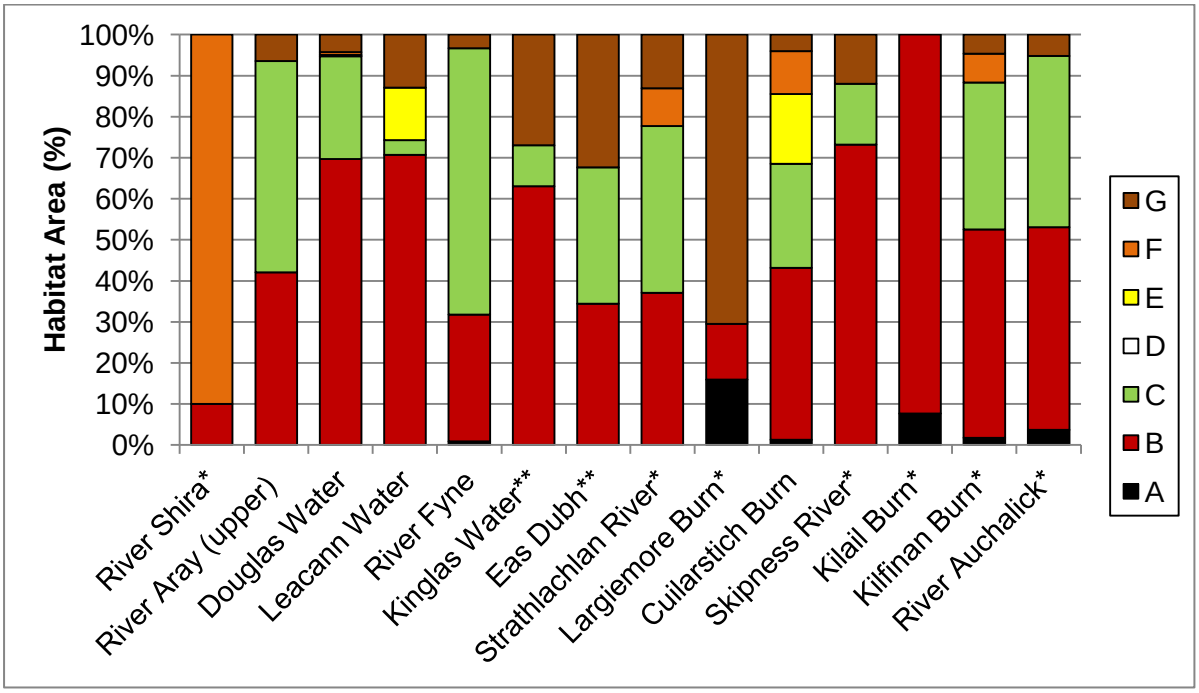
Fig. 3.2.2 Habitat Type abundance (m²) and average gradient (m/100m slope)



While the distribution of high gradient channels (type A) was found in six catchments (Figure 3.2.3), large areas (> 10 %) were found in the Largiemore Burn. Although present in all the other catchments they were not found in habitats accessible by migratory salmonids. Moderate gradient channels (types B or G) were found in all catchments surveyed while low

gradient habitat (types C, E and F) were found in the lower reaches of 12 of the 14 catchments surveyed. No significant areas of habitat with multiple (braided) channel form (type D) were found.

Fig. 3.2.3 Habitat Type distribution (% of habitat area)



The river-bed substrates (Figure 3.2.4) found that are unsuitable for juvenile fish were dominated by bedrock substrate (type 1) found in 11 % of the habitat area (11 catchments) surveyed, mostly in the highest gradient habitat (average 4.5 m fall over a 100m length). Boulder (type 2) dominated habitat that is more suited to older parr life-stages was found in 24 % of the habitat area (10 catchments) surveyed (average 3.2 m fall over a 100m length). Cobble (type 3) dominated habitat that is more suited to mixed fry and parr life-stages was found in 44 % of the habitat area (all catchments) surveyed (average 2.3 m fall over a 100m length). Gravel (type 4) dominated habitat that is more suited to fry, but has poorer cover potential for older fish was found in 21 % of the habitat area (seven catchments) surveyed (average 1.0 m fall over a 100m length).

The survey found that 64% of river channel length was unable to migrate laterally across the valley floor, 78 % of which was naturally confined by natural features, while the remaining 22 % was retained by channel straightening and bank hardening. The plan form of river channels (Figure 3.2.5) was found to be realigned and straightened on 15 % of the channel length in nine catchments and a mix of realigned and natural channel in 7 % of channel length in six catchments.

Fig. 3.2.4 substrate type distribution (% of habitat area)

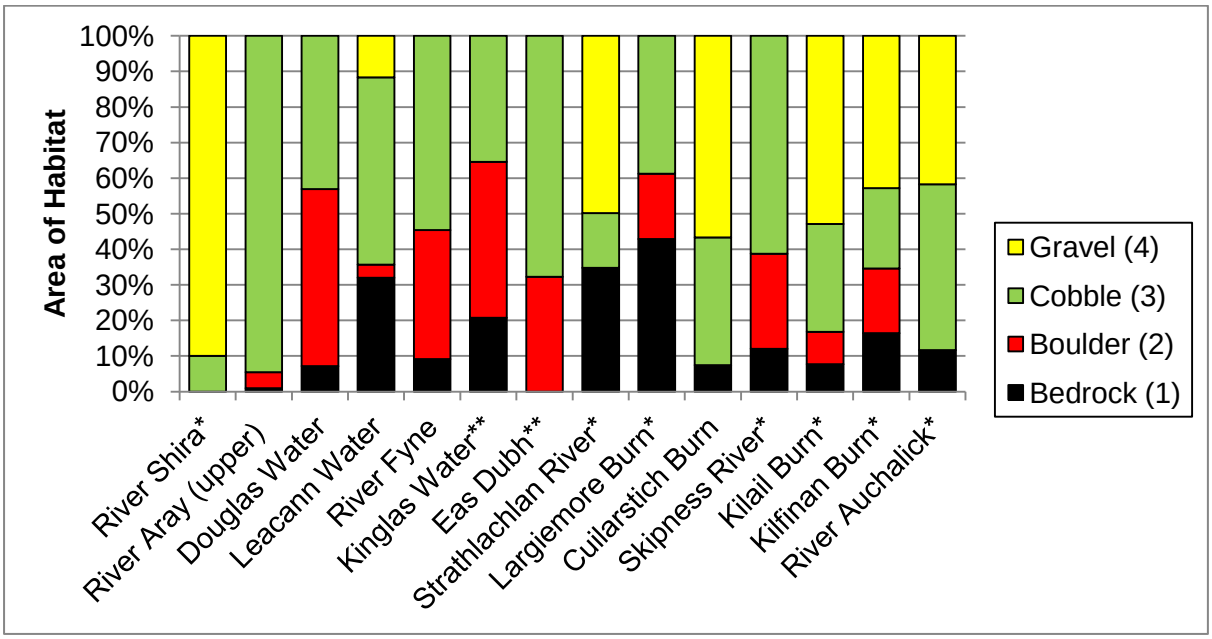
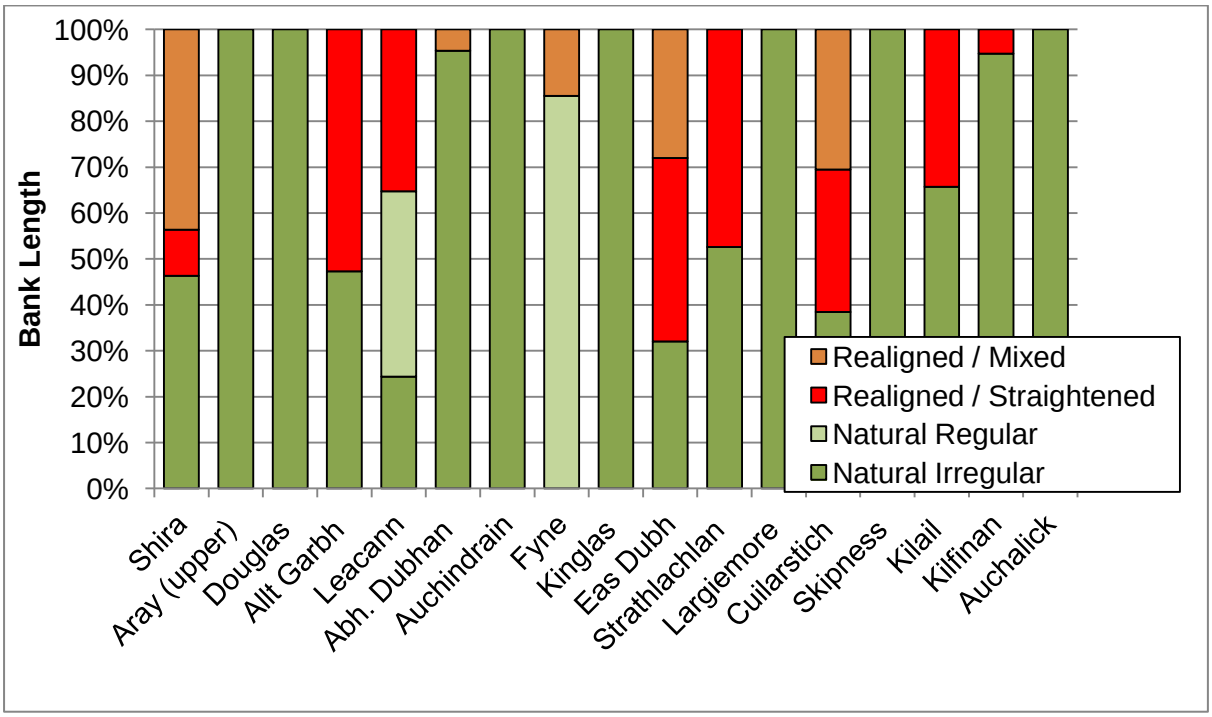


Fig. 3.2.5 Morphological characteristics (% of bank length)



Embankments that restrict access of the river to the flood-plain (Figure 3.2.6) were found to be present on an average of 22 % of bank length in 12 of the 14 catchments surveyed and extensive on a further 13 % of banks in eight catchments. Bank revetments that prevent lateral migration of the channel across the valley floor (Figure 3.2.7) were found to be present on 28 % of bank length in 12 catchments and extensive on a further 11 % of banks.

Fig. 3.2.6 Embanked river banks (% of bank length)

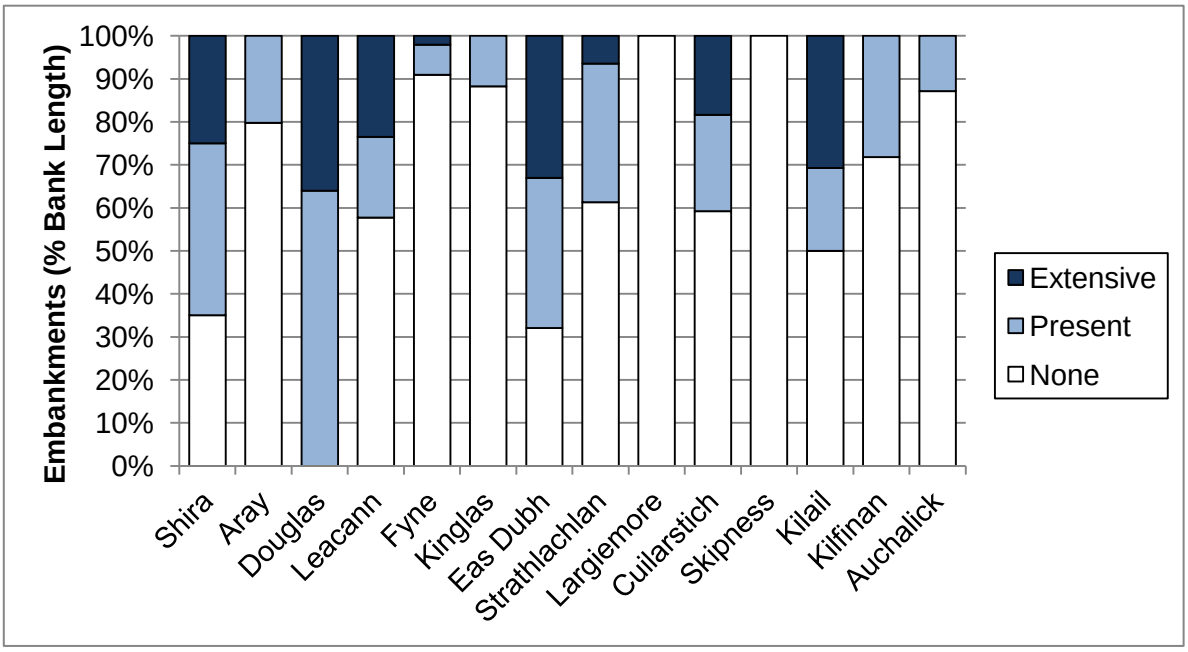
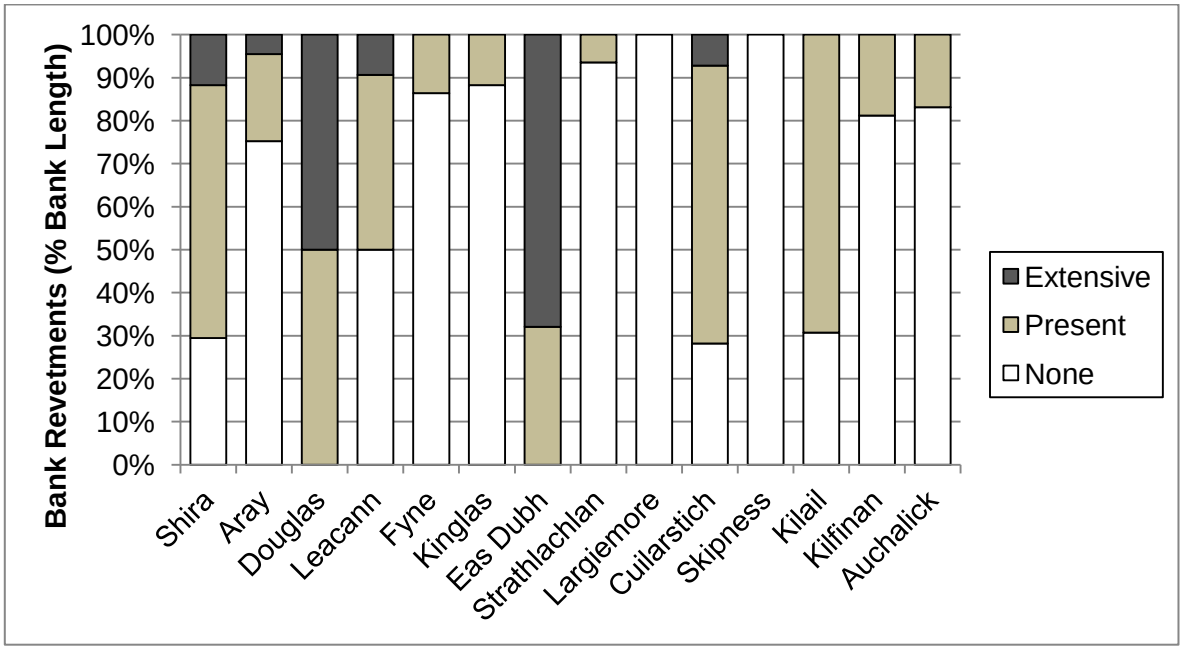


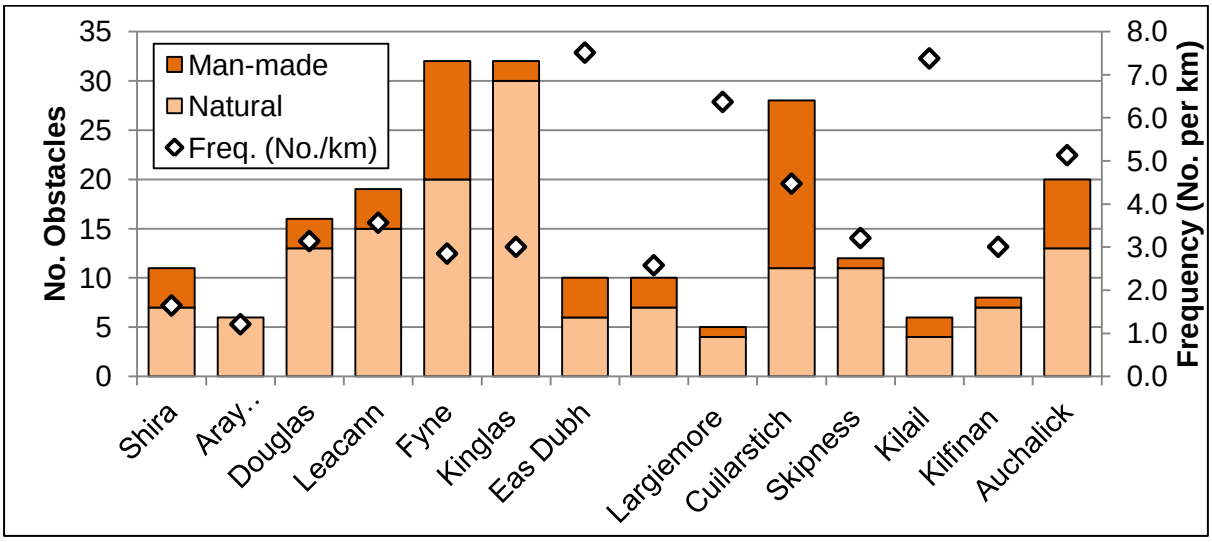
Fig. 3.2.7 Bank revetments (% of bank length)



3.2.2 Connectivity of key habitats

A total of 216 significant obstacles to fish passage were recorded during the surveys (Figure 3.2.8), 154 (71 %) of which were natural and 61 (28 %) were man-made obstacles, such as weirs and bridge aprons. The frequency of obstacles recorded in each catchment averaged 3.9 obstacles per km, but ranged from 1.2 in the upper Aray to 7.5 in the Eas Dubh

Fig. 3.2.8 Obstacle abundance and frequency (No. per km)

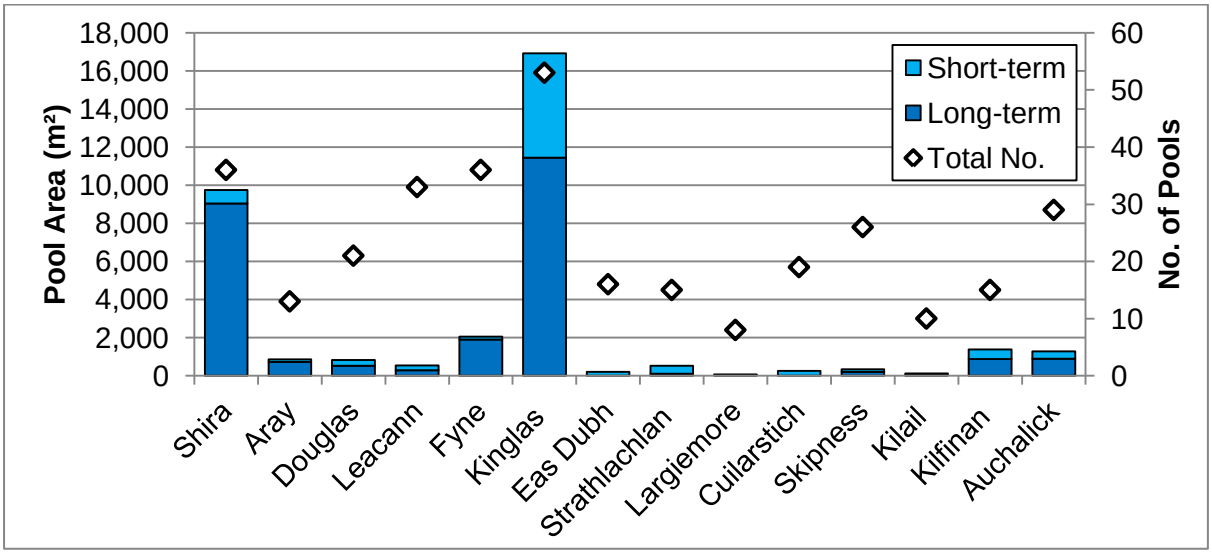


A total of 18 obstacles (8 %) were assessed as likely to prevent further upstream migration to salmonid fish, which consisted of 16 waterfalls or cascades and two log jams. Fewer obstacles (three) were assessed as likely to prevent upstream migration of eels, while most obstacles (85 %) were assessed as likely to prevent upstream migration of lamprey. The distribution of obstacles is mapped in appendix V.

3.2.3 Adult holding pools

A total of 330 pool habitats that are suitable for adult salmonid fish were recorded during the surveys (Figure 3.2.9) with a total area of 35,154 m² of habitat. A total of 178 pools (54 %) of pools were suitable for longer-term habitat (during low water events) with a total area of 26,086 m² (74 % of pool area), while the remaining 152 smaller pools were more suitable as short-term habitat during migration between larger pools and spawning sites.

Figure 3.2.9 Pool habitat area (m²) and no. of sites



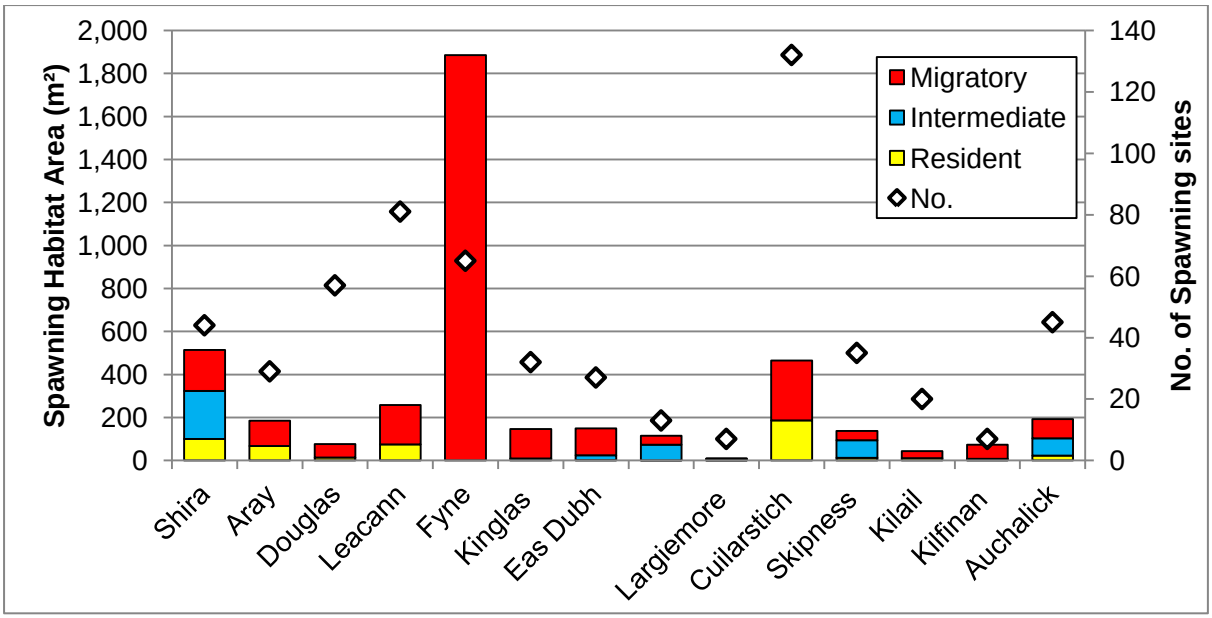
The frequency of pool habitat was found to be highest in relatively short and high gradient catchments, such as the Kilail Burn (12.3 pools per km), Eas Dubh (12.3) and Largiemore Burn (10.2), although the total number of pools was relatively low. Pool frequency was lowest in the upper Aray (2.6), Cuilarstich (3.0) and Fyne (3.2). The highest number and largest area of pool habitat was found in the Kinglas Water where bedrock substrate and relatively high gradient form relatively frequent (5.0 per km) pools in the lower half of the river. The River Shira also had a relatively high number of large pools (4.9 per km), most of which are suitable for longer-term habitat for adult fish.

No longer-term pool habitat was found in the Eas Dubh, Cuilarstich and relatively small areas were found in the Strathlachlan (104 m²), Largiemore (36), Kilail (43) and Skipness (200) catchments. Some relatively large catchments such as the Leacann (284 m²) and Douglas (530) had relatively little longer-term pool habitat.

3.2.4 Spawning sites

A total of 594 salmonid fish spawning sites was recorded during the surveys (Figure 3.2.10) with a total of 4,250 m² of spawning habitat. A high proportion of the spawning habitat (77 %) was suitable for larger migratory salmonids, while smaller proportions were suitable for small resident trout (12 %) and an intermediate mixture of substrates in a similar area (12 %).

Figure 3.2.10 Spawning habitat area (m²) and no. of sites



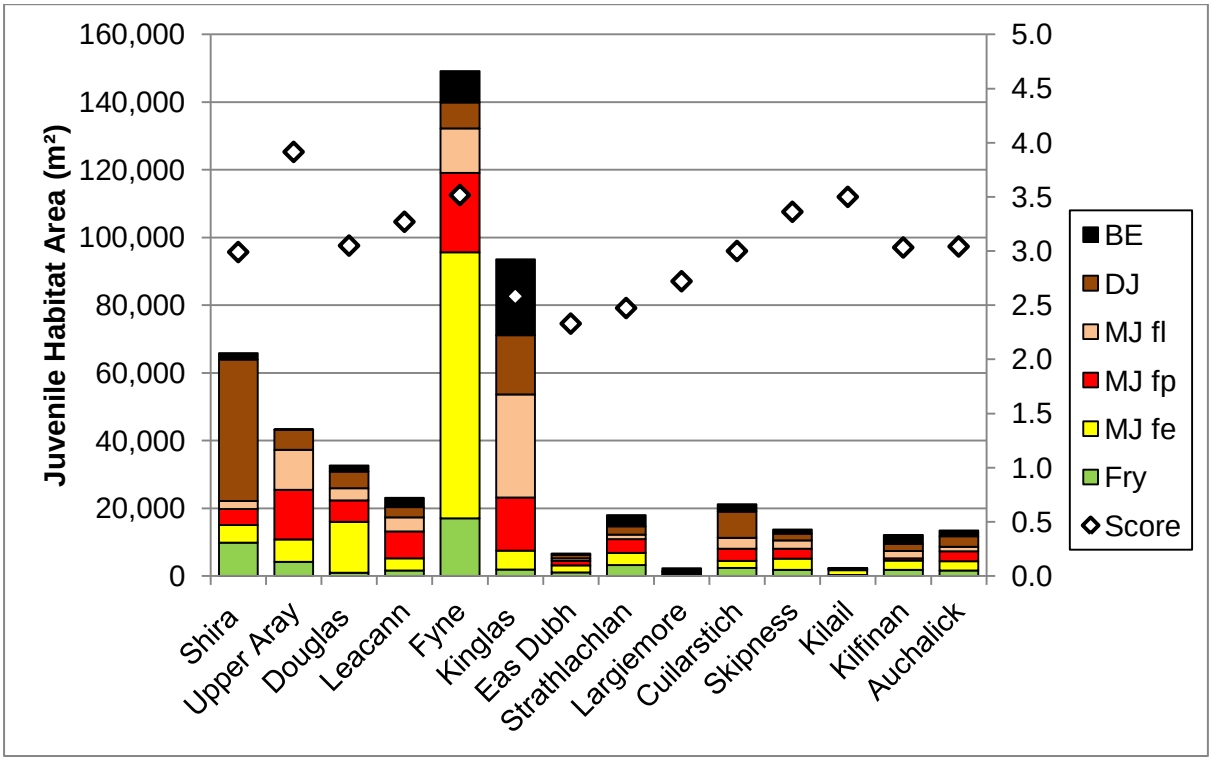
An average of 70 % of spawning habitat area was assessed as being in optimal condition, while the remaining 30 % was sub-optimal. The frequency of sites recorded in each catchment ranged from relatively low abundance in the Kilfinan (2.6 per km), Kinglas (3.0) and Strathlachlan (3.4) to relatively high frequency of smaller sites in the Kilail (24.6),

Cuilarstich (21.1) and Eas Dubh (20.3) with an average of 10.6 sites per km for all catchments. The largest area of spawning habitat for migratory fish was found in the lower River Fyne (1,886 m²) and more modest amounts in the River Shira (514 m²) and the Cuilarstich (465 m²).

3.2.5 Juvenile Habitat

The survey found a total of 497,354 m² of habitat suitable for juvenile life-stages of salmonid fish (Figure 3.2.11), an average of 10 % of which was dominated by bedrock habitat (BE) that is less suitable than other substrates due to lack of cover for juveniles.

Figure 3.2.11 Juvenile habitat area (m²) and average suitability score (1-5)



An average of 10 % of relatively shallow water (< 0.15 m depth) habitat was also suitable for fry and a further 56 % of habitat was suitable for a mixed juvenile (MJ) age classes (fry and parr), 27 % of which was extensively suitable for fry (fe). The remaining mixed juvenile habitat was a composition of habitat where fry are likely to be present (fp) in 18 % and a further 16 % where habitat is limited for fry (fl) as depth and substrate size increases. The remaining deep juvenile (DJ) habitat was assessed as being too deep (> 0.4 m depth) to be suitable for fry, but is likely to be preferred by older parr.

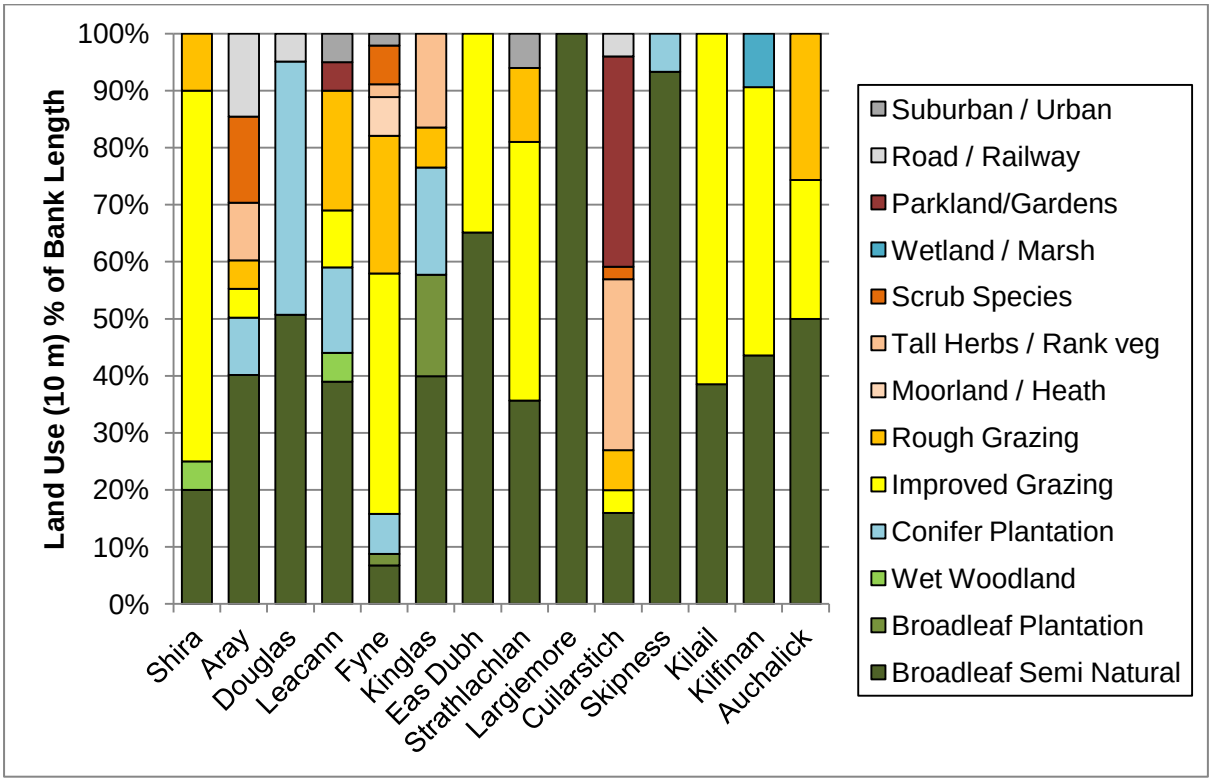
The relative suitability of all juvenile habitats was scored at an average of 3.1 out of a possible 5.0. Suitability scores were below average for the Eas Dubh (2.3), Strathlachlan (2.5), Kinglas (2.6), Largiemore (2.7), Shira (3.0), Cuilarstich (3.0), Kilfinan (3.0) and

Auchalick (3.0). An average score was given to the Douglas (3.1) and above average scores given on the Leacann (3.3), Skipness (3.4), Kilail (3.5), Fyne (3.5) and Upper Aray (3.9).

3.2.6 Habitat Condition

The natural characteristics of habitats and anthropogenic factors affecting habitat condition that influence fish habitat were recorded separately for in-stream and riparian influences. Land use in the immediate riparian zone (up to 10 m from the bank) was found to be largely a mixture of Semi-natural and broadleaf woodland (average of 46 % of bank length) livestock farming (34 % improved grazing and 14 % rough grazing) and forestry activities (17 % conifer plantation and 10% broadleaf plantation) (Figure 3.2.12).

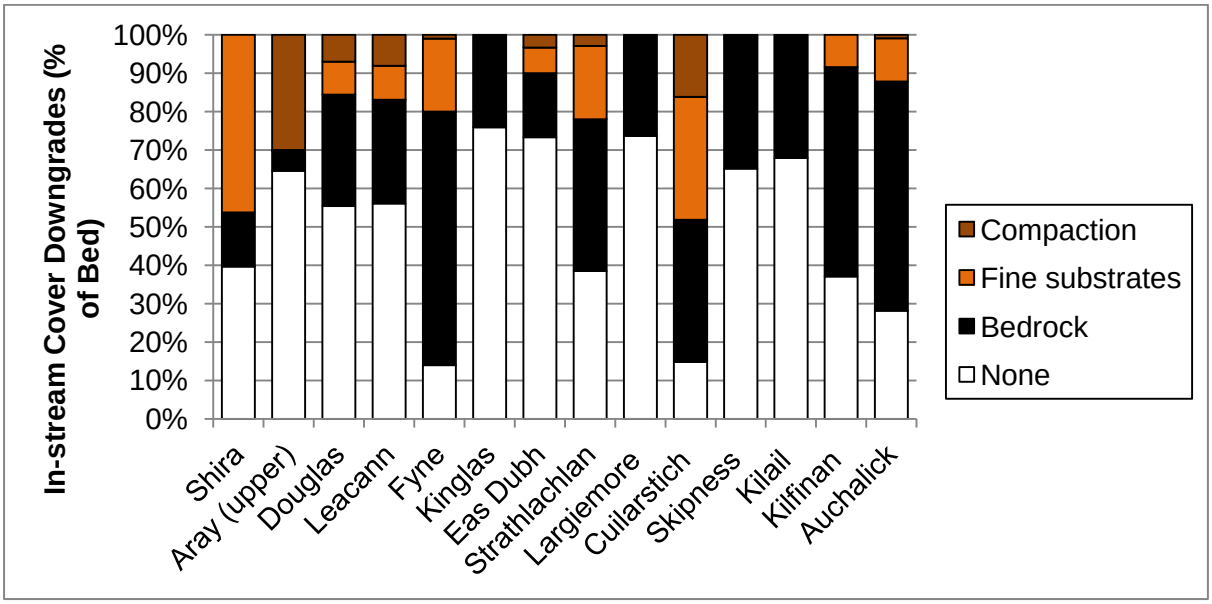
Figure 3.2.12 Riparian Land Use (10 m) (average % of bank Length)



Smaller areas of wet woodland, moorland heath, scrub and tall herbs, marsh and some more developed parkland, gardens, roads and urban development were also present.

In-stream characteristics likely to reduce cover for fish were mostly related to natural bedrock substrates and fine sediments that fill the interstitial spaces between larger substrates, reducing cover for fish and invertebrates (Figure 3.2.13). While, on average, half the habitat surveyed was found to have no downgrades for in-stream cover, natural bedrock features affect an average of 33 % of habitat, while fine substrates (12 %) and bed compaction (5 %) were also identified.

Figure 3.2.13 In-stream factors affecting fish cover (downgrades; % of bank Length)

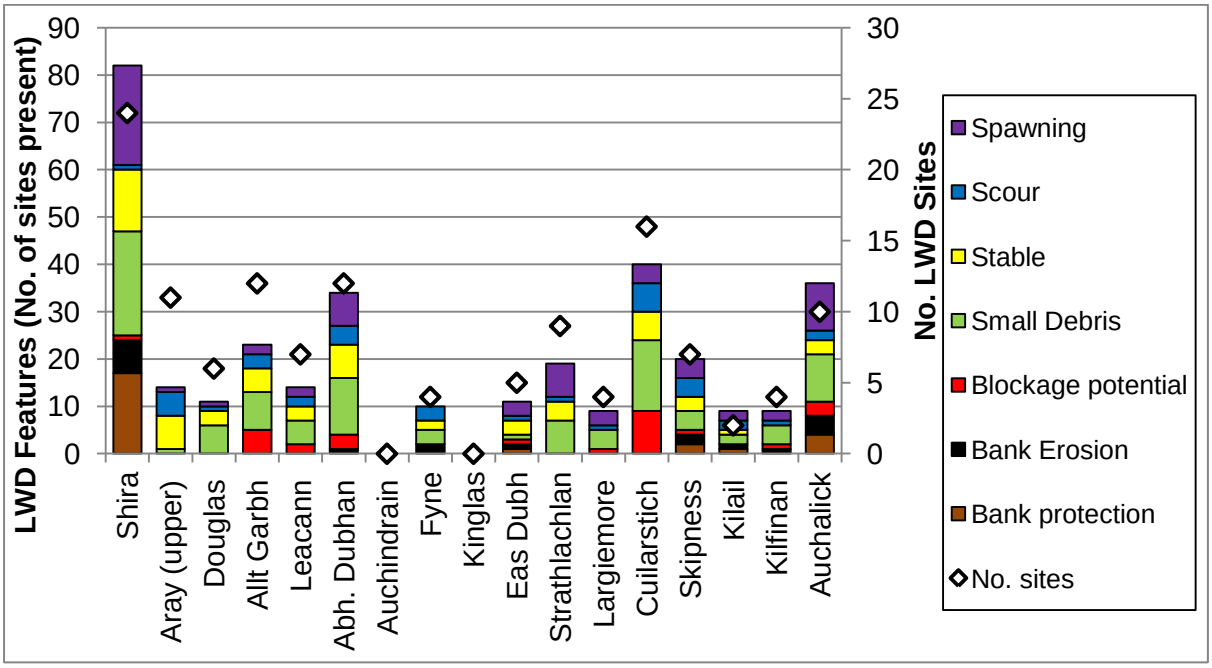


Downgrades for bedrock were identified in all catchments surveyed and were above average (50 %) proportions in the Fyne (66 % of habitat area), Auchalick (60 %) and Kilfinan (55 %). Downgrades for fine substrates were identified in 10 catchments and were above average (12 %) in the Shira (46 % of habitat area), Cuilarstich (32 %), Strathlachlan (19 %) and lower Fyne (19 %). Downgrades for compaction of the river bed substrates were identified in eight catchments and were above average (5 %) in the upper Aray (30 %), Cuilarstich (16 %), Leacann (8 %) and Douglas (7 %).

Large woody debris from fallen trees were found within the river channel at a total of 133 sites in 80 different habitat units (Figure 3.2.14) in 12 of the 14 catchments surveyed (not recorded in the Auchendrain tributary of the Leacann Water and the Kinglas Water). The frequency of LWD sites averaged 3.6 per km and were lower than average in the Fyne (0.4), Kilfinan (1.5), Douglas (1.7), Skipness (1.9), Aray (upper) (2.2), Leacann (2.2), Strathlachlan (2.3), Kilail (2.5), Auchalick (2.6) and Cuilarstich (2.6), but higher than average in the Eas Dubh (3.8), Largiemore (5.1), Abhainn Dubhan tributary of the Leacann (9.1), and highest in the Shira (15.4).

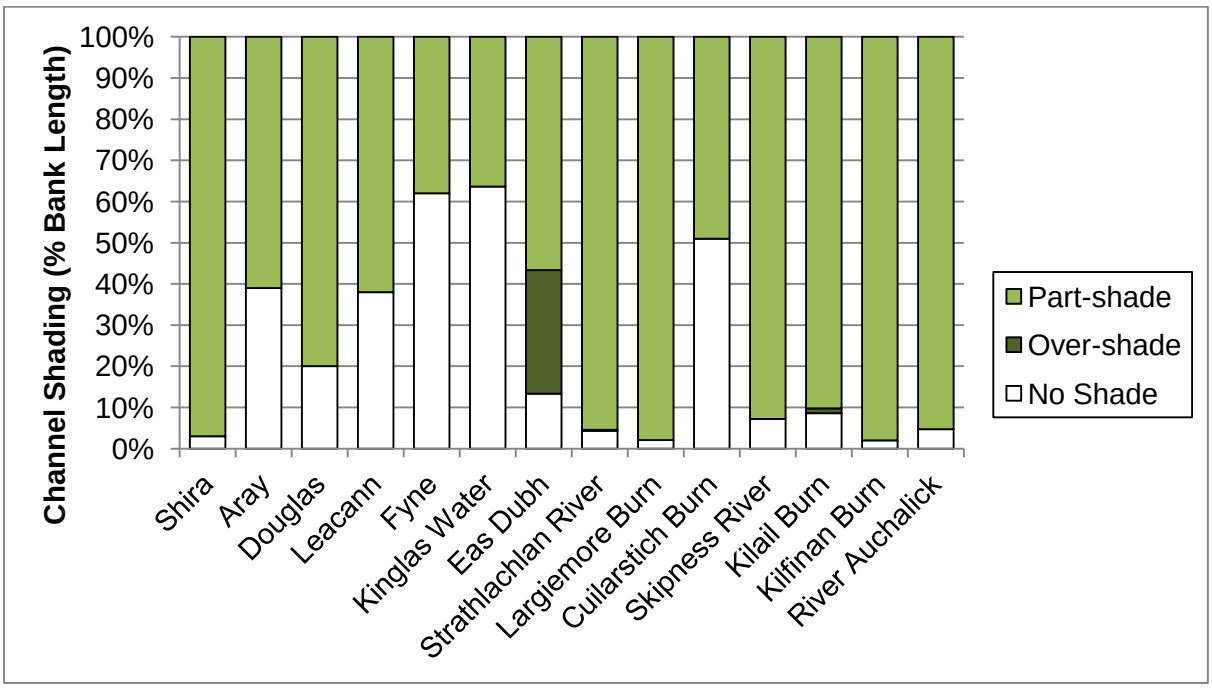
Additional features of LWD presence included bank protection from erosion at 25 sites (19 % of sites), bank erosion at 19 sites (14 %), accumulation of small woody debris (at 104 site (78 %), bed scour at 37 sites (28 %) and spawning habitat at 69 sites (52 %). LWD features were also assessed as being stable at 60 sites (45 %), but also had potential to become an obstacle to fish migration at 27 sites (20 %).

Figure 3.2.14 Large Woody Debris (LWD) features (No. of sites present)



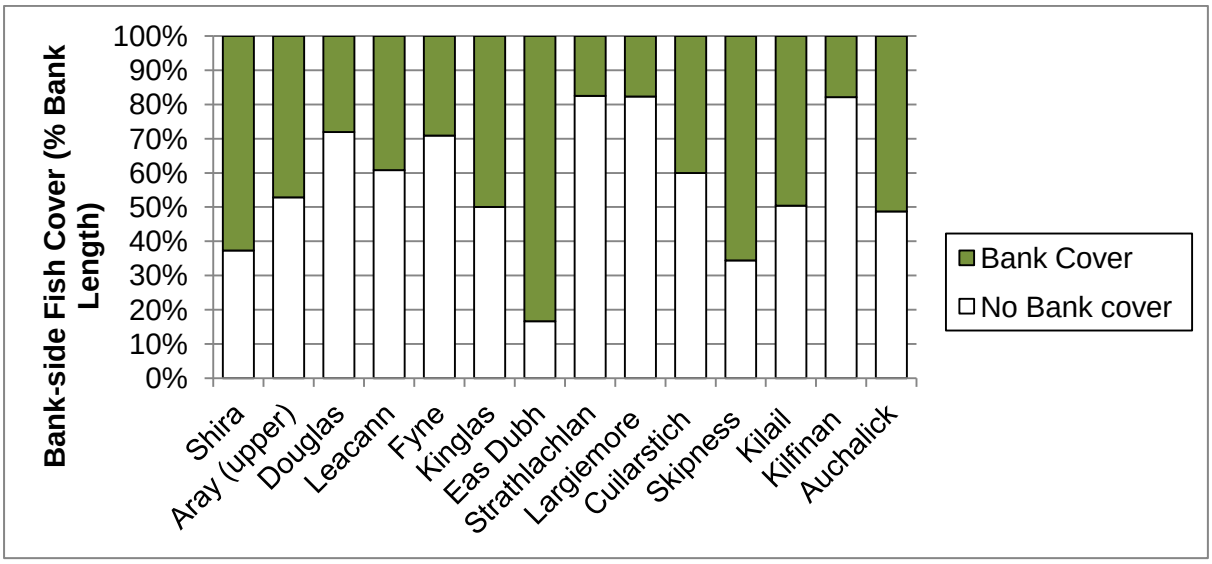
Desirable part-shading of the river channel by bank-side trees was found in all catchments (average of 75% of all bank length surveyed), while lack of shade was identified in lower proportions in all catchments (23 %) and over-shading by heavy canopy in two catchments (2 %); the Eas Dubh and Kilail Burn (Figure 3.2.15). A lack of shade was found in above average proportions on the Kinglas (64 %), Fyne (62 %), Cuilarstich (51 %), upper Aray (39 %) and Leacann (38 %).

Figure 3.2.15 Relative Shade provided by bank-side trees (% of habitat bed area)



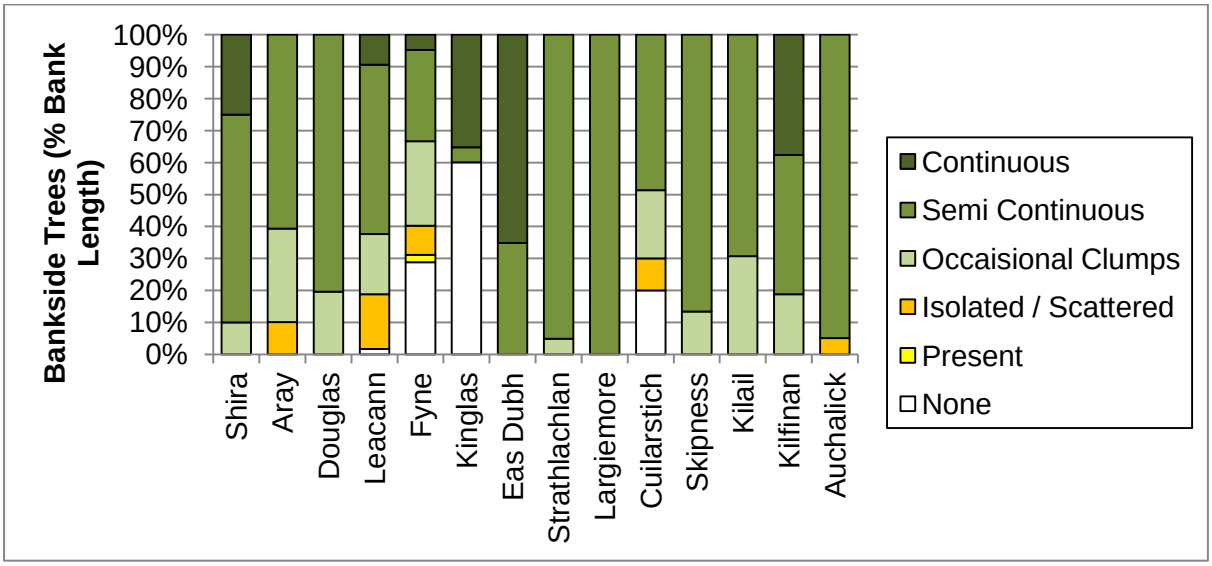
Bank-side cover for fish was identified as a mixture of tree roots, draped vegetation and undercut banks in varying proportions in all catchments surveyed. On average, 43 % of bank length provided cover for juvenile fish (Figure 3.2.16), but was below average in the Strathlachlan (17 %), Largiemore (18 %), Kilfinan (18 %), Douglas (28 %), Fyne (29 %), Leacann (39 %) and Cuilarstich (40 %).

Figure 3.2.16 Bank-side cover for juvenile fish (% of bank length)



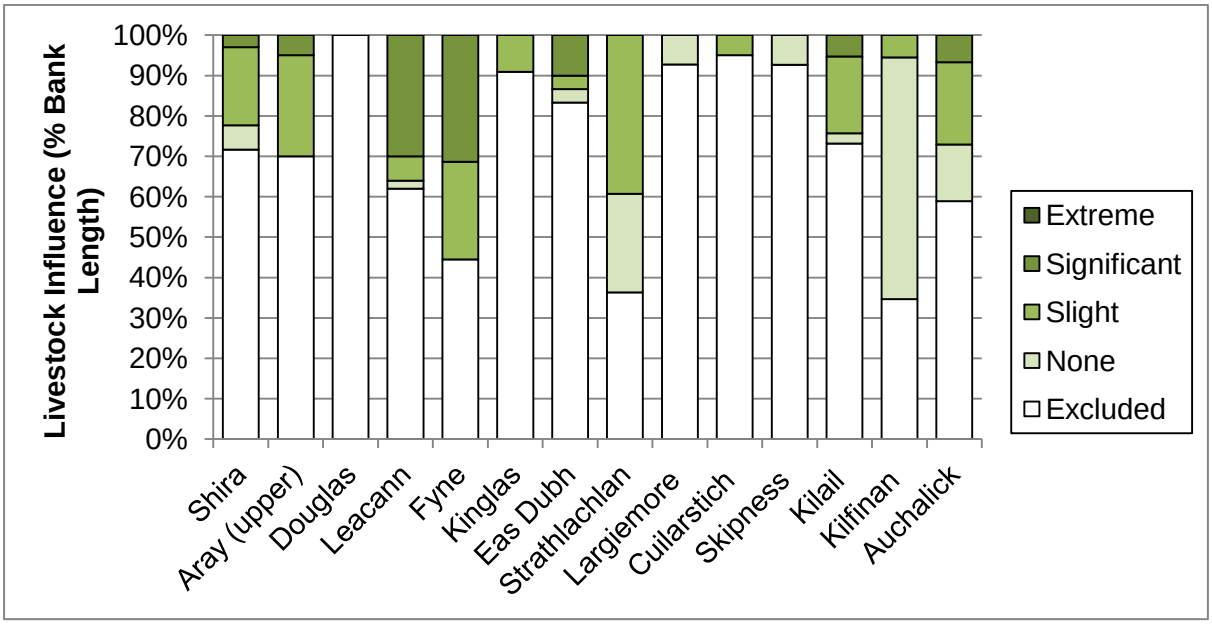
On average, bank-side trees were absent (8 % of bank length), isolated or scattered (4 %) or occasional clumps (14 %) in a relatively small (26 %) proportion of the bank length surveyed. More desirable semi-continuous (62 % of bank length) or continuous (13 %) tree presence on bank sides were more common (Figure 3.2.17). Less than desirable tree presence on banks were more prevalent on the Fyne (62 % of bank length), Kinglas (60 %), Cuilarstich (51 %), upper Aray (39 %) and Leacann (38 %).

Figure 3.2.17 Bank-side trees (% of bank length)



Surveys found that an average of 72 % of stream banks were not accessible to grazing livestock (Figure 3.2.18), while lower than average livestock exclusion was found on the Kilfinan (35 % of bank length excluded), Strathlachlan (36 %), Fyne (44 %), Auchalick (59 %) and Leacann (62 %).

Figure 3.2.18 Livestock access to stream banks (% of bank length)



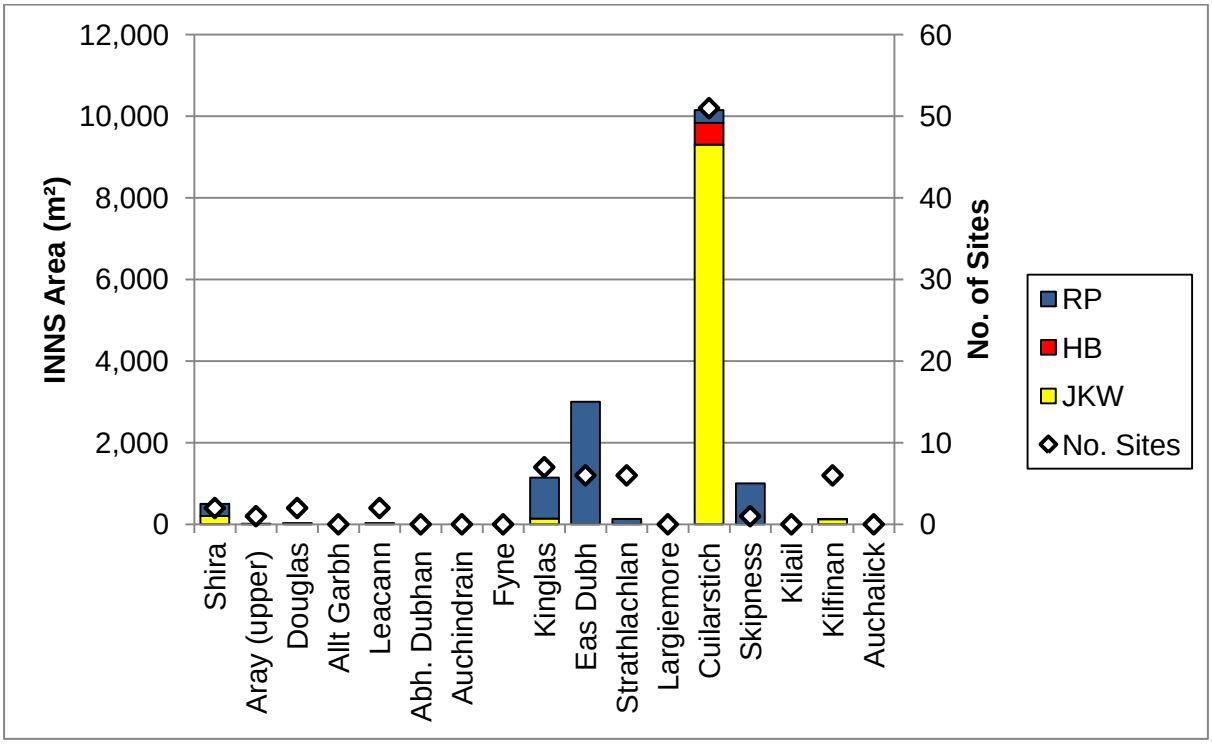
Where access to livestock was apparent, assessment of the impact of the livestock was on average predominantly slight (13% of bank length), while no impact was found in some others (9 %) and significant impact in a lower proportion (7 %). Slight impact on riparian habitat from stock access was higher than average on the Strathlachlan (39 %), upper Aray (25%), Fyne (24 %), Auchalick (20 %), Shira (19 %) and Kilail (19%). Significant impact on riparian habitat from stock access was found on Fyne (31 % of bank length), Leacann (30 %), Eas Dubh (10 %), Auchalick (7 %), upper Aray (5 %), Kilail (5 %) and Shira (3 %).

3.2.4 Invasive Non-Native Species (INNS)

Invasive non-native plant species were recorded at 84 sites in 10 catchments, infecting a total of 16,111 m² of riparian habitat (Table 3.2.19). Japanese knotweed (JKW) was found at 48 sites in five catchments; Shira (200 m²), upper Aray (10 m²), Kinglas (140 m²), Cuilarstich (9,307 m²) and Kilfinan (119 m²). Himalayan Balsam (HB) was found at five sites in the Cuilarstich catchment (531 m²). Rhododendron *(Ponticum)* (RP) was found at 31 sites in nine catchments; Shira (300 m²), Douglas (32 m²), Leacann (26 m²), Kinglas (1,000 m²), Eas Dubh (3,000 m²), Strathlachlan (130 m²), Cuilarstich (312 m²), Skipness (1,000 m²) and

Kilfinan (5 m²)

Figure 3.2.19 Invasive non-native plants (no. sites and area of infestation)



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 fish surveys indicate that all catchments in upper Loch Fyne are utilised by Atlantic salmon for recruitment, while juvenile salmon were found in only one catchment in Lower Loch Fyne; Kilfinan Burn, where only very low density of juveniles were found. While salmon and parr found in the Kinglas Water were likely to be as a result of a stocking programme, natural recruitment of salmon appear to be currently limited to catchments with an accessible area of habitat of 20,000 m² or more (with the exception of the Cuilarstich Burn, where no salmon were found). Although Atlantic salmon were found in one catchment; Eas Dubh, which has a smaller habitat area (6,971 m²) only parr of one year class were present, which may suggest that this population may not be established or stable. It is likely that smaller catchments in Lower Loch Fyne do not have sufficient accessible habitat for salmon to generate the numbers of smolts that consequentially will provide sufficient adult sea returns to maintain the population. Historically, some of these smaller catchments have been known to support modest salmon fisheries, such as the Kilfinan and the Skipness, but current sea survival of post-smolts is relatively low in comparison and therefore may not have sufficient freshwater resources to maintain a population at this time.

Salmon fry were not found in the Leacann Water, which suggests that either there were no adult-sea returns to the catchment in 2010 or other freshwater factors may have affected recruitment. Historical electrofishing data on the Leacann found access of salmon was affected by a weir, which was subsequently modified to improve fish access over the structure. The 2011 survey suggest that fish passage past this obstacle require further investigation. Other natural, but temporary obstacles; log jams, that appeared to have potential to be problematic to fish passage were found in the Skipness, Eas Dubh and other catchments which also require further investigation to assess their affect on fish distribution.

While the juvenile fish distribution found in the 2011 survey indicate that natural topographical features such as bedrock waterfalls or high gradient currently limit fish distribution in most catchments, it is possible that environmental conditions during the spawning period (October through December) can affect spawning distribution. The very cold and dry autumn of 2010 may have therefore affected the fry distribution found by the

2011 survey if there was insufficient water flow and temperature to allow adult fish to access their full range of habitats.

The distribution of salmon fry found by the survey was affected by the stocking of salmon fry and parr in the upper River Fyne and Kinglas Water where previous surveys found they were no longer present. The translocation of spawning effort from the lower River Fyne salmon stock to these locations over the last three years appear to be have been successful in that there are now some smolts being produced in these habitats. While further investigation is required to ascertain if these juveniles are able to establish a self-sustaining population, the refurbishment of a fish pass in the lower Kinglas require evaluation to assess if any returning adult salmon are able to ascend the weir at Ardkinglas.

Where present, juvenile salmon were occasionally found at relatively high abundance at some sites, salmon fry were also more commonly found at relatively low abundance in the Douglas, Shira and Fyne and moderate abundance in the River Aray. The patchy distribution and low abundance of salmon fry at the majority of sites surveyed indicate that adult sea returns are not yet sufficient to establish optimal numbers of juvenile salmon in sites with favourable habitat condition. However, if adult sea returns improve (which catch return data suggest that this is the case) increases in egg deposition will require that freshwater habitats are in good condition if optimal numbers of smolts are to be produced in the near future.

4.1.2 Brown trout

The fish data collected as part of this study indicate that all freshwater habitats are currently able to support trout populations (even though trout were not sampled at all survey sites in all catchments). The relatively low distribution and abundance of trout found in some catchments indicate that there may be limitations on freshwater habitat suitability for this species. Unlike salmon it is not thought likely that there is a potential threat of local extinction as trout are able to complete their life-cycle in freshwater and are therefore not reliant on marine survival of post-smolts to the same degree as are salmon.

The distribution and abundance of trout fry in favoured habitats (tributary streams or smaller main river sites less than 3m wet width) found in 2011 suggest that maximum classes of abundance were generally high in upper Loch Fyne catchments, but were more varied in Lower Loch Fyne catchments where fry were not found in the Largiemore and were of low maximum abundance in the Strathlachlan and Auchalick. The low abundance of fry in these catchments suggests that recruitment of juveniles may be affected primarily by low adult sea trout returns. Where moderate or high abundances of fry are found, trout recruitment may be limited by habitat condition. 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.

4.1.3 Non-salmonid species

The distribution of European eel (20 % of sites surveyed in nine catchments) was relatively patchy compared to other non-salmonid fish (4 % or less of sites). Unlike salmon and sea trout this migratory species utilises freshwater 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. There are international concerns over the status of eel populations and their modest distribution recorded in this survey compared to a similar survey on the Isle of Mull in 2010 (AFT, 2011) indicate that they may not be as well established in Loch Fyne rivers. There are currently no data on their density or age class distribution to assess their relative abundance and age class presence.

Flounder were found at 4 % of sites in the lower reaches of four catchments in lower Loch Fyne in 2011, but have also been found in two others (Shira and Kinglas) in previous surveys. Flounder are commonly known to inhabit estuarine and coastal marine habitats (Maitland & Campbell, 1994), but 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, but may not be present in the catchments where there are obstacles near the estuary. Similarly, although Sticklebacks were found in the Shira and Strathlachlan catchments (2 % of sites) in 2011, this may be an artefact of the type of habitat surveyed, which was mostly faster flowing turbulent flow types primarily suited to juvenile salmonid fish. Stickleback are poorer swimmers compared to salmonids and may therefore actively avoid most of the habitat sampled during this survey.

Lampreys were also found in 4 % of all sites surveyed in the Shira, Strathlachlan, Cuilarstich and Kilfinan catchments. Lamprey may be present in other catchments, but habitat preferences for lamprey ammocoetes are likely to be for silt beds and free-swimming transformer life-stage may not be present at the time of sampling. Habitat survey data indicate that potential habitat for juvenile lamprey (ammocoetes) may be abundant in some catchments (Shira and Cuilarstich), but if present may be limited to a small number of sites in other catchments. Further site specific sampling would be required to establish their wider distribution.

Minnow are understood to be a translocated species in most Scottish Waters and are unlikely to be native to the Auchalick (and the Aray where they have been found in previous surveys). The presence of minnow 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 freshwater habitat

The assessment of habitat condition in 14 catchments in Loch Fyne provided as part of the Argyll and Lochaber River Basin Plan highlight that four of the largest six catchments are heavily modified; Shira, Fyne, Kinglas and Douglas due to hydroelectric generation, one other; the Leacann Water is abstracted for hatchery rearing of farmed fish, while only the River Aray is not influenced by significant use of water resources and is consequently classified as having good ecological status. There are also more widespread aspects of land management; Forestry and livestock grazing that are identified as influencing freshwater habitat condition as well as some urban development that influence a smaller number of catchments; Cuilarstich. Improvement of ecological status on a wide basis will require a wide range of initiatives involving multiple users of land and water resource users.

4.2.1 River morphology and channel characteristics

The majority of channel types found in the survey; B, C and E generally host suitable habitats for juvenile salmonids with favourable substrate types; boulder for older parr (type 2), cobbles for mixed fry and parr (3) and some pebble and gravel for fry (4). Where not compacted by fine substrates, the interstitial spaces between substrates offer cover for juvenile fish from predators and high flow events. Additionally, production of invertebrates utilised for food by juvenile fish also prosper in this type of habitat. Natural channel features of types A and G are generally of higher gradient are less productive due to bedrock substrate (type 1) as fewer interstitial spaces are available as cover for juveniles (and invertebrates), particularly as flows are usually of high energy and can be torrential during spate events. which they may host limited areas of useful habitat for other life-stages such as pools. The channel type F found in modified habitats (realigned and straightened) in the majority of the Shira and to a lesser extent in the Cuilarstich, Strathlachlan and Kilfinan were dominated by gravel substrate (type 4) and fine sediments that fill interstitial spaces were more common. While spawning habitat may be abundant in these habitats, subsequent survival of eggs and fry are affected by fine sediments that reduce ingress of oxygen-bearing water to eggs and alevins and fill interstitial spaces required for fry cover and invertebrates.

The morphology of river channels surveyed was thought to be natural in most survey sections in the moderate and higher gradient habitat, generally in the middle and upper reaches of most catchments. Historical channel re-alignment and straightening appear to

have been undertaken in the moderate to low gradient habitats in many catchments; Shira, Aray, Leacann, Fyne, Eas Dubh, Kilfinan, Cuilarstich and Auchalick. Significant morphological alteration both reduce stream length (and habitat area), sinuosity and habitat diversity. Subsequent affects are particularly relevant to the early stages of recruitment of juvenile fish, particularly a reduction in pool frequency and loss of spawning habitat through increased bed scour through increased gradient (reduction in channel length). Loss of pool habitat also has implications for fisheries with fewer locations for adult fish to use as seasonal habitat close to spawning grounds.

Additional influences of embankments and revetments in both modified and natural habitat with low gradient are likely to reduce connectivity of the channel with the floodplain. Where channels are able to spill floodwater onto the floodplain, the erosive forces are generally dissipated, but where entrapped within the channel by embankments, down-cutting and coarsening of the bed substrates is likely to occur as a result of increased stream force. The storage of valuable spawning substrate is consequently less likely to occur in these habitats, particularly with increased intensity of rainfall experienced in recent years and widespread hill-side drainage that exacerbate peaks in water run-off from the catchment. Bank revetments also prevent natural erosion of banks that recruit new substrates to the river bed, which in combination with changes in bed mobility can affect both substrate type and stability in the catchment.

In an attempt to overcome loss of habitat diversity and increase fishery amenity, some in-stream structures have been constructed in a number of catchments. The lower River Aray and Fyne have significant numbers of weirs, while most other catchments have a smaller number, some of which are as a result of use of water resources.

The relative effect on fish populations is likely to be significant as a substantial proportion of the most productive lower gradient habitat has been impaired. Typically a lower diversity of habitat and fewer locations suitable for adult holding pools and spawning sites which have consequences for the early stages of recruitment.

Man-made obstacles to fish migration were frequent in the lower Aray, Fyne, Cuilarstich and Auchalick and were also present at lower frequency in all other catchments with the exception of the upper Aray. While the majority of these obstacles were assessed as being passable to migratory salmonids they may have a more significant affect on the migration and subsequent recruitment of smaller resident trout and poorer-swimming native species such as lamprey, sticklebacks and flounder. While some weirs appear to be advantageous to migratory salmonids in some catchments such as some structures on the Fyne where the limited adult pool and spawning habitat has been increased, many other structures hinder

river processes and commonly over-long pools created upstream of weirs may act as gravel traps, further reducing available spawning habitat.

The existing and historical land-use on Loch Fyne catchments strongly influences the condition of riparian habitats found in the survey. Most catchments were found to have a relatively high proportion of semi-improved or plantation broadleaf woodland present on stream banks, but these were largely limited to higher gradient habitats (which are fenced to minimise losses of livestock). Where found on lower gradient habitat broadleaf trees consisted of a relatively thin riparian corridor some of which was single year-class alder planted on modified habitats to prevent channel mobility. Lack of broadleaf woodland on parts of the upper Aray, Kinglas and Fyne have a consequence for the production of food (leaf litter forms the basis of the aquatic food chain), supply of terrestrial insects as food (particularly important during the summer months), the provision of tree roots that are used as cover by fish and bank stability, shading from the canopy that damper extremes in water temperature (cold and hot) that affect juvenile fish feeding behaviour and will help to mitigate the effects of future climate change. Additionally the lack of riparian woodland and subsequent delivery of large woody debris from fallen trees in these catchments also reduce habitat heterogeneity, particularly in their ability to trap and shelter spawning-grade sediment, which is scarce in these habitats. Wet woodland, which was likely to have been a significant habitat type prior to agriculture and subsequently forestry becoming established, was found in only two small areas of the Shira and the Leacann. Planting or regeneration of broadleaf trees in some habitat units in the upper Kinglas Water, but these trees have not yet grown sufficiently to become influential on the condition of riparian habitat.

Forestry activity directly affecting riparian habitat was limited to a few catchments; Aray, Douglas, Leacann, Fyne, Kinglas and Skipness. Conifer plantation that did not appear to conform with current guidelines were found on the Aray, Fyne, Cuilarstich and Kinglas (mature stands close to harvest), the Allt Garbh tributary of the Douglas Water (replanting close to the stream) and Leacann Water (non-commercial conifer left post-harvest). Future intervention (restructuring) in these habitats, particularly the Allt Garbh, will be necessary to improve habitat productivity. Where plantation trees had been harvested, habitat recovery in the form of tall herbs and broadleaf regeneration was found to be widespread, but re-establishment of conifers was significant in some areas through self-seeding. Additional benefit in these habitats was found by increased frequency of in-stream large woody debris from windblown conifer and broadleaf trees.

Grazing of livestock on improved and rough grazing pasture was found to affect riparian habitat in the Shira, upper Aray, Strathlachlan, Kilfinan, Eas Dubh and Auchalick, but was particularly significant on the Leacann and Fyne. Restricting access of livestock to riparian

habitat may improve vegetation diversity and productivity, but additional measures may be required, such as broadleaf tree replanting, where insufficient seed stock is present.

Invasive non-native plants were found in a relatively small number of sections in relatively few catchments, but are noted to be well distributed around the shoreline of Loch Fyne, particularly Japanese knotweed and Himalayan Balsam, which may act as a source of further infection of freshwater catchments. Of particular note is Japanese knotweed and Himalayan Balsam found in multiple sites in the Cuilarstich catchment and isolated patches of knotweed in the upper Aray and Shira which have potential to spread rapidly downstream infecting large areas of habitat. More widespread is *Rhododendron Ponticum*, but its slow rate of spread compared to knotweed and balsam mean that it may be less of a priority in most cases with the exception of the Eas Dubh where significant areas of the riparian zone were infested, some of which completely over-shaded the channel.

4.3 Factors affecting productivity in marine habitats

The productivity of marine habitats may be considered in two ways; the wider Atlantic ocean that are utilised by Atlantic salmon and the coastal inshore waters which sea trout utilise throughout the marine life-phase, while salmon move through relatively quickly as smolts on their way to the open ocean and on return as adults.

4.3.1 Wider ocean habitats

The wider marine survival of post-smolt salmon is possibly associated with the affects of climate change on the marine environment, but are less well understood compared to that of local marine factors known to affect migratory salmonids. A growing number of studies have indicated that the productivity of ocean habitats may have declined over time with a recorded reduction in sea age of multi sea-winter salmon and reductions in growth of one-sea winter grilse (Todd et. al, 2008). Recent sea survival of post-smolt salmon has also been highly variable with relatively good counts of adult sea returns in the Awe catchment (recorded by the Awe Barrage counter) as recently as 2007 and near record low numbers in 2009, but increasing slightly in 2010-11. It is not currently known if the most significant factors affecting survival of post-smolt salmon are related to the open-ocean or inshore waters.

4.3.2 Inshore marine habitats

Although not studied as part of this survey, the Argyll and Lochaber River Basin Plan classifies the upper, middle and outer basins of Loch Fyne are of good status. There is potential that aquaculture related factors such as sea lice (*Lepeophtheirus salmonis*) burdens affecting survival and growth of post-smolts and interaction with farmed escapee

salmon (McGinnity et. al, 2004) may have an influence on the current status of migratory salmonid fish. 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 relative contribution of the wider and inshore marine factors effecting adult sea returns has not been established, but the increases in juvenile salmon and trout abundance found upper Loch Fyne since changes were made to fish farm production throughout Loch Fyne. The changes made since 2001 include the movement of fish cages from the head of the Loch and a changed from multiple to a single year class production system with contiguous fallow and strategic sea lice treatments. Despite increases in farm fish production, some signs of wild fish recovery are also evident in fishery catches and reduced sea lice burdens found on sea trout as part of the Area Management Agreement process (Tripartite Working Group, 2011).

New information on the influence of salmon farm location, wind and tidal movements on sea lice larvae distribution is currently being collected in Loch Fyne which may further establish this methodology, previously used in Loch Torridon (Penston & Davies, 2009). The data collected as part of this survey indicate that similar information for the Firth of Lorn, Sound of Mull and possibly Loch Spelve would better inform management of aquaculture and wild fish interaction.

4.4 Factors affecting survey results and interpretation of data

There are a number of factors that may influence 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 the actual abundance of fish found in the survey are likely to be somewhat lower than recorded. However, the classification scheme used to assess juvenile salmonid fish abundance is established for one-run fishing and estimates of minimum abundance are therefore comparable.

The environmental conditions at the time of survey were relatively favourable for efficient sampling, although the relatively low conductivity of the water in some catchments; the Kinglas and Fyne may reduce efficiency and fish capture. The relatively low number of smaller tributary streams sampled is likely to provide less detailed information on the status of juvenile trout, compared to salmon that usually dominant 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, which are likely to be favoured habitats of trout parr and other non-salmonid fish. Subsequently, higher abundance of some species maybe present in deep pool and still-water habitats than that found by this survey.

4.4.2 Fishery intervention

The stocking of juvenile salmon and trout into freshwater habitats has been undertaken by fishery managers on the River Fyne and the Kinglas Water catchments in 2010 and 2011. Similar stocking was also undertaken on the River Aray until 2009. The location of stocking and subsequent electrofishing results suggest that the technique of planting un-fed fry at relatively low density (< 1 per m²) has been relatively successful in rearing juveniles to the parr stage, but further investigation is required to establish if planted fry are able to complete their life-cycle and propagate future generations. The lack of salmon fry found in the upper River Aray may be as a result of cessation of the hatchery programme, but the low and cold water flow conditions in the autumn and winters of 2010/11 may have had an impact on fish migration into the headwaters with subsequent reduction in spawning opportunity in this area of the catchment.

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 in Loch Fyne and how land owners and managers can improve habitats for benefit of fisheries and wider biodiversity.

5.1 Fishery management

The fish species sampled in the survey; Atlantic salmon, brown trout, European eel, stickleback, lamprey and flounder have value as part of local biodiversity, additionally migratory salmonids also have potential to support fisheries that are important to local recreation and economy. Historical catch records and data on juvenile salmon and trout indicate that there is significant potential for sustainable fisheries for salmon in upper Loch Fyne rivers and for sea trout in all of the catchments surveyed. However, smaller catchments with limited pool habitat are likely to limit fisheries to the coastal marine environment.

Given the current status of both salmon and trout populations in most catchments in Loch Fyne, they are not yet able to support exploitative fisheries at this time. Exploitation is likely to decrease potential for future restoration and increase potential for local extinctions as has been identified for salmon on the Skipness and Kinglas Water. Where fisheries are active it is important to maximise spawning escapement of adult fish by employing effective catch and release measures on recreational fisheries to ensure that sufficient spawning escapement and recruitment of smolts is improved over time. Even where populations are depressed, there are benefits to fishery activity in monitoring the abundance of sea-run adult fish returning and identifying potential farm escapes.

5.1.1 Maximise spawning escapement

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

5.1.2 Stocking

Current efforts to restore or enhance fishery performance through stocking activities appear to have potential to stimulate recovery, but they are not able to overcome the causes of the decline of catches. While short-term benefit from a stocking strategy may be realised in the

first phases of stock restoration, longer-term improvement and sustainment of salmonid fish will require management of freshwater habitat and improvement in management of land and water resources, which are more likely to derive a sustained improvement in fish health and abundance (Webb et. al, 2009).

Short-term hatchery intervention, where appropriate 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. The genetic samples collected as part of this study may be used to better inform management of populations, particularly with populations in larger catchments where stock structuring may be more complex.

Avoiding in-breeding depression in small populations and out-breeding depression by crossing different genetic groups is a management consideration for restoration intervention and possibly the longer-term health of populations. Undertaking stocking, even with natal fish, without up-to-date robust information on use of habitats by wild spawned juveniles is likely to result in the over-stocking of sites and increased competition between juveniles.

Given the range of issues raised by the use of hatchery intervention techniques for fish health, biology and ecology, it is likely to be beneficial to review stocking programmes on a case-by-case basis to avoid inappropriate practices and maximise benefit from existing operations.

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.

It is unlikely that minnow, found in the Rivers Aray and Auchalick 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 on the island. 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.

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 throughout Loch Fyne. A co-ordinated approach by land managers to control and eventual eradication is likely to bring benefit to fish populations and biodiversity more widely.

The survey found Japanese knotweed, a priority non-native species, at ? location in the ? catchment, which if tackled in the short-term may be eradicated from the island and avoid the spread and significant associated management costs in the future. Larger-scale intervention in control and eradication of Japanese knotweed and Himalayan Balsam (and Giant Hogweed in one location) around much of the coastal fringe of Loch Fyne will require significant resources to tackle. Further assessment of potential for re-infection from outside sources is required prior to any intervention.

5.2 Habitat management

Land owners and managers are the primary drivers for managing habitats and have a very important role to play in securing improvement in management of habitats that influence the productivity of fish populations and fisheries. 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 ecological status of most of the rivers on Mull, 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 deer has left few broadleaf woodland riparian habitats on the island. 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 be particularly important to low productivity rivers such as the Ba (where acidification may be a factor), Forsa, Lussa and Coladoir where in-stream food production will be naturally limited compared to rivers with more influence from relatively base-rich geology.

Future phases of the RBP 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 (CAR) 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.

Land owners may action some or all of the habitat management and improvement initiatives with financial assistance from the Scottish Rural Development Programme (http://www.scotland.gov.uk/Topics/farmingrural/SRDP). 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 can be found here (http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Argyll), and include areas such as biodiversity, landscape, water and soils and adaptations to mitigate climate change.

Attached to these priorities are packages that can help deliver the desired improvements. For example, forest management or habitat improvements to address morphological pressures are accessed through the Waters and Soils priorities, regional code ARG18 directs you to packages 27-30 to address the issues. Control and eradication of invasive non-native species and improving freshwater habitats supporting salmonids or freshwater pearl mussels, the Biodiversity priority within SRDP provide relevant packages to support this work. Further guidance in relation to SRDP may be undertaken via a land agent or directly in Argyll with:

SGRPID
Cameron House
Albany Street
Oban
PA34 4AE
Tel: 0300 244 9340
Fax: 0300 244 9331
Email: SGRPID.Oban@scotland.gsi.gov.uk

Further guidance for habitat management initiatives are provided in catchment specific reports in support of the summary findings given here.

5.3 Aquaculture management

Changes to the management of marine salmon fish farm production in Loch Fyne since 1999 as part of the Loch Fyne and subsequent Firth of Clyde 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. In combination with the closure of the fish

farm at the head of Loch Fyne, 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 efficacy of sea lice treatments and increases in biomass of farm fish in the area, where a significant part of the Scottish production of farm salmon is grown.

The AMA process ended in March 2011 but dialogue between farm and wild fish has been maintained in the Firth of Clyde area, but 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 and habitat surveys in 2011 provides a number of conclusions, some of which are compared to previous surveys undertaken in upper Loch Fyne (1985-2010).

6.1 Fish distribution and abundance

The patchy distribution and low abundance (in most sites surveyed) of juvenile salmon in upper Loch Fyne catchments; Aray, Shira, Fyne, Kinglass, Douglas, Leacann and Eas Dubh found in 2011 indicate that while these are key habitats for **Atlantic salmon**, the status of these populations is currently sub-optimal and are not able to support exploitative fisheries. Fishery catch data show a significant decline in the salmon catch during the 1990s and subsequent closure of rod and net fisheries in the early 2000's. Comparison of data collected on juvenile salmon in these catchments data collected prior to 2003 indicate that juvenile salmon abundance also decreased before increasing in distribution and abundance post 2003. Reasons for the decline in salmon abundance is related to marine survival of post-smolts and reduced numbers of adult sea returns.

Similarly, fishery catch data of **sea trout** (the migratory form of brown trout), have also shown a decline in the population, but these have been longer-term compared to salmon prior to the 1990's before collapsing in a similar manner post 1990. The longer-term decline of sea trout in Loch Fyne indicate that habitats specific to this species; smaller tributary streams used for recruitment in freshwater and in-shore coastal water used for growth may have been impaired over a longer time-scale compared to those habitats preferred by salmon; larger main rivers for recruitment and the wider Atlantic ocean for growth.

The halt of decline of both species in **Upper Loch Fyne** has been achieved through a combination of initiatives; closure of exploitative fisheries, re-organisation of aquaculture activity and subsequent stock restoration programme. The initial data collected on fish populations in the seven smaller catchments in **lower Loch Fyne** in 2011 show that juvenile salmon are at a very low abundance in one catchment (Kilfinan) and were not found in other (Skipness and Auchalick) where modest salmon fisheries are known to have operated in the past. Juvenile trout abundance was also generally patchier compared to upper Loch Fyne.

6.2 Factors affecting fish habitat

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 modification of channel features and land use.

To continue the recovery of salmon and trout stocks in Loch Fyne, bottlenecks acting on smolt production in the freshwater habitats need to be addressed as well as ensuring that use of local marine resources are not detrimental to the health of migratory salmonids and their habitats.

This survey found a wide range of natural geologic and topographic features affecting the productivity of freshwater habitats for salmonid and other native fish. However, the survey also found significant human derived influence from **use of land and water resources** which are currently affecting recruitment of juveniles and subsequent smolt production.

Although outside the remit of this survey, the long-term **use of water resources** in the Shira, Kinglas and Fyne catchments and newer developments on the Douglas and Kinglas for generation of hydro electric generation schemes, future investigation is required to better understand the effects on fish populations and their habitats. There are opportunities under the review of Controlled Activities Regulations (CAR) under the Water Framework Directive (WFD) to better utilise compensation and freshet flows for the benefit of fish and the wider ecology of these rivers.

This survey did however identify significant modification of natural river morphology in significant reaches of the **main channels** in some catchments. Where possible, restoration of habitats that have been straightened, realigned, embanked and constrained by revetments and weirs are likely to have significant long-term benefits for fish populations and wider biodiversity. However, there are significant hurdles to overcome in the availability of resources, technical know-how and land use considerations before this can be achieved. Therefore, these options for habitat restoration need to be considered in the medium to long-term in most cases.

This survey did not have sufficient resources to consider the many **tributary streams** that are important to sea trout recruitment. Anecdotal habitat information and fish survey data presented here suggest that a significant proportion of tributary stream habitat has been affected by channel straightening and constraining with a consequential loss of habitat features, particularly pool and spawning sites that are important to the early phases of salmonid fish recruitment. Further study and prescription of remedial activity is therefore required in the future if sea trout populations are to benefit.

While a significant proportion of river banks surveyed were found to host favourable semi-natural broadleaf woodland habitat, this **land use** was mostly restricted to higher gradient habitat (often sub-optimal for fish recruitment) or used to secure river banks in modified reaches of river. Expanding **riparian woodland** coverage into moderate and lower gradient habitats that are currently affected by grazing of livestock will have significant benefits for

fish populations. These benefits include bank cover, large woody debris provision, food production and water temperature regulation which will have a positive long-term effect on the health of cold water fish in relation to **future climate change**.

Localised **fencing of stream banks** affected by grazing may improve the diversity of riparian vegetation, but a more significant scale of broadleaf tree planting and protective fencing are required in some upland areas to improve the diversity of vegetation. Additional control of deer numbers may also be required to reduce significant grazing pressure on stream banks. An integrated approach to control of grazing and restoration of stream morphology is likely to be required to achieve widespread and significant improvement as measures to regenerate bank vegetation may prevent or impair natural recovery of morphology where river channels have been modified.

Forestry activity in a number the catchments in Loch Fyne has a significant influence on riparian habitat, which will require re-structuring to achieve standards outlined in the Forest and Water Guidelines. Most of morphological impacts of conifer plantations are being addressed by the Forestry Commission under the Water Framework Directive over the next two-to-three cycles of the Argyll and Lochaber River Basin Plan, but privately owned forests will also need to prioritise felling and subsequent restoration of broadleaf woodland if fish populations are to benefit.

Timely measure for control and eradication of **Invasive non-native plants** such as the Japanese Knotweed on the foreshore of Loch Fyne and a number of catchments including the Aray, Shira and Cuilarstich are likely to prevent further spread and impairment of local biodiversity. Measures for prevention of introduction and spread of all priority invasive non-native species are likely to have longer-term benefits in protecting against new threats to biodiversity. Two populations of **minnows** found by this and other surveys are not likely to be removed, but preventing further translocation must be a priority to prevent competition and biosecurity risks to native fish.

6.3 Fishery 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. Where stocking is carried out, site specific information needs to be collected to better inform the use of hatcheries, but this type of intervention is unlikely to overcome the causes of decline in salmonid fish populations.

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 basic information 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 lamprey specific surveys were not fully carried out, but the habitat survey found suitable locations for future surveys.

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 Mull and fishery management plans for individual fisheries. The habitat survey also indicate a relatively limited potential of accessible habitat in some catchments.

7.3. Future work

Establishing baseline information and subsequent repeat sampling of fish populations is an important element upon which to understand the current status of the fish and fishery resource. Repeat sampling over a number of generations (3-5 years per generation) will provide a better understanding of changes in populations over time, particularly in lower Loch Fyne where no historical data exists. The data will also inform response of fish populations to future management initiatives.

The results of this survey indicate that more regular monitoring of fish populations and further investigation into the factors affecting in the Heavily Modified Waterbodies; Rivers Fyne and Shira are also required to better inform management of water resources if the fragile salmon population is to be conserved in the longer term.

Future consultation and joint working with centres of expertise will provide useful information to further assess the habitat data and implications for restoration of morphology, river

processes and habitat functionality that are likely to benefit fish populations and wider biodiversity and promote activities that contribute to improving ecological status in future River Basin Plan cycles.

Additional information on wild spawning (redd counts) and stocking activity will be important to establish better understanding of the use of habitat by salmonids and inform policy on the stocking of hatchery reared fish. Analysis of the genetic samples collected in the River Fyne will also be required to inform the conservation of diversity within the salmon population.

There are also opportunity to better inform the management of aquaculture and interaction between wild and farm fish through the work on sea lice dispersal modelling undertaken previously in Loch Torridon and currently being undertaken in Loch Linnhe and Loch Fyne.

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