Fish and Fishery Resources of the River Etive, Loch Etive 2014

Potential Fishery and Habitat Management Initiatives

For further information on this report please contact:

Argyll Fisheries Trust
Cherry Park
Inveraray
Argyll
PA32 8XE
Telephone: 01499 302322
E-mail: info@argyllfisheriestrust.co.uk

This report should be quoted as:

Argyll Fisheries Trust (2014). Fish and Fishery Resources of the River Etive, Loch Etive 2014. Potential Fishery and Habitat Management Initiatives.

Fish and Fishery Resources of the River Etive, Loch Etive 2014. Potential Fishery and Habitat Management Initiatives

Year of publication: 2014

• REPORT SUMMARY

In August 2014 Argyll Fisheries Trust undertook fish surveys and habitat surveys of the River Etive catchment on the west shore of Loch Etive, Argyll, Scotland as part of a wider study of 11 catchments flowing into this sea loch. The aims of the surveys were to identify the distribution of fish within the catchment, provide an indication of their relative abundance and assess the quantity and quality of fish habitat available to fish. The data collected was assessed in relation to the wider management of fisheries, biodiversity and the use of land and water resources.

1.1 Main findings

- The fish habitat survey found 22.7 Ha of habitat along 9.85 km stream length of the mainstem of the River Etive that was accessible to migratory fish.
- The habitat consisted of eight low-to-moderate gradient areas of habitat suitable for recruitment of salmonid fish (spawning and nursery habitat). The low diversity of riparian vegetation limit the bank-side cover for and provide little shading of the channel, which may be susceptible to future effects of climate change on water temperature.
- Salmon fry and parr were found to be widespread and their abundance varied between low and high densities at different sites when compared to other west of Scotland data. Juvenile trout were found at only three of the sites surveyed, but their density was high at all of these sites when compared to other west of Scotland data. European eel were also found at four of the sites surveyed
- Fish and habitat data suggest that current production of salmon smolts from the River Etive is slightly lower than that required to maintain a robust population, but there are likely to be sufficient trout smolts produced to sustain a healthy population of sea trout, but further sampling is required to better understand year-to-year variability in fish numbers.
- Previous counts of adult fish and fishery catches suggest that marine survival of post-smolts may be higher than expected and is likely to be the most significant factor currently limiting numbers of returning adults.

1.2 Future work:

There are activities that can be undertaken in the short, medium and longer-term to improve productivity of freshwater habitats, recruitment of fish and ecological status;

- Additional multiple benefits can be generated by maximising complexity of bank-side vegetation (trees, shrubs and grasses) which provide cover for fish, increase food production from terrestrial sources and will also help to regulate water temperature against the detrimental effects of climate change on cold water fish.
- Maintenance of existing and introduction of new large woody debris features in lower gradient habitat are likely to improve habitat condition and complexity and increase availability of spawning sites.
- To ensure natural regeneration of fish is maintained and improved, any fishery activity should operate on a catch and release basis to maximise egg deposition and population robustness.
- Further surveys are required over time to assess the performance of fish stocks and benefit of habitat improvement works undertaken.
- The use of the salmon hatchery to enhance fishery catches need to be re-assessed as it may contribute to the poor survival of smolts at sea.
- The condition of riparian habitat in some tributaries and parts of the main river may also be improved by tackling infestations of non-native plants (Rhododendron).

Acknowledgements

Argyll Fisheries Trust thanks Land owners for the opportunity to undertake the surveys and financial support provided by Scottish Natural Heritage.

2. SURVEY METHODS

To assess the fish populations and the availability and condition of habitat in the catchment two survey methods were employed; assessment of habitats by walk-over survey of four survey sections and sampling of fish by electrofishing at seven sites on the River Etive (Fig.2.1).

2.1 Habitat survey

Productive freshwater habitats for recruitment of migratory salmonid fish are ideally formed by numerous habitat units that each contains a proportion of adult, spawning and juvenile nursery habitat. These units are replicated along a sufficient length of river channel to generate enough smolts and subsequently returning adults from the sea to maintain a healthy and stable population. To better assess the natural capacity of the habitat to support fish populations and factors affecting it, the survey combined parts of a number of established survey methods that best suited our requirements.

The walkover habitat survey was undertaken in an upstream direction during low flow conditions and the type, character and condition of in-stream and riparian habitats assessed with left and right banks described facing downstream (SFCC, 2007). To assess the accessibility of the habitat to fish, the type, height and length of obstacles (usually waterfalls and other high gradient habitat) were assessed and used in conjunction with electrofishing data to determine the range of fish in the catchment.

The characteristics of the habitat was assessed by comparing it with classifications developed for use in the river basin planning process (SNIFFER, 2006), which are recognised by their physical characteristics. River channels that are usually found in high gradient terrain have a higher percentage of larger substrates (class A; bedrock and cascade channel types) which typically are better suited to older juveniles and adult salmonids if pools are present. More moderate gradient terrain usually has a more mixed combination of large and small substrates (class B; Plane bed and step-pool channel types) which usually has habitat well suited to both fry and parr life stages of salmonid fish, but small patches of habitat suited to spawning and adult refuge. Lower gradient terrain typically has a more smaller river bed substrates (Class C; Plane riffle, braided and wandering channel types) usually found in the lower reaches of rivers in the Argyll region, which are highly suited to recruitment of salmonid fish with large areas of spawning and deeper pools for adults. Very low gradient terrain typically has a mix of small and fine substrates (Class D; active meander and class F; passive meander channel types) which

can be less well suited to fry and parr life-stages of salmonid fish as there is usually relatively little cover for fish in the stream bed but may have a high proportion of deeper pools suited to older juvenile and adult salmonids. The lower gradient habitat is also usually more suited to other fish species found in the region with the exception of European eel which may be found in a wide range of habitat. Often, the types of channel found changed frequently with changes in gradient of the terrain and therefore to aid survey efficiency, the survey was broken into different sections according to distinctive changes in the channel class which has relevance to fish recruitment and therefore more than one channel type may be included in each survey section. By classifying the habitat in this way it enables units of similar and different habitat to be compared alongside fish survey data within and between catchments with the aim of better understanding the influences of the habitat on fish recruitment in the region.

The suitability of the habitat to different life-stages of salmonid fish was assessed using criteria based on average water depth; where younger fish are expected to be found in shallower water and older fish in deeper water (Hendry and Cragg-Hine, 2003). This assessment was further informed by ascribing a score between one and five according to the availability of cover for fish which includes both stream bed substrate roughness, stability and access of fish into the bed substrate matrix and complexity bank-side cover provided by riparian vegetation.

Riparian habitat was assessed according to the percentage of bank where vegetation, trees and livestock access to stream banks was found; extensive (66-100 % of bank length), present (33 – 66 %), limited (0 – 33 %) or none (Raven et al., 1997, 1998b). The location of the start and end of the survey sections, modifications to natural channels, obstacles to fish migration, pools suitable for adult refuge habitat and spawning sites were recorded by GPS for mapping purposes. The area of pools and spawning habitat was estimated on site and the features and condition of each site was assessed being optimal or sub-optimal according to the characteristics found. Digital photographs were taken of significant features found by the survey to provide further opportunity to assess the habitat during the reporting phase of the survey.

2.2 Fish survey

The fish survey sites were selected on the basis of suitable habitat accessible to surveyors found in the habitat survey. All surveys were undertaken in accordance with the Scottish Fisheries Co-ordination Centre protocols (SFCC, 2007a) for semi-quantitative surveys. An

assessment and photographs (Appendix I) of the habitat characteristics were taken at each site. In order to provide a guide to the relative abundance of salmonid fish sampled during the survey, minimum density estimates were divided into six percentile ranges according to a classification scheme (Godfrey, 2005) for salmon and trout on the west coast of Scotland region according to stream width at the survey site. This classification system compares minimum fish abundance sampled at 185 sites in the West of Scotland and places abundance into six percentile ranges according to stream width at the survey site. Classes A (very high density), B (high density), C (moderate density), D (low density), through to E (very low density) are given for abundance within each quintile range and class F represents an absence of fish.

2.3 Estimates of smolt production and fishery potential

Having reliable estimates of salmon and trout smolt production from a catchment, subsequent survival at sea and potential catches of returning adults by fisheries provides managers with important information on the current status of the resource. However, this information is both difficult and expensive to collect, particularly where populations are relatively small and there are few resources for management. Alternately, data collected in Scotland and elsewhere may be used to provide guidance for local management, although it must be used cautiously as there may be significant variation found between locations and over time.

Studies of the production of salmon smolts (Symons, 1979), suggest that approximately 5 two-year-old smolts and 2 three-year-old smolts may be generated by 100 m² of freshwater stream habitat. Similar densities of smolt production have been reported from some more recent Scottish studies found a range from 7.1 to 9.2 smolts per 100 m² from tributaries of the River Spey (Spey DSFB, 2012) and 7 smolts per 100 m² from a tributary of the River Dee (Buck and Hay, 2006). While sea-run brown trout have similar a life-cycle to salmon, there are significant differences in the use of freshwater and marine habitats as well as a higher proportion of juvenile trout remaining and maturing in freshwater. One study in Denmark (Mortensen, 1997) suggested that smolt production for trout is lower than that found for salmon at around 4 smolts per 100 m². Given the lower productivity of freshwater habitat found in west coast rivers, this study has therefore used 5.0 smolts per 100 m² of habitat as a comparative target values.

There are less data available for comparison of sea or brown trout smolt production than for salmon and estimating smolt numbers is further complicated by their tendency to utilise smaller tributary streams for recruitment (Armstrong, 2003), which have not been surveyed as part of

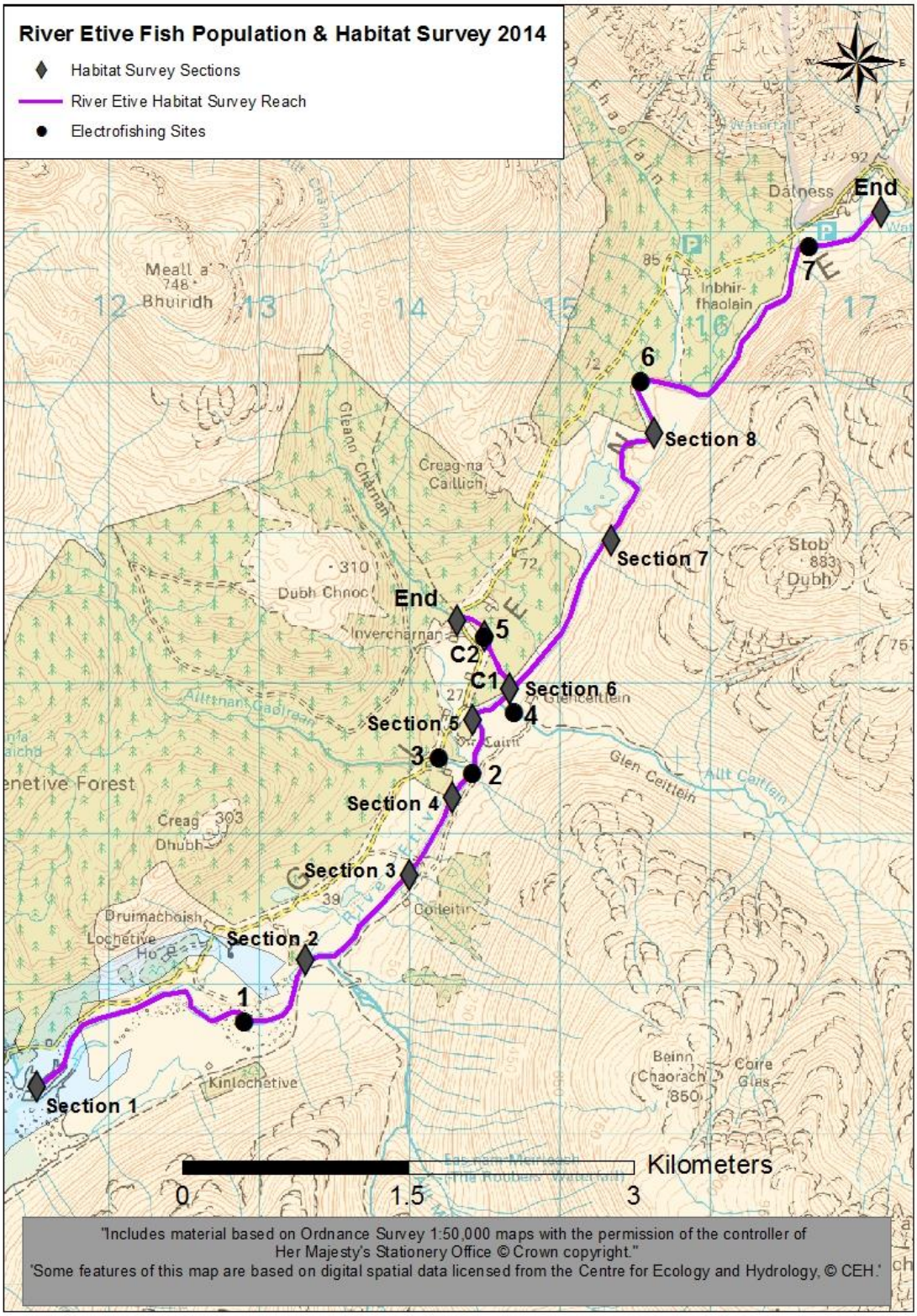
this study. Additionally, while sea-run brown trout have similar a life-cycle to salmon, there are significant differences in the use of marine habitats as well as a higher proportion of juvenile trout remaining, maturing and completing their life-cycle in freshwater. Therefore, estimates of sea trout smolt production are commonly reported to be lower than that for salmon (Molin, 2008) in larger rivers, but estimates are likely to vary depending on the character and productivity of freshwater habitats and therefore locally derived data will be required to establish smolt production levels in the River Orchy and its tributaries.

Wider studies suggest that the sea survival of salmon smolts has fallen in recent decades from highs of 30 % of smolts returning as adults from the sea to more recent estimates of 5 % or less. Other studies on sea trout suggest that and may have a higher expected smolt to adult survival rate than salmon; 14.9 % of smolts surviving to the mature adult stage (Jonsson and Jonsson, 2009). Additionally, sea trout are also known to have a higher potential than salmon for mature adults to survive after spawning and may subsequently return to spawn on multiple occasions. Studies undertaken using locally derived data will be required to gain a better understanding of the current pressures acting on different life-stages of salmonid fish.

While actual smolt production may be difficult to accurately estimate from counts of fry and parr in electrofishing surveys as semi-quantitative electrofishing do not catch all the fish present and there will be some over-winter losses of parr prior to smolting. However, parr density may be used to compare with smolt production targets until there are better locally derived data upon which estimates can be developed. For the purposes of this study, it is presumed that some 80 % of the parr found in electrofishing surveys will survive to the smolt stage. Where there are no electrofishing data for a section of habitat, an average of the number of parr found at the nearest sites up and downstream have been used to provide an estimate, which may vary from the actual numbers.

The lack of locally comparable data on the freshwater production and marine survival of salmon and sea trout smolts make estimating actual smolt production and adult returns of mature adults very difficult. However, the data gathered as part of this survey may be used to compare with other data reported from elsewhere. While these estimates cannot yet be verified and must be taken as a very rough guide to local potential for smolt production, population size and fishery performance they do however provide some comparable information for management purposes.

Figure 2.1 River Etive habitat survey and electrofishing locations



3. SURVEY FINDINGS

The findings of the survey is described below in relation to the suitability of the habitat for salmonid fish (section 3.1), the results of the electrofishing survey (section 3.2) and the subsequent estimates of the number of smolts produced by the catchment (section 3.3).

3.1 Habitat survey

The habitat was assessed in regard to the accessibility to salmonid and other fish (section 3.1.1), the characteristics of the habitat (section 3.1.2) and relative quality of habitat suited to juvenile and adult fish life-stages (section 3.1.3)

3.1.1 Habitat accessibility

A total of seven natural obstacles to fish migration were found on the main River Etive and two on Allt Charnan by this survey. All obstacles in the main river were found in sections seven and eight (Figure 3.1.11) were assessed as being potentially passable to adult salmonid fish in higher flows with the exception of the upper-most waterfall obstacle at Dalness (Figure 3.1.1). Other obstacles that are passable by fish were all boulder or bedrock cascades (Figure 3.1.2).

Figure 3.1.1 Impassable obstacle *(RE8)*

Figure 3.1.2 Passable cascade obstacle *(RE7)*

3.1.2 Habitat characteristics

The survey of River Etive collected information on 227,295 m² of habitats over 9.85 km of the main river length and 1,788 m² of habitat over a 0.64 km of the Allt Charnan tributary (Table 3.1.1). The average gradient of fall over the survey section length in the main river ranged between 0.4 and 1.2 m per 100 m length and between 2.3 and 4.0 in Allt Charnan. Stream channel types consisted mainly of low gradient actively meandering channel (class D) in section one of the lower main river (Figure 3.1.3) and plane riffle channels (class C) in six other sections of the main river and one in Allt Charnan (Figure 3.1.4).

Table 3.1.1 River channel type and dimensions

Section ID	Channel type	Class	Length (m)	Wet width (m)	Bed width (m)	Area (m²)	Gradient (m/100 m)
RE1	Pane riffle - Meander active	C / D	2,467	30	100	74,010	0.41
RE2	Plane bed - plane riffle	B / C	938	23	27	21,574	0.85
RE3	Bedrock - plane riffle	A / C	602	10	12	6,020	1.16
RE4	Plane bed - plane riffle	B / C	609	18	30	10,962	0.16
RE5	Plane riffle	C	359	34	55	12,206	0.56
RE6	Plane bed - plane riffle	B / C	1,235	30	45	37,050	0.89
RE7	Bedrock – Plane bed	A / B	936	15	23	14,040	0.64
RE8	Plain bed - bedrock	B / A	2,707	19	23	51,433	0.92
Avg. / Total			9,853	22.4	39.4	227,295	0.70
Allt Charnan							
AC1	Plane bed - plane riffle	B / C	394	2	3	788	2.28
AC2	Step-pool	B	250	4	5	1,000	4.00
Avg. / Total			644	3.0	4.5	1,788	3.14

Figure 3.1.3 Active meander channel (RE1)

Figure 3.1.4 Plane riffle channel (RE5)

Plane bed channel type (class B) was found in parts of four sections of the main river and one section of Allt Charnan (Figure 3.1.5) and step-pool channel (class B) were found in one section of Allt Charnan (Figure 3.1.6). Patches of bedrock channel (class A) were also present in three sections of the main river (Figure 3.1.7).

Figure 3.1.5 Plane bed channel (RE4)

Figure 3.1.6 Plane bed channel (RE8)

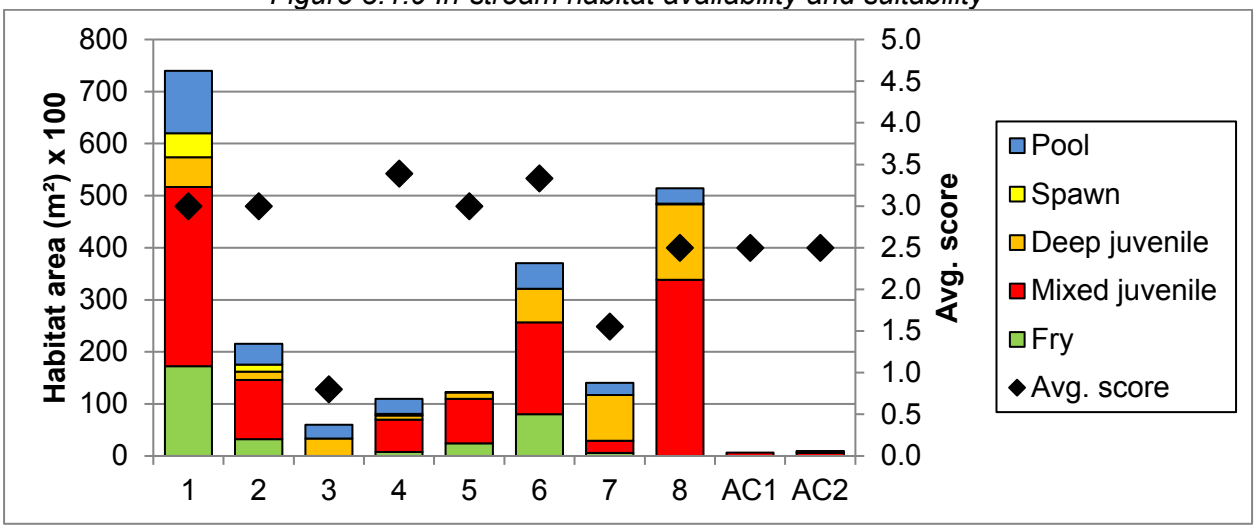
Figure 3.1.7 Step-pool channel (AC2)

Figure 3.1.8 Bedrock channel (RE7)

2.1.3 Fish habitat availability and suitability

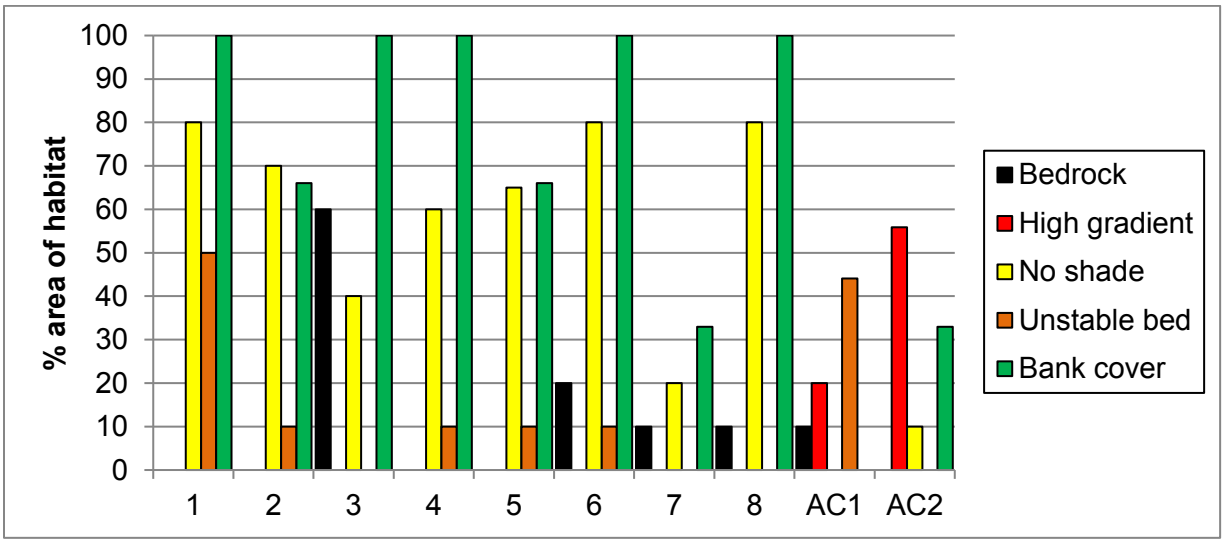
The availability of habitat suited to different age groups of salmonid fish (Figure 3.1.9) found in the River Etive was proportionately split between relatively small areas of spawning habitat (2.8 % of all habitat) and shallow fry habitat (12.6 %). More varied habitat suited to mixed ages of juveniles was relatively more abundant (505. %) and widely distributed as was deeper water habitat suited to older parr (18.5 %) and adult holding pools (14.0 %).

Figure 3.1.9 In-stream habitat availability and suitability



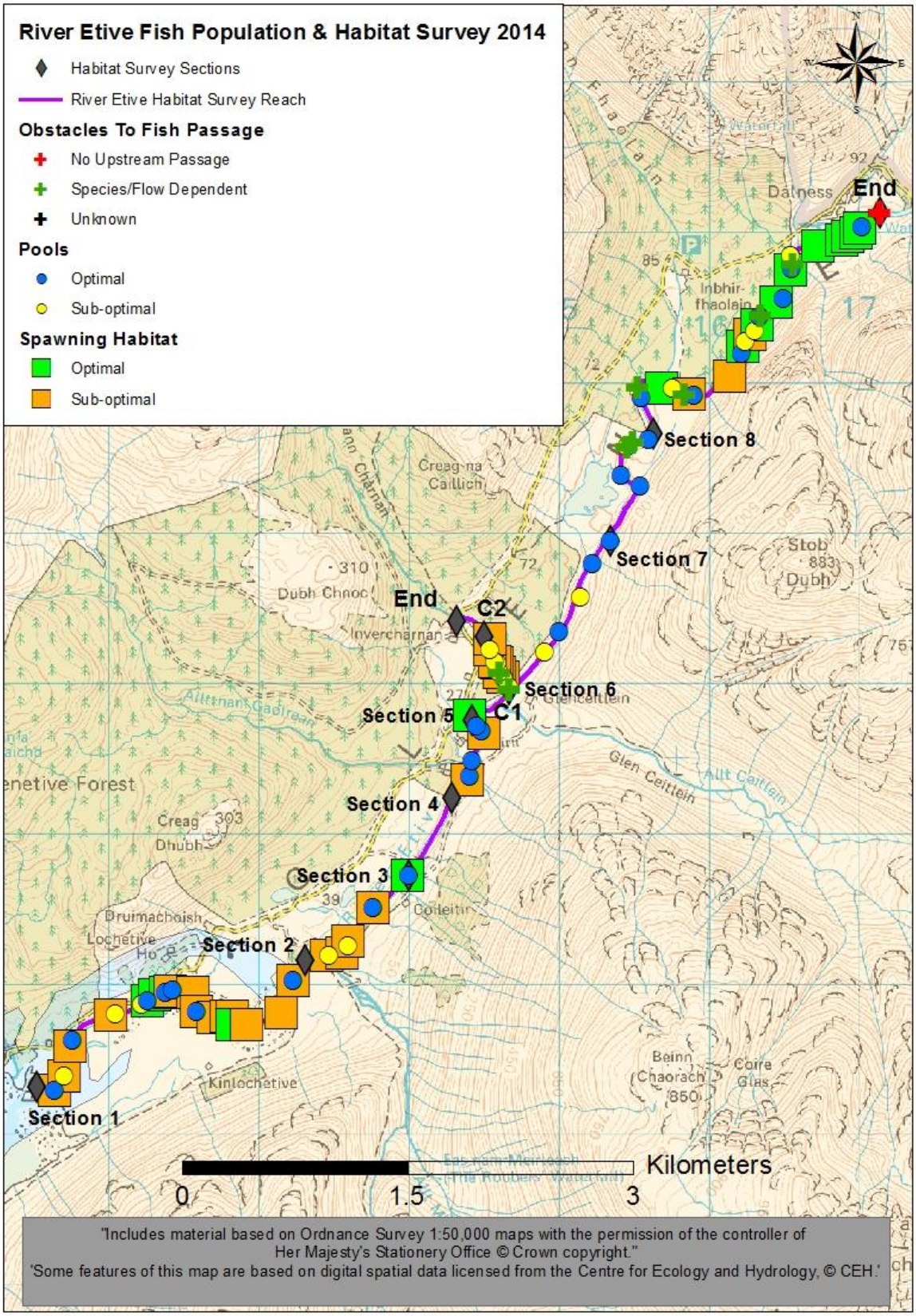
Average scores of suitability of habitat for juvenile fish (fry, mixed and deep juvenile habitats) ranged between 0.8 and 3.3 out of a possible 5.0 which were influenced by elements of the habitat that reduce cover for fish (Figure 3.1.10) which were mainly due to lack of shade and bank cover and unstable bed substrates and high gradient was recorded in some sections but in smaller proportions, while bedrock was limited to relatively small areas in five habitat sections.

Figure 3.1.10 Factors affecting juvenile fish habitat suitability (% of habitat area)



The frequency of adult holding pools ranged between no pools per km of stream length in section five and 6.6 pools in section four (Figure 3.1.11) and the frequency of spawning sites ranged between no sites per km in four sections and 9.2 in section one of the main river and 15.2 in section one of Allt Charnan.

Figure 2.1.11 Distributions of obstacles, pools and spawning sites in the River Etive



3.2 Fish population survey

Of the seven electrofishing surveys conducted, juvenile salmon were found at all sites and trout were found at three sites. European eels were also found at four sites. Estimates of minimum density of juvenile salmon and trout are given as the minimum number of fish per 100m² of wetted stream bed and the classification of density for stream width in the west coast region of Scotland (Table 3.2.1).

Table 3.2.1 Electrofishing survey densities for salmon and trout (Min. no. of fish per 100m²)

Site	Salmon				Trout				Other species
	Fry		Parr		Fry		Parr		
	Min. density	Class	Min. density	Class	Min. density	Class	Min. density	Class	
1	10.1	C	3.4	C	0.0	F	0.0	F	Eel
2	3.9	D	10.8	A	0.0	F	0.0	F	Eel
3	7.3	D	23.1	A	3.7	B	3.7	B	Eel
4	18.8	B	3.6	C	0.0	F	0.0	F	Eel
5	2.3	E	14.0	A	0.0	F	3.5	A	
6	37.5	A	1.7	D	0.0	F	0.0	F	
7	23.6	A	5.0	B	2.5	B	0.0	F	

The classification of salmon fry density was low (class E) at one site, moderate (Class C) at one other and high (class B) or very high (class A) at three others. The classification of Salmon parr density was low (class D) at one site, moderate (class C) at two sites and high (class B) or very high (class B) at four other sites. Where found at two sites, the classification of trout fry density was high (class B) and trout parr density was also high (classes B and A) at two sites.

3.3 Estimates of smolt production

The availability and productivity of habitat for fish recruitment has a strong influence on the number of salmon and trout smolts produced. Habitat and electrofishing data provide some basis for current numbers of smolts produced and comparison with that found by studies elsewhere.

Based on the 2014 electrofishing data, current estimates of salmon smolt production from the River Etive is approximately 12,056 fish which is slightly higher than the target of 11,365 smolts (Table 3.3.1), although electrofishing data indicate that average numbers of smolts produced by each section of habitat varies considerably.

Table 3.3.1 Estimates of salmon smolt production from the River Etive

Habitat unit	Area (x100m²)	Avg. no. parr / 100 m² (2014)	Total est. no. smolts	Target no. smolts
RE1	740	3.4	2,013	3,701
RE2	216	14.0	2,416	1,079
RE3	60	1.0	48	301
RE4	110	16.9	1,485	548
RE5	122	3.6	352	610
RE6	371	14.0	4,150	1,853
RE7	140	2.0	225	702
RE8	514	3.3	1,368	2,572
Total / Avg.	2,273	7.3	12,056	11,365

These data suggest that if there is a 5 % survival of the smolts, it is estimated that there will be around 603 adult salmon returning to the River Etive compared to the target number of 568 salmon. However, recent adult fish counts established by snorkel surveys (2013 to 14) where less than 200 have been counted. This suggests that either the smolt run is smaller than that estimated by this exercise or that marine survival of the smolts is much lower than the 5 % value ascribed. This discrepancy suggests that there need to be further work undertaken to establish more accurate numbers of fish at different life-stages.

Sea trout have historically been present in Loch Etive, but reported catches remain very low in this fishery district. Based on reported figures from studies done elsewhere, a crude estimate of some 2,010 sea trout smolts may be produced as compared to a target value of 6,819 smolts (Table 3.3.2).

The number of returning adult sea trout may be expected to around 301 mature sea trout, which may be increased by multi-spawning adult fish which have survived previous spawning migrations. On this basis, there is likely to be sufficient to maintain a robust population of sea trout in these catchments and a small catch and release fishery.

Figure 3.3.2 Estimates of sea trout smolt production from the River Etive

Habitat			Trout smolt production					Adult sea trout	
Habitat unit	Habitat Class	Area (x100m²)	E-fish site no.	Avg. no. parr / 100 m² (2014)	No. smolt / 100 m²	Total est. no. smolts	Target no. smolts	Returning adults (15 %)	Est. catch (20 %)
RE1	C / D	740	1	1.0	0.9	666	2,220	100	20
RE2	B / C	216		1.0	0.9	194	647	29	6
RE3	A / C	60		1.0	0.9	54	181	8	2
RE4	B / C	110	2 & 3	1.8	1.6	178	329	27	5
RE5	C	122	4	1.0	0.8	98	366	15	3
RE6	B / C	371	5	1.0	0.8	296	1,112	44	9
RE7	A / B	140		1.0	0.8	112	421	17	3
RE8	B	514	6 & 7	1.0	0.8	411	1,543	62	12
Total		2,273	6	1.1	0.9	2,010	6,819	301	60

It should also be noted that a proportion of the one-year-old salmon and trout parr will remain in freshwater for a further year and become smolts in their third year and some males will become mature parr and may not survive to smolt although they play a vital role in the recruitment process. Therefore, the estimates of the smolt run may not be spread over more than one year.

4. MANAGEMENT RECOMENDATIONS

The information on fish distribution, abundance and their habitat collected in 2014 provide some indication of the factors affecting abundance of fish, the productivity of habitats and how landowners and managers can improve habitats for benefit of fisheries and wider biodiversity.

4.1 Habitat Management

The sea survival of post-smolt salmon and trout and subsequent adult sea returns of adults to their home rivers has been a significant factor influencing the status of freshwater populations in recent years. This study found a number of factors affecting habitat condition which naturally limit smolt production and the performance of fisheries. Other human-derived pressures such as lack of shading of the channel and bank cover were also identified by this survey. Ensuring the freshwater habitat is optimal for recruitment of fish will have a significant beneficial influence in the longer-term health of fish populations and productivity of fisheries.

The River Etive (water body ID numbers 10315 and 10316) catchment has been classified as having good ecological status as part of the Argyll and Lochaber River Basin Plan with an aim to remain at good status by the 2027 phase of the plan. Therefore it is important to communicate with the regulators (SEPA) and land owners so that best practice guidance may be integral to the future management of water resources and land management.

A number of initiatives may be implemented to further improve the condition and productivity of the in-stream and riparian habitat for fish. The main in-stream (Table 4.1.1) and riparian (Table 4.1.2) habitat factors identified during the habitat survey are summarised below along with remedial activities and links to further guidance and potential funding streams.

4.1.1 In-stream habitat and river channel management

The short-term priority for management of fisheries is to ensure returning adult fish are able to access and successfully spawn in all accessible parts of the catchment. Further improvement in smolt production may be secured through in-stream habitat improvement by retaining beneficial large woody debris (LWD) within the stream and pro-actively constructing engineered log jams (ELJ) which will help to stabilise spawning grade sediment in unstable reaches of the river channels. LWD will also improve cover for fish in all other parts of the main river where there are natural limitations to fish cover.

Table 4.1.1 In-stream habitat management and improvement

Habitat Unit	In-stream factor	Remedial activity	Guidance & funding
All	Improve in-stream cover	Introduction of LWD / ELJ	SEPA - Conceptual Design Guidelines[1] Managing Woody Debris[2] Upland Rivers Habitat Manual[3]

1. http://www.sepa.org.uk/water/water_regulation/guidance/idoc.ashx?docid=3808b106-3a12-4e61-a7af-f6833c2078f7&version=-1
2. http://www.staffs-wildlife.org.uk/files/documents/203.pdf
3. http://www.wildtrout.org/content/wtt-publications

In-stream works are likely to require licensing under the controlled activities regulation (CAR) through the Scottish Environment Protection agency (SEPA).

4.1.2 Riparian habitat management

The restoration of productive riparian habitats requires regeneration of native broadleaf tree cover to improve vegetation structure diversity and species richness. Encouragement of lighter shading river-side trees such as willow and alder are likely to improve condition. The benefits for fish are improved bank-side cover as well as improving food availability for fish from terrestrial sources, indirectly via leaf litter for invertebrates and regulating stream water temperature.

Table 4.1.2 Riparian habitat management and improvement

Habitat Unit	Riparian factor	Remedial activity	Guidance & funding
All	Maintain shade	Protect / restore riparian woodland	Keeping Rivers Cool [1]

1. http://www.wildtrout.org/sites/default/files/news/Keeping%20Rivers%20Cool_Guidance%20Manual_v1%20%2023%2008%2012.pdf

The management of broadleaf trees in the riparian zone may maintain the benefits that support primary production.

4.1.3 Biosecurity issues

Invasive plants such Rhododendron Ponticum, Japanese knotweed and Himalayan balsam are widespread in the region of Argyll. Rhododendron Ponticum was found to be widespread on the right bank in a number of habitat sections on the River Etive. To reduce the impact on aquatic habitats, river-side infestations will require control and eradication measures. Where new infestations are found, it is important to act quickly to before it becomes widely established and will prevent further spread and loss of biodiversity and primary production of riparian habitats. Vigilance of land and water resource users will avoid significant associated management costs of future management.

4.2 Fish and fishery management

The results of the surveys indicate that while there is sufficient stock to support a modest salmon fishery on the River Etive. However, projections of smolt production, adult sea returns contrast with reported catches of salmon and snorkel survey counts, suggesting that there may be significantly higher losses of smolts at sea than previously thought. Therefore, until better estimates of the number of smolts produced and returning adults, exploitation of both salmon and trout population may be limited with a catch and release policy. Future operation of a fishery will require close monitoring of populations to assess trends in stock strength (which can be affected by a number of factors outside the influence of local management). Therefore, it is important to establish fishery management practices tailored to ensuring that salmon and trout populations are able to self-regenerate in optimal numbers.

4.2.1 Maximising spawning escapement

Where fishing for mature adult fish is undertaken it is important to communicate with anglers to establish beneficial angling practices such as catch and release that minimise loss of returning adults. This fisheries management tool is proven to benefit salmon and trout populations and help ensure that the escapement of valuable brood fish from the fishery is then able to spawn. This is essential at a time when egg deposition is lower than that required to fully re-populate the catchment with juveniles, and subsequently produce optimal numbers of smolts going to sea.

4.2.2 Monitoring of adult fish abundance

Further information, along-side angling catch data, may provide a better understanding of the status of adult fish populations over time. Counts of adult fish prior to spawning by snorkel

surveys and / or counting of redds post-spawning will provide information on population abundance and improve understanding of the use of habitat for recruitment of juvenile fish.

4.2.3 Stocking intervention

Efforts to restore or enhance fishery performance through stocking activities may have potential to stimulate recovery in severely depleted fish populations if the causal factors of decline can be tackled or mitigated. Hatcheries however are unlikely to overcome the causes of the decline of population abundance or fishery catches unless the reason for decline exists within the freshwater phase of the life-cycle (i.e. loss or impairment of spawning habitat which cannot be restored).

The results of this survey suggest that there appear to be relatively good numbers of salmon smolts being produced, but freshwater habitat condition may limit smolt recruitment. Therefore investment in regeneration of riparian trees (to combat threats from future climate change on cold water fish) and introduction of large woody debris (to increase spawning habitat availability) will provide long-term cost effective investment when compared to potentially on-going maintenance costs of running a hatchery and stocking programme.

The scale of the current stocking programme of unfed fry is relatively modest, which is likely to limit any unintended damage to genetic variation in the wild population. However, all measures need to be undertaken to avoid inclusion of escapee farm salmon and mixing of stocks from the upper and lower river which may be genetically discrete populations with different life-histories. It is recommended that any future use of the hatchery facility is informed by a genetic audit to establish the relative complexity of the population and the potential for mixing of broodfish which can undermine the long-term fitness of the population. Although not conclusive, the relatively high numbers of parr and the relatively low numbers of returning adults suggest that far fewer of the smolts produced are surviving at sea than may be expected, which has been noted in studies other hatchery-reared salmon populations undertaken elsewhere. There is also a need to continue to undertake surveys of adult and juvenile salmon to inform future management.

4.2.4 Biosecurity issues

Fishery activity has potential to introduce fish diseases and parasites through contamination of clothing and fishing gear or direst introduction of infected fish. Preventing non-licensed introductions of fish and increasing awareness of anglers in cleaning and drying fishing gear before and after visiting fisheries will help to avoid loss of native biodiversity and productivity of the fishery.

4.2.5 Aquaculture

There has been significant development of aquaculture of salmon in Loch Linne and of rainbow trout in Loch Etive. Potential breaches of containment can lead to escapee farm fish entering rivers and therefore competing with and disrupting native fish populations. There are longer-term consequences from escapee farm salmon breeding with wild salmon. Removal of escapee farm fish should be reported to Marine Scotland Science and high parasite burdens to Argyll District Salmon Fishery Board and Argyll Fisheries Trust.

Table 4.2.1 Fishery improvement and other management

Management	Limiting factor	Remedial activities	Guidance
Fishery	Adult fish	Catch & release fishery	Marine Scotland Science[1]
Information	Smolt production	Monitoring & investigation	Argyll Fisheries Trust[2]
Stocking	Brood-fish Genetic diversity	Assess natural stock recovery	RAFTS and ASFB[3]
Biosecurity	Productivity	Vigilance	Argyll Fisheries Trust[4]
Aquaculture	Genetic fitness Sea survival	Reporting	Marine Scotland Science[5] Argyll DSFB[6]

1. http://www.scotland.gov.uk/Resource/Doc/295194/0100050.pdf
2. http://www.argyllfisheriestrust.co.uk/
3. http://www.rafts.org.uk/wp-content/uploads/2011/08/ASFB-RAFTS-Salmon-stocking-policy-paper.pdf
4. http://www.argyllfisheriestrust.co.uk/pdfs/argyllbiosecuritymanagementplan09.pdf
5. http://www.scotland.gov.uk/Topics/marine/Fish-Shellfish/18364/18692/notification-forms
6. http://www.asfb.org.uk/members/#Argyll

5. REFERENCES

Armstrong JD, Kemp PS, Kennedy GJA, Ladle M, Milner NJ. (2003). Habitat requirements of Atlantic salmon and brown trout in rivers and streams. Fisheries Research **62**: 143-170.

Argyll Fisheries Trust (2010). Awe District Atlantic Salmon & Sea Trout Catches 1952-2010. Argyll Fisheries Trust, Cherry Park, Inveraray, Argyll. PA32 8XE.

Argyll Fisheries Trust (2009a). Argyll & The Islands Strategic Fisheries Management Plan. Argyll Fisheries Trust, Cherry Park, Inveraray, Argyll. PA32 8XE.

Argyll Fisheries Trust (2009b). Argyll & The Islands Fisheries Biosecurity Plan. Argyll Fisheries Trust, Cherry Park, Inveraray, Argyll. PA32 8XE.

Buck, R. J. G and Hay, D. W. (2006). The relation between stock size and progeny of Atlantic salmon, *Salmo salar* L., in a Scottish stream. *Journal of Fish Biology. Volume 24, Issue 1, pages 1–11, January 1984*

Godfrey, J. D. (2005). Site condition monitoring of Atlantic salmon SACs. Report by the SFCC to Scottish Natural Heritage, Contract F02AC608, 274 pp.

Hendry, K. & D Cragg-Hine (2003). Ecology of the Atlantic salmon. Conserving Natura 2000 rivers. Ecology series No.7. LIFE inUK Rivers, English Nature, Peterbrough.

Jonsson, B and Jonsson, N. (2009) Migratory timing, marine survival and growth of anadromous brown trout *Salmo trutta* in the River Imsa, Norway. Journal of Fish Biology. Volume 74, Issue 3, pages 621–638, February 2009

Molin, J (2008). Linking habitat characteristics and juvenile density to quantify *Salmo salar* & *Salmo trutta* smolt production in River Sävarån, Northern Sweden. Wildlife, Fish, and Environmental Studies **2008:3** Swedish University of Agricultural Sciences SE901 83 Umeå, Sweden

Mortensen, E. (1997). Population, Survival, Growth and Production of Trout Salmo trutta in a Small Danish Stream. *Oikos.* Vol. 28, Fasc. 1 (1977), pp. 9-15: http://www.jstor.org/stable/3543316

Raven, P.J., Fox, P., Everard, M., Holmes, N.T.H. and Dawson, F.H. 1997. 'River Habitat Survey: a new system for classifying rivers according to their habitat quality', in Boon, P.J. and Howell, D.L. (Eds), Freshwater Quality:

Raven, P.J., Holmes, N.T.H., Fox, P.J.A., Dawson, F.H., Everard, M., Fozzard, I.R. and Rouen, K.J. 1998b. River Habitat Quality: The Physical Character of Rivers and Streams in the UK and the Isle of Man, Environment Agency, Bristol.

Scottish Fisheries Coordination Centre (2007a). Electrofishing survey training course manual. FRS, Pitlochry, pp 1-64.

Scottish Fisheries Coordination Centre (2007b). Habitat survey training course manual. FRS, Pitlochry, pp 1-64

SNIFFER (2006). A new impact assessment tool to support river engineering regulatory decisions. WFD49 (Rivers) Final Technical Report.

Spey District Salmon Fishery Board (2012). http://www.speyfisheryboard.com/smolt-traps-2012

Symons, P. E. K., (1979). Estimated Escapement of Atlantic Salmon (*Salmo salar*) for Maximum Smolt Production in Rivers of Different Productivity. *Journal of the Fisheries Research Board of Canada*, 1979, 36(2): 132-140, 10.1139/f79-022.

Whalen, K. G., Parrish, D. L., Mather, M. E. and McMenemy, J. R. (2000). Cross-tributary analysis of parr to smolt recruitment of Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquatic Sciences*, 2000, 57(8): 1607-1616, 10.1139/f00-093