Fish Population and Habitat Survey of the

River Goil, Argyll 2009

Summary Report of survey findings and potential Fishery and Habitat Management Initiatives

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1. Report Summary

Argyll Fisheries Trust undertook surveys of fish populations at 16 sites and fish habitat along 4.75 km of the main channel of the River Goil in September 2009. The aim of the surveys was to assess fish species distribution and their relative abundance and collect information on fish habitats. This report has two main purposes:

1. To provide fishery management advice to fishery interests based on sustainable use of the fishery resource.
2. To enable land managers and landowners to identify riparian improvement works that will enhance the fishery and identify potential sources of grant aid to fund the work.

Main findings

- Habitat surveys of the main channel identified around 4.75 km of potentially accessible habitat, which appear to be limited by the bridge apron at the B880 road crossing and a weir further upstream. The distribution of Juvenile salmon and trout was widespread, but patchy (species and year classes missing at some sites) and commonly at low-to-moderate abundance.
- Fish data suggest that subsequent production of smolts from the Black Water catchment is estimated to be at a minimal-to-low level, which may not be able to maintain a healthy population over the longer-term. Any further decline in smolt production and subsequent adult sea-returns may cause the population to fail.
- While marine survival of post-smolts is likely to be a significant factor currently limiting numbers of returning adults, habitat data indicate that the productivity of freshwater habitats are sub-optimal and is impairing maintenance and recovery of the stock.
- Lack of pool and spawning habitat (and other habitat diversity) throughout the catchment is a direct result of channel straightening, which is maintained by embankments and revetments.
- The sub-optimal productivity of the catchment is mainly due to loss of natural morphology and river process that provide key habitats for salmonid fish. It is possible that abstraction of water from the catchment and active sediment management (dredging) within the channel exacerbates the loss of substrate transport and floodplain connectivity.
- Fine sediment delivered through a network of open ditches compact the river bed and impair fish habitat. Single-age trees in riparian woodland impair sunlight and base productivity.

Future work:

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

- Grant funding is required to provide further expertise to assess potential for restoration of morphology and river processes in the catchment.
- Additional multiple benefits can be generated by improving bank-side cover for fish cover, food production, habitat stability and complexity.
- Introduction of large woody debris features in the middle and lower catchment are likely to improve habitat condition and complexity where in-stream cover is relatively poor.
- Tackling invasive plants in the riparian zone is required to maintain bank stability and production of terrestrial food items for fish.
- To ensure natural regeneration of fish is maintained and improved, fishery activity should operate on a catch and release basis to maximise egg deposition.
- Further surveys are required over time to assess the performance of fish stocks and benefit of habitat improvement works undertaken.

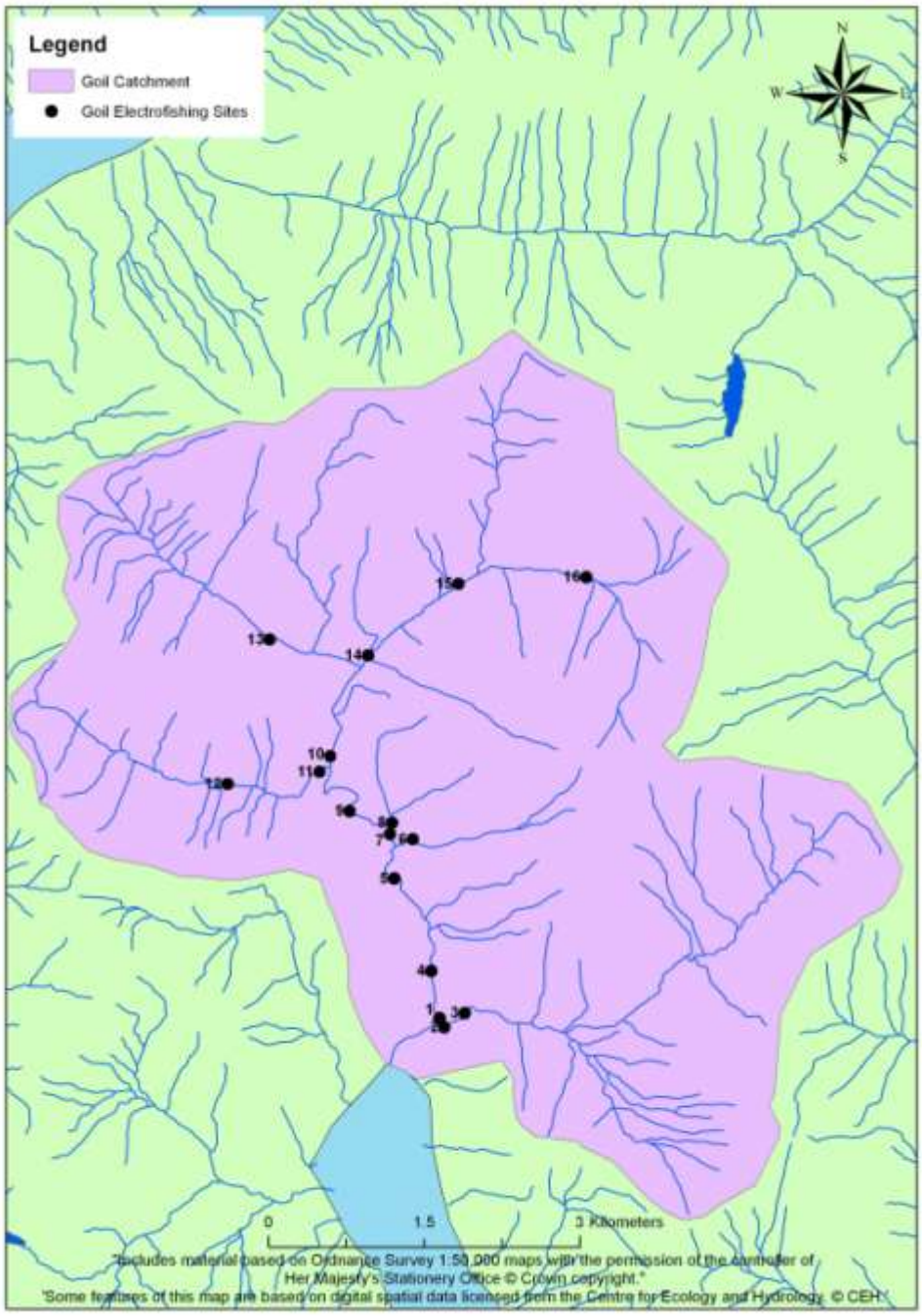
Acknowledgements

Argyll Fisheries Trust thanks land owners for the opportunity to undertake this assessment of fish populations.

2. SURVEY FINDINGS AND RECOMENDATIONS

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 and sampling of fish by electrofishing (Fig.2.1).

Figure 2.1 Distribution of survey sites



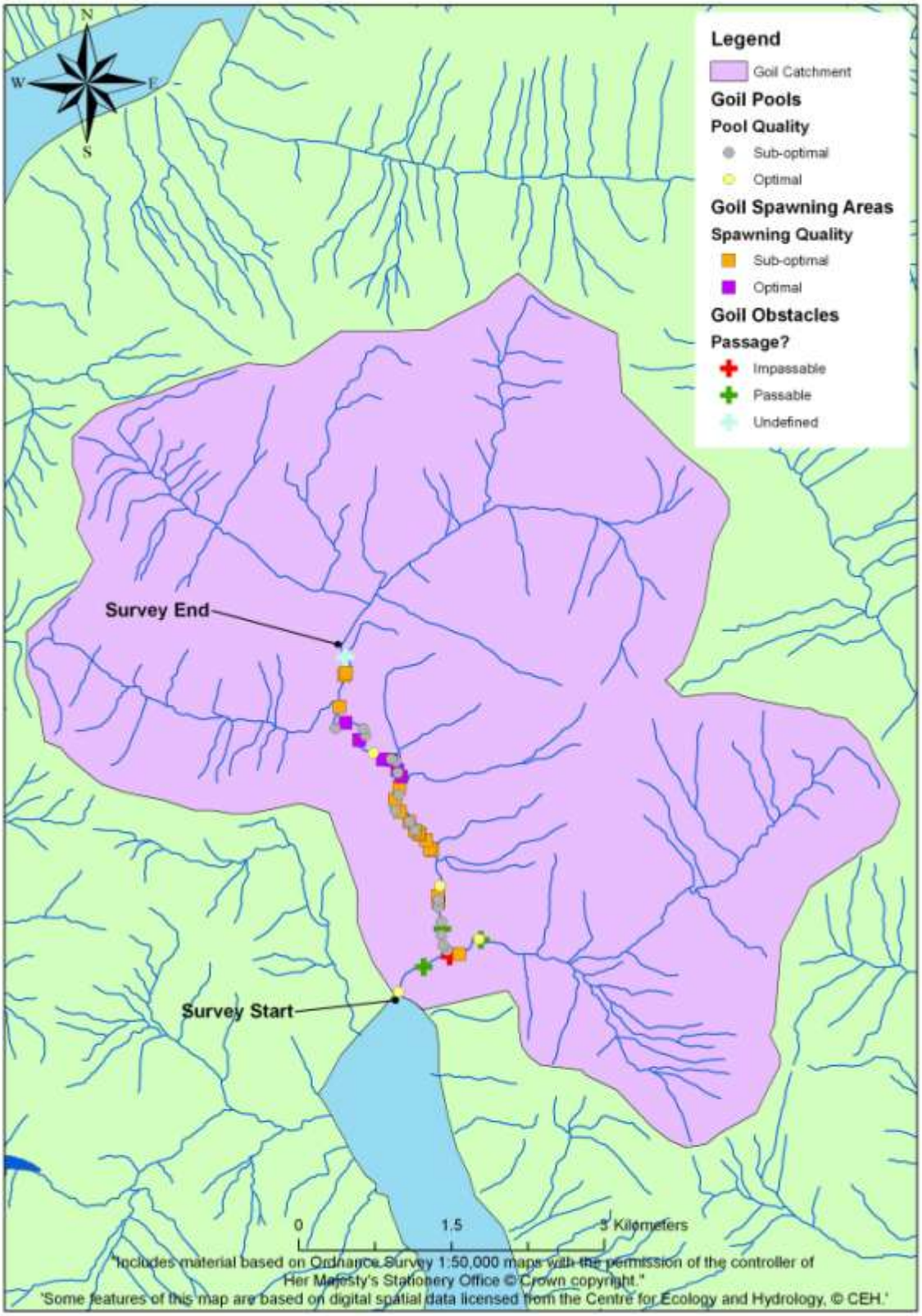
2.1 Habitat survey

The habitat survey found 64,500 m² of habitat over a channel length of 4.75 km. The habitat assessed averaged 11.5 m width, which is generally more suitable for recruitment of Atlantic salmon, while smaller tributary streams and headwaters are likely to be utilised by trout for recruitment but were not assessed as part of this habitat study.

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. The ideal habitat within each unit should have a pool for adults at the upstream end with a spawning site (usually a glide on the outflow of the pool). Downstream of the spawning habitat a larger area relatively shallow broken-water habitat (riffle) is required by emergent fry as they disperse from the spawning redds. Subsequent growth in the first summer and over-wintering of juveniles requires larger territories of deeper water further downstream. Increasingly larger substrates are required by juveniles as they grow which have sufficient gaps between them to allow fish to into and under the bed to shelter from floods and predators. The spaces between and under individual substrates also provide refuge for invertebrates which are utilised for food in winter, spring and early summer. The scale of each habitat unit is ideally less than 0.5 km, which is considered to be at the outer range of downstream distribution of juveniles from a spawning site, but is more commonly half this distance.

Food for fish is also delivered by riparian habitat, which is particularly important in summer and autumn as the number of invertebrates naturally reduce once they have hatched, laid their eggs and died. Provision of a ‘year-round’ food supply is therefore best achieved by a diversity of native vegetation types in the catchment that support a wide-range of insect life. Shading (water temperature regulation), leaf litter (food for invertebrates) and root systems (fish cover and bank stabilisers) are provided by native species of bank-side trees. Compared against the ideal freshwater habitat scenario described above, most actual habitat has both natural and human-derived influences that render it sub-optimal.

Fig. 2.2 Machrie Water habitat; distribution of pools, spawning sites and obstacles



The survey found that the condition of in-stream habitat was generally poor, which is a direct consequence of changes to the natural form of the river channel (straightening), severe bank erosion and accumulation of fine sediment in the river bed substrate (Table 2.1).

Table 2.1 Major habitat units, frequency of spawning and availability of other habitat components

Major Habitat Unit	Major Unit length (km)	Freq. of spawning habitat (no. per km)	Avg. habitat sub-unit length (km)	Habitat components present	Limiting habitat component(s)
A (Lower)	1.25	0.8	1.25	Adult pool Juvenile	Compact substrate Morphology Riparian veg.
B (Middle lower)	1.5	8.0	0.13	Adult pool Spawning / fry Juvenile	Compact substrate Morphology Riparian veg.
C (Middle upper)	1.0	6.0	0.17	Adult pool Spawning / Fry Juvenile	Unstable banks Morphology Riparian veg.
D (Upper)	1.0	3.0	0.33	Spawning / Fry Juvenile Riparian veg.	Adult pool

The four habitat units identified consisted of a number of smaller breeding units defined by the average distance between spawning sites (between 0.13 and 1.25 km in length). Spawning site frequency was highest in the middle lower (8 per km), middle upper (6 per km) and upper (3 per km), but was comparatively low in the lower river (0.8 per km). The limitations on the distribution and abundance of important habitat types; adult pool and spawning sites are directly related to the morphological alterations of the river channel.

Lower Black Water

Comparisons between the major habitat units in the Goil catchment identify that the lower 1.25 km of the river is suitable for older juveniles (parr) and adults as few spawning sites were found (Figure 2.3). Similarly the lower reach of the Donich Water tributary may have limited spawning opportunities (Figure 2.4).

Fig. 2.3 Mixed juvenile habitat in the main river

Fig. 2.4 Mixed juvenile habitat in the Donich Water tributary

Fine sediment and iron deposit was commonly found in the substrate matrix of habitat suitable for juvenile (Fig. 2.5) and adult (Fig. 2.6) fish, reducing availability of in-stream cover for fish.

Fig. 2.5 Adult pool in bedrock habitat

Fig. 2.6 Bedrock outcrop waterfall obstacle

Middle-lower Goil

Upstream of the B828 road crossing, the morphology of the middle-lower main river channel appears to have been modified from a tortuous meander to a slightly sinuous channel form. Embankments and planting with riparian trees has been undertaken to retain the modified channel in place (Figs. 2.7 and 2.8).

Fig. 2.7 Straightened and down-cut channel

Fig. 2.8 Embankment & revetment on bends

Grazing of stream banks and conifer plantation (Fig. 2.9) has reduced influence of native riparian trees over time, exposing fine sandy soils to erosion, causing slumping of the bank, channel over-widening and compacted substrates. Spawning sites are present, but are sub-optimal due to fine sediments (Fig. 2.10) and little cover for fry emerging from redds .

Fig. 2.9 Land use influence on bank stability

Fig. 2.10 low quality spawning habitat

Middle-upper Goil

Upstream of the confluence with the Allt Chriche tributary, channel form meanders more sinuously with significant erosion on the outside of bends and deposition of substrate on point bars (Fig. 2.9). Substrates are generally coarser than that found downstream creating abundant spawning and fry habitat (Figure 2.10).

Fig. 2.9 Erosion and deposition on bends

Fig. 2.10 Spawning and fry habitat

While the wide and shallow channel form provide significant spawning and fry habitat (Fig. 2.11), adult pools are generally relatively shallow and provide little cover for fish with the exception of one pool at the head of the reach where habitat has been modified (Fig. 2.12).

Fig. 2.11 shallow water and relatively small substrates provide little cover for older fish

Fig. 2.12 Large adult holding pool in modified habitat

Upper Goil

The upper main river and accessible parts of tributaries is characterised by higher gradient stream type with more diverse flow and substrate types (cobbles and boulder) suitable for mixed age classes of juvenile fish (Figs. 2.9 and 2.10).

Fig. 2.9 Mixed juvenile habitat

Fig. 2.10 Chanachadan Burn

Allt Glinne Mhor

Upstream of bedrock waterfalls, which may restrict movement of migratory fish upstream, the river channel is relatively straight, entrenched and high gradient. Bedrock and boulder substrates are common (Fig. 2.11), but there is significant areas of suitable juvenile fish present (Fig. 2.12).

Fig. 2.11 Bedrock substrate reduce cover for fish

Fig. 2.12 Cobble & boulder substrate offer good cover for juvenile fish

Riparian habitat productivity

This survey found a combination of rough grasses, native trees and conifer plantation along the riparian land downstream of waterfalls, but was more diverse in vegetation type higher in the catchment. Grazing livestock severely affect the vegetation on the main river and tributary stream banks (Fig. 2.13). Trampling by livestock and loss of vegetation have undermined banks and contribute to loss of trees (Figure 2.14) which is likely to be a significant factor affecting in-stream cover for juvenile fish.

Fig. 2.13 Trampling of banks and loss of vegetation

Fig. 2.14 Hoof shear and erosion of tree roots undermine the remaining trees

Rhododendron Ponticum was found in the lower reach of the main river and the Donich Water (Figure 2.15) and Japanese knotweed on the middle reach of the main river (Figure 2.16); both of which reduce productivity by displacing insect-bearing native species.

Fig. 2.15 R. Ponticum affect riparian habitat

Fig. 2.16 Japanese knotweed

2.2 Fish population survey

Of the 16 electrofishing surveys conducted in 2009, juvenile salmon were found at nine sites and trout at 13 sites. Estimates of abundance for juvenile salmonids (minimum number of fish per 100m²) were classified according to stream width (Table 2.2). Classification was banded between A (very high), B (high), C (moderate), D (low), E (very low) and F where fish were not found. No European eels or other species were found.

Table 2.2 Comparison of Classification of fish abundance

Site		2009				2002			
		Salmon		Trout		Salmon		Trout	
No.	Location	Fry	Parr	Fry	Parr	Fry	Parr	Fry	Parr
1	Lower main	E	C	F	F	E	B	F	A
2	Donich trib.	F	C	A	A	F	D	F	B
3	Donich trib.	F	D	F	A				
4	Mid-lower main	C	B	F	F				
5	Mid-lower main	E	F	E	F				
6	Mid-lower trib.	F	F	B	B	C	B	A	A
7	Mid-upper main	E	E	E	F	E	D	F	F
8	Mid-upper trib	F	F	C	B	F	F	B	C
9	Mid-upper main	C	A	E	F	B	B	E	E
10	Upper main	E	B	E	F				
11	Upper trib.	B	E	E	F	C	A	C	A
12	Upper trib.	F	F	F	F				
13	Hells Glen trib	F	F	D	D	F	F	E	A
14	A. Ghlinne Mhor	F	F	E	F				
15	A. Ghlinne Mhor	F	F	D	F				
16	A. Ghlinne Mhor	F	F	E	F				

Salmon fry (less than one year of age) abundance was low (class E) at four sites, moderate (class C) at two sites and high (class B) at one other site. Salmon parr (more than one year of age) abundance was generally higher than for fry; low at two sites (classes D and E), moderate at two sites and high or very high (classes B & A) at three other sites. Trout fry abundance was commonly low (classes D and E) at nine sites, moderate abundance (class C) at one site and higher abundance (class B) at two others. Trout parr were found at low abundance (class D) at one site and at high abundance (classes A & B) at four sites.

Comparisons made at eight sites first sampled in 2002 found that salmon fry were found at similar density in 2009 at five sites, lower density at two sites and at higher density at one other

site. Similar comparison of trout fry found similar density at two sites, lower density at three sites and higher density at three other sites.

2.3 Estimates of salmon smolt production

Estimates of smolt production in the North Atlantic region have been reported between 1 and 10 per 100 m² of available habitat depending on habitat productivity. The current (2009) smolt production of the River Goil may be estimated by the habitat area available (Table 2.3) and the number of parr found in surveys.

Table 2.3 Estimated smolt production at different levels of productivity (no. smolt produced per 100 m² of habitat)

Habitat unit	Area (100 m²)	Area (%)	Min. (1-2)	Low (3-4)	Mod. (5-6)	High (7-8)	Max. (9-10)	Avg. no. parr /100 m²
Lower	185	29	278	648	1,018	1,388	1,850	3.3
Mid-lower	220	34	330	770	1,210	1,650	2,200	2.4
Mid-upper	130	20	195	455	715	975	1,300	3.7
Upper	110	17	165	385	605	825	1,100	2.5
A. Glinne Mhor	0	0	0	0	0	0	0	0.0
Total	645		968	2,258	3,548	4,838	6,450	3.0

Average parr densities found by the 2009 survey was 3.0 parr per 100 m² (one and two year-old juveniles). However, not all one-year-old parr are likely to smolt in the following spring and further mortalities may be expected over-winter. Therefore, the current level of smolt production of the River Goil is likely to be at a minimum production level (1 to 2 smolts per 100 m²); estimated at 968 smolts produced. Subsequent marine survival of smolts through to returning adult has been known to vary between years but has been relatively low in recent years (estimated to be between 1 and 6%). Marine survival will vary depending on a number of factors; controls on sea lice in inshore fish farms and climate driven factors affecting food availability in the North Atlantic Ocean and bi-catch of other fisheries. Snorkel counts undertaken in other rivers in upper Loch Fyne (in 2007) indicate that marine survival of smolts was in the region of 4 % to the adult return stage of the life-cycle (Table 2.4). If the estimated 4 % marine survival of smolts to returning adults is sustained at this level, an estimated 39 adults may be expected to return to the system at current smolt production levels.

Table 2.4 Estimated no. of adult sea-returns at different levels of smolt production and sea survival to adult

Smolt-adult Survival (%)	Min. (1-2)	Low (3-4)	Mod. (5-6)	High (7-8)	Max. (9-10)
1	10	23	35	48	65
2	19	45	71	97	129
3	29	68	106	145	194
4	39	90	142	194	258
5	48	113	177	242	323
6	58	135	213	290	387

The estimated number of adult spawning stock returning to the River Goil is below safe biological limits to be able to maintain a genetically healthy breeding unit. Improvement in juvenile production to low-to-moderate levels are required to increase adult sea-returns (i.e. 90 to142 adults) to improve the longer-term health and genetic fitness of the population.

Given the estimated 20% exploitation by anglers, the performance of the fishery may currently be expected to yield around 8 salmon to the rod (Table 2.5), but would be raised to 18-28 salmon at low-to-moderate levels of smolt production.

Table 2.5 Estimated rod catch (20 %) at different levels of smolt production and sea survival to adult

Smolt-adult Survival (%)	Min. (1-2)	Low (3-4)	Mod. (5-6)	High (7-8)	Max. (9-10)
1	2	5	7	10	13
2	4	9	14	19	26
3	6	14	21	29	39
4	8	18	28	39	52
5	10	23	35	48	65
6	12	27	43	58	77

3. IMPLICATIONS FOR THE MANAGEMENT OF FISH RESOURCES

The information on fish distribution, abundance and their habitat collected in 2009 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.

3.1 Habitat Management

The sea survival of post-smolt salmon and trout and subsequent the return of adults to their home rivers has been a significant factor influencing the status of freshwater populations in recent years. Additionally, freshwater habitat in sub-optimal condition can also exacerbate population decline. Ensuring the freshwater habitat is optimal for recruitment of fish will have a significant influence in the longer-term health of fish populations and productivity of fisheries. Land owners and managers are the primary drivers for securing improvement in productivity of habitats, fish populations and fisheries.

This study found a number of factors affecting habitat condition and a number of initiatives may be implemented to further improve the condition and productivity of the in-stream and riparian habitat. The main river morphology, in-stream (Table 3.1) and riparian (Table 3.2) habitat factors identified during the habitat survey are summarised below with remedial activities and links to further guidance and potential funding streams.

In-stream habitat and river channel management

The River Goil catchment has been classified as having good ecological status as part of the Clyde River Basin Plan. It is the aim of the directive to maintain the ecological status of the waterbody in each cycle of the plan. However, the habitat and fish data collected by this survey found that both habitat and fish numbers are less than good. Therefore it is important to communicate with the regulators (SEPA) so that best practice management is implemented by land and water resource users that will improve the productivity of fish habitats.

In-stream habitat improvement may be undertaken through retaining existing beneficial large woody debris (LWD) features within the stream and pro-actively constructing new features, such as engineered log jam (ELJ) which will help to provide cover for adult and juvenile fish in the middle reach of the Goil.

Table 3.1 In-stream habitat management and improvement

Habitat Unit	In-stream factor	Remedial activity	Guidance & funding
Middle lower Middle upper	Embankments Excessive erosion Sediment transport Fine sediment	Restore natural morphology	SEPA - SEPA: Water environment restoration fund: Apply [1] Managing River Habitats for Fish[2]
Middle lower Middle upper	in-stream cover for fish	Introduction of LWD / ELJ	SEPA - Conceptual Design Guidelines[3] Managing Woody Debris[4] Upland Rivers Habitat Manual[5]

1. http://apps.sepa.org.uk/bmp/
2. http://www.sepa.org.uk/water/water_regulation/regimes/engineering/habitat_enhancement/best_practice_guidance.aspx#Managing
3. http://www.sepa.org.uk/water/water_regulation/guidance/idoc.ashx?docid=3808b106-3a12-4e61-a7af-f6833c2078f7&version=-1
4. http://www.staffs-wildlife.org.uk/files/documents/203.pdf
5. 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).

Riparian habitat management

The restoration of productive riparian habitats requires restructuring of existing native broadleaf trees 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 and indirectly via leaf litter for invertebrates.

Landowners 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).

Table 3.2 Riparian habitat management and improvement

Habitat Unit	Riparian factor	Remedial activity	Guidance & funding
Middle lower Middle upper	Lack of vegetation Bank collapse	Fencing & tree planting	SRDP Native woodlands [1] Keeping Rivers Cool [2]
Lower	Invasive plants	Control & eradication	SEPA - SEPA: Water environment restoration fund: Apply [3]

1. http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Packages/NativeWoodlandsandasso
2. http://publications.environment-agency.gov.uk
3. http://apps.sepa.org.uk/bmp/

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. Attaching to these priorities are packages that can help deliver the desired improvements. For example, if you are interested in forest management or habitat improvements to address morphological pressures, then under 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

3.2 Fish and fishery management

While there has traditionally been a modest rod and line fishery on the River Goil, juvenile surveys indicates that both the salmon and the trout populations are not in a condition that will allow them to be sustainably exploited by a fishery. 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 (Table 3.3).

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.

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.

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 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 investment in restoring fish access to the upper river and restoration of spawning habitat in the upper river will be a cost effective investment when compared to potentially on-going maintenance costs of running a hatchery and stocking programme. However, if the stock fails to recover in the near future it may be necessary to develop a

hatchery-based support programme to re-establish salmon throughout the catchment. These management options should be informed by regular collection of data on fish populations.

Biosecurity issues

Priority invasive non-native species (INNS) were found in the catchment by this survey; Rhododendron and Japanese knotweed. Surveillance and fast response to control and quickly eradicate INNS is required to prevent the spread of any introduced species. Vigilance of land and water resource users will avoid significant associated management costs of future management.

Aquaculture

There has been development of aquaculture production in the Firth of Clyde which has potential to have breaches of containment and exacerbate affects of other fish health issues, such as sea lice, that can affect wild salmonids. 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 3.3 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	Assess natural stock recovery	RAFTS and ASFB[3]
Biosecurity	Habitat 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