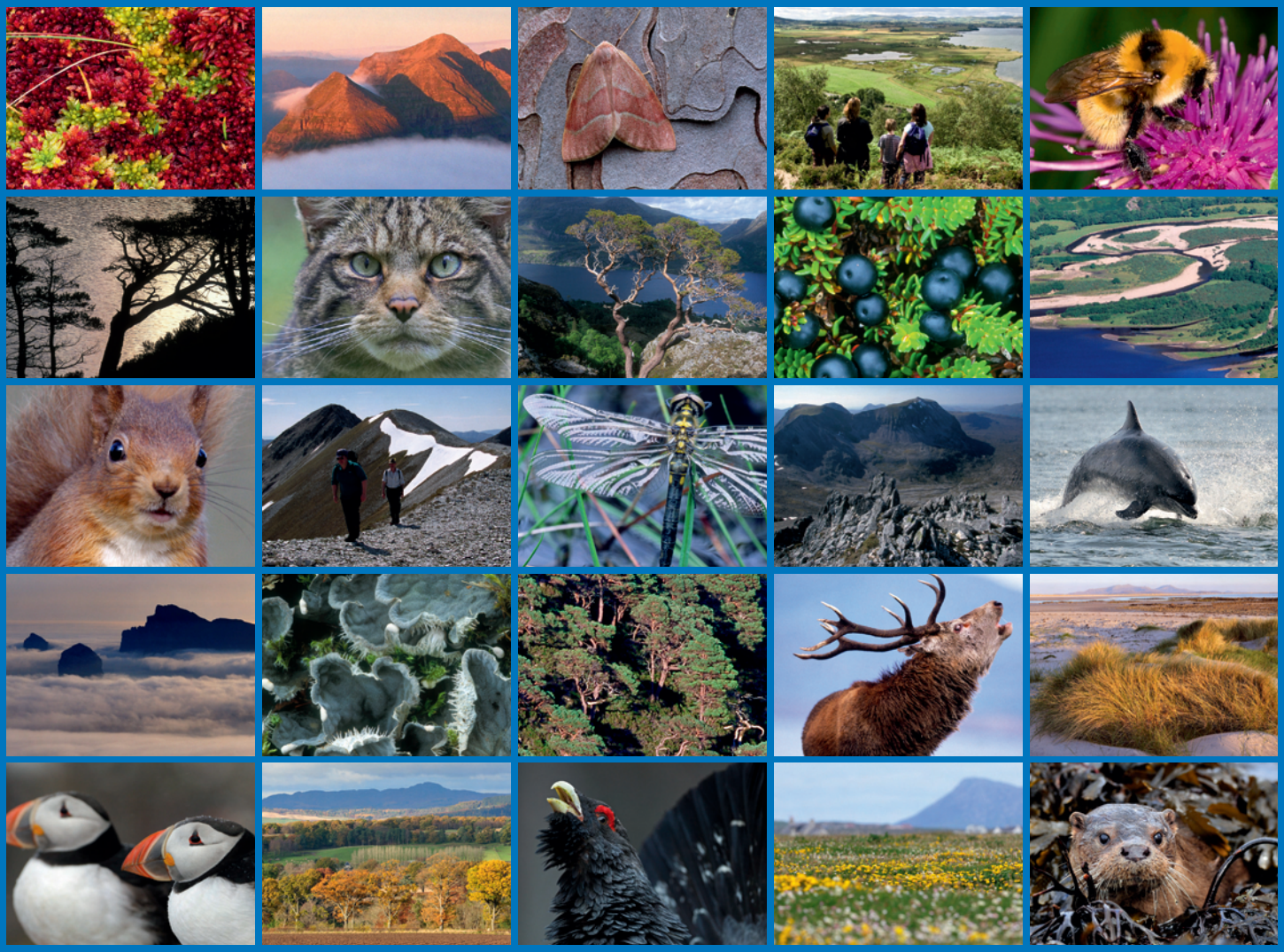
Scottish Natural Heritage
Commissioned Report No. 399

The Scottish Beaver Trial: Survey of fish populations 2008



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COMMISSIONED REPORT

Commissioned Report No. 399

The Scottish Beaver Trial: Survey of fish populations 2008

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COMMISSIONED REPORT

Summary

The Scottish Beaver Trial: Survey of fish populations 2008

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BACKGROUND

Argyll Fisheries Trust is undertaking electrofishing and redd count surveys of fish populations as one of a number of studies to inform the Scottish Beaver Trial of the effects of beaver activities on the natural environment. The surveys will inform the local management of the freshwater systems. Pre-release, baseline survey of fish populations at Knapdale was undertaken in late 2008.

MAIN FINDINGS

Three native species were recorded in the survey; brown trout (*Salmo trutta*), European eel (*Anguilla anguilla*) and stickleback (*Gasterosteus aculeatus*). Minnow (*Phoxinus phoxinus*) were also recorded at some sites.

Redd counts surveys of a sub-sample of habitats identified significant use of a wide range of habitat types for recruitment of salmonid fish within the trial area.

The following conclusions were reached:

- Some populations of juvenile brown trout may be derived from the migratory form, sea trout.
- Fish distribution and abundance is influenced by the accessibility and character of aquatic habitats within the trial area.
- In addition to the ongoing habitat surveys, further sampling of the fish populations is required to better inform the study.
- Assessment and review of the data is required to inform future work to ensure that sufficiently robust information is collected to detect significant change in the character of fish populations and habitats as a potential result of beaver activity.

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1 INTRODUCTION

In 2008 The Scottish Government issued a licence to undertake a trial reintroduction of European beaver (*Caster fiber*) at Knapdale in Argyll. The five year trial is to be monitored with a series of studies including that of the implications for the management of fish populations and fisheries.

1.1 European beaver and fish

The European beaver has been reintroduced to a number of countries that were part of its natural range prior to extinction. As a consequence, aspects of their natural behaviour, such as dam building have raised issues in relation to management of fisheries and water resources (Collen, 1997, Collen & Gibson, 2001, Kemp *et al.* 2010). Current published research indicate that potential for European beaver to impact on migratory salmonid fish (Atlantic salmon *Salmo salar* and sea trout *Salmon trutta*) and other native fish varies depending on geographical location, relief and habitat type (Rosell *et al.*, 2005). Loss of habitat penetration by migratory salmonids is described as insignificant (Parker & Ronning, 2007) or unclear (Halley & Lamberg, 2001) in two Norwegian studies and serious by another in Estonia during drought conditions (Tambets *et al.*, 2005). Other published studies also recognised potential for changes in fish habitats (Hartman & Tornlov, 2006) and fish assemblages due to changes in habitat type related to dam construction (Hagglund & Sjoberg, 1999). This five year study (2008 to 2013) aims to evaluate the response of all fish populations to the reintroduction of beaver at the trial site.

1.2 Fish studies at Knapdale

Native fish are a significant ecological and economic resource in Scotland. Therefore, it is important to identify the potential for beaver to affect fish populations at Knapdale during the trial period and provide data to inform decision makers in regard to the potential for wider reintroduction across Scotland. The surveys will inform the local management of the freshwater systems.

This report describes the initial investigations undertaken to assess the fish species, their distribution and their use of the range of aquatic habitats present in the trial area prior to the reintroduction of European beaver. This initial phase of the programme seeks to collect information that will inform future work and provide a useful baseline dataset. It should be noted that the narrow time period between the approval of the licence by the Scottish Government and the start of the Trial constrained the collection of comprehensive pre-release data. However, some of the findings of the 2008 study have also been compared with a similar study commissioned by Scottish Natural Heritage in 2002 (Kettle-White, 2002). Methods for the 2008 study are appraised in Section 7, with details of planned changes, where appropriate, for future surveys during the Trial.

2 METHODS

To assess the fish populations and their habitat use in the freshwater streams of the Knapdale trial area two survey methods were employed; sampling of fish by electrofishing (October 2008) and assessment of spawning activity of salmonid fish over a range of habitats by walk-over survey (December 2008). The electrofishing survey re-sampled sites originally investigated by Kettle-White (2002).

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. The surveys are designed to investigate the relatively shallow areas of flowing water (< 1m depth) present in the study area at Knapdale in which juvenile salmonid and other 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. The technique is also effective for non-salmonid species, but the shallow water habitats sampled may not reflect their preferences, which may change on a seasonal basis and therefore data may be less representative for such species.

Fish surveys were conducted in October 2008 during low-to-medium flow conditions with backpack electric fishing equipment, using smooth direct current between 200 and 350 volts to ensure sampling was effective. The voltage was varied depending on the conductivity, depth and flow of the water at each site; higher voltage was used in larger watercourses and lower voltage used in smaller watercourses to avoid damage to fish while maintaining effective sampling. All surveys (see below) were undertaken in accordance with the Scottish Fisheries Co-ordination Centre (SFCC) protocols. An assessment of the in-stream and riparian habitat characteristics were undertaken at each site (SFCC, 2007). Digital photographs were taken of each site to aid identification during future surveys (Appendix I).

Fully-quantitative sampling (i.e. each site fished three times over a known area) over a known area of stream were utilised to estimate the density of fish present within the site at the time of the survey. Where no fish were sampled during the first or second run, no further sampling was conducted. When data was collected by single-run (semi-quantitative) sampling or where the number of fish sampled was too few, estimates of minimum density of salmonid and other fish species was generated. To enable comparison between sites, minimum estimates of fish density are used throughout the text.

Captured fish were anaesthetised prior to being identified to species level and measured for length. Scale samples were removed from a small 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. Other non-salmonid species were recorded for length only.

2.1.1 Classification of fish abundance

Densities of fish were calculated separately for fry (young of the year; 0+ years) and parr (juveniles that have spent at least one winter in freshwater; 1+ years, 2++ years or more, but have not yet been to sea) for salmonids. Estimates of minimum density for non-salmonids were also 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) for West of Scotland Region (Table 2.1).

Table 2.1 Quintile ranges for juvenile trout (no. fish per 100m²) for West of Scotland region

Min. Percentile	River Width Class				
Trout fry (0+)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
No fish					F
0th	1.4	0.7	0.5	0.2	E
20th	9.9	3.0	1.1	0.8	D
40th	28.5	5.0	1.8	1.5	C
60th	44.7	12.4	2.7	2.6	B
80th	74.4	19.0	5.3	4.0	A
100th	181.3	103.5	94.6	9.8	
Trout parr (1++)	**<4m**	**4-6m**	**6-9m**	**>9m**	**Class**
No fish					F
0th	0.9	0.9	0.8	0.5	E
20th	3.9	2.3	1.5	0.7	D
40th	5.6	3.3	2.1	0.9	C
60th	7.6	5.4	3.2	1.5	B
80th	12.1	8.4	4.9	1.8	A
100th	66.7	30.3	10.8	6.0	

This classification system compares minimum fish abundance sampled at 185 sites in the West of Scotland and places abundance into six quintile ranges according to stream width at the survey site. Classes A through to E are given for abundance within each quintile range and class F represents an absence of fish as described for the national classification scheme developed for England and Wales (National Rivers Authority, 1994). The 100th percentile represents the highest density found at any one of the 185 sites compared.

2.1.2 Survey sites

A total of 14 survey sites were sampled in 2002 on the basis of their distribution in three catchments in the trial area (Table 2.2); Lochs Linne, Coille-Bharr / Barnluasgan and Creagmhor. Sites sampled were representative of the variety of nursery habitat available to salmonid fish in three categories; afferent (in-flowing) streams to freshwater lochs (AF), efferent (out-flowing) streams to freshwater lochs (EF) and efferent streams flowing into marine habitats (EM). The survey undertaken in 2008 repeated sampling at 13 of the original 14 sites as no suitable habitat for fish was identified at site 9 in the 2002 survey. The surveys sampled a representative area of stream habitat less than one meter deep to include the variety of habitat present, such as pool and riffle flow sequences, but were limited to small areas at some sites due to limited habitat availability.

Table 2.2 Electrofishing survey sites sampled in 2002 and 2008

Site	Catchment	Category	Easting	Northing	Altitude (m)	Avg. width (m)	Site length (m)	Area sampled (m^2)
1	Linne	AF	180052	691000	40	0.5	50	25
2	Linne	AF	180010	691446	39	0.7	50	35
3	Linne	AF	179920	691465	42	0.4	20	8
4	Linne	AF	179969	691442	40	0.6	100	60
5	Linne	EM	179243	690418	38	2.2	34	75
6	Linne	EF	180055	691010	52	0.3	20	6
7	Linne	EF	179513	690478	45	0.7	40	28
8	Linne	EF	179234	689951	65	0.4	50	18
9*	Creagmhor	AF	180545	691290	66	0.2	10	2
10	Creagmhor	EF	180166	690757	65	1.0	53	53
11	Coille-Bharr	AF	178494	690669	37	1.9	41	78
12	Coille-Bharr	EF	178901	690936	49	2.0	61	122
13	Coille-Bharr	EM	177683	689705	28	3.7	34	126
14	Barnluasgan	AF	179506	691495	36	0.7	37	26

** Site not sampled in 2008*

2.2 Redd count surveys

In late November and early December 2008 a walkover survey was undertaken on a sub-sample of the habitats present within the trial area. The aim of the survey was to identify the distribution of spawning habitat being utilised for recruitment by salmonid fish in these habitats through the recording of nest or 'redd' sites. The data was also required to provide background information for interpretation of electrofishing survey data. A map-based estimate of the amount of habitat surveyed was also undertaken to provide estimates of redd density, which may be compared between survey sites.

The survey technique was founded on the basic elements of the SFCC habitat survey protocols and undertaken by walking upstream during low and clear flow conditions. Redds were identified as a depression (pot) in the stream bed lying at the head of a slightly raised area of excavated material (tail) (Ottaway *et.al.,* 1981*)*. The location of active spawning sites were recorded (six figure grid reference by hand-held GPS) as were the number and relative

size of redds observed at each site (Table 2.3). The size of each redd was categorised from the estimated area of the pot only.

Table 2.3 Size categories of redds

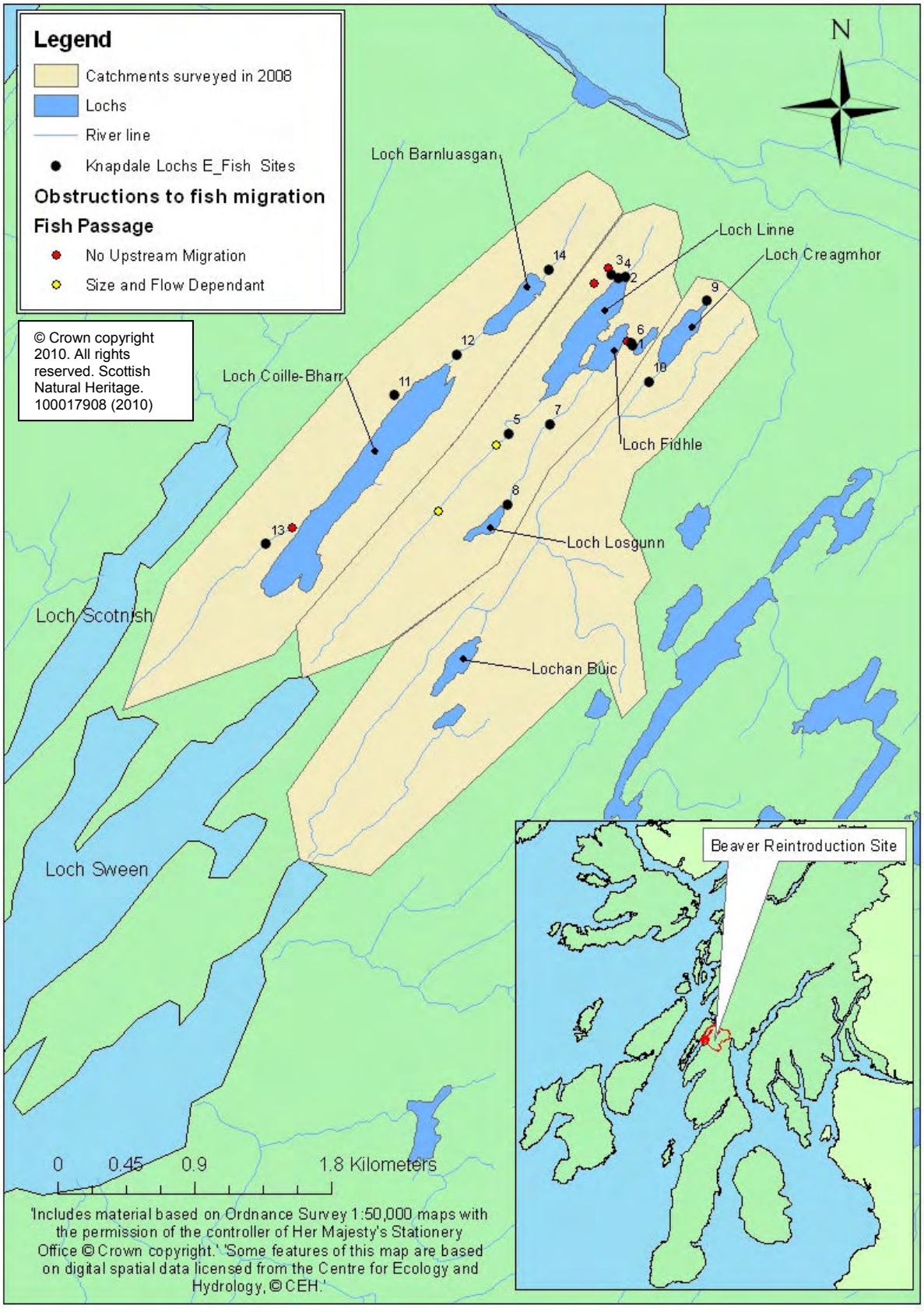
Category	Area (m²)
Small	<0.5m²
Medium	>0.5 and <1m²
Large or composite	>1m²

Information on site characteristics which were associated with spawning habitat was also recorded; stream width, in-stream situation of redds and other features, such as woody debris. Information on the location (100km O.S. grid reference) and area of habitat surveyed are given in Table 2.4 and Figure 2.1.

Table 2.4 Spawning habitat survey site description

Survey			**Start Downstream**		**End Upstream**		
Site	**Loch system**	**Category**	**Northing**	**Easting**	**Northing**	**Easting**	**Length (m)**
A	Barnluasgan	EF stream	178842	690858	178980	691009	300
B	Barnluasgan	AF loch	179385	691264	179196	691068	300
C	Linne	EM stream	177992	688932	179279	690450	2,000

Figure 2.1 Electrofishing & spawning habitat survey locations



3 RESULTS

3.1 Electrofishing survey

The results of electrofishing sampling of salmonid and other fish species are given separately below.

3.1.1 Salmonid fish

Of the 13 electrofishing surveys conducted, brown trout were found at eight sites. At sites where brown trout were present, fry (young of the year) were found at seven sites while parr (fish older than one year) were sampled at six sites. Both fry and parr together were sampled at five sites. Fully-quantitative estimates of trout density (number of fish per 100m² of wetted stream bed) with a 95% confidence interval (C.I.) were established by catch depletion over three fishing runs (Zippen, 1956) at three sites (sites 5, 10 and 13) while the relatively low number of fish sampled at five others (sites 2, 7, 11, 12 and 14) meant that only minimum estimates of abundance were obtained from one fishing run (Table 3.1 and Figure 3.1). Atlantic salmon were not found at any of the sites surveyed and no fish of any species were found at five sites (sites 1, 3, 4, 6 and 8).

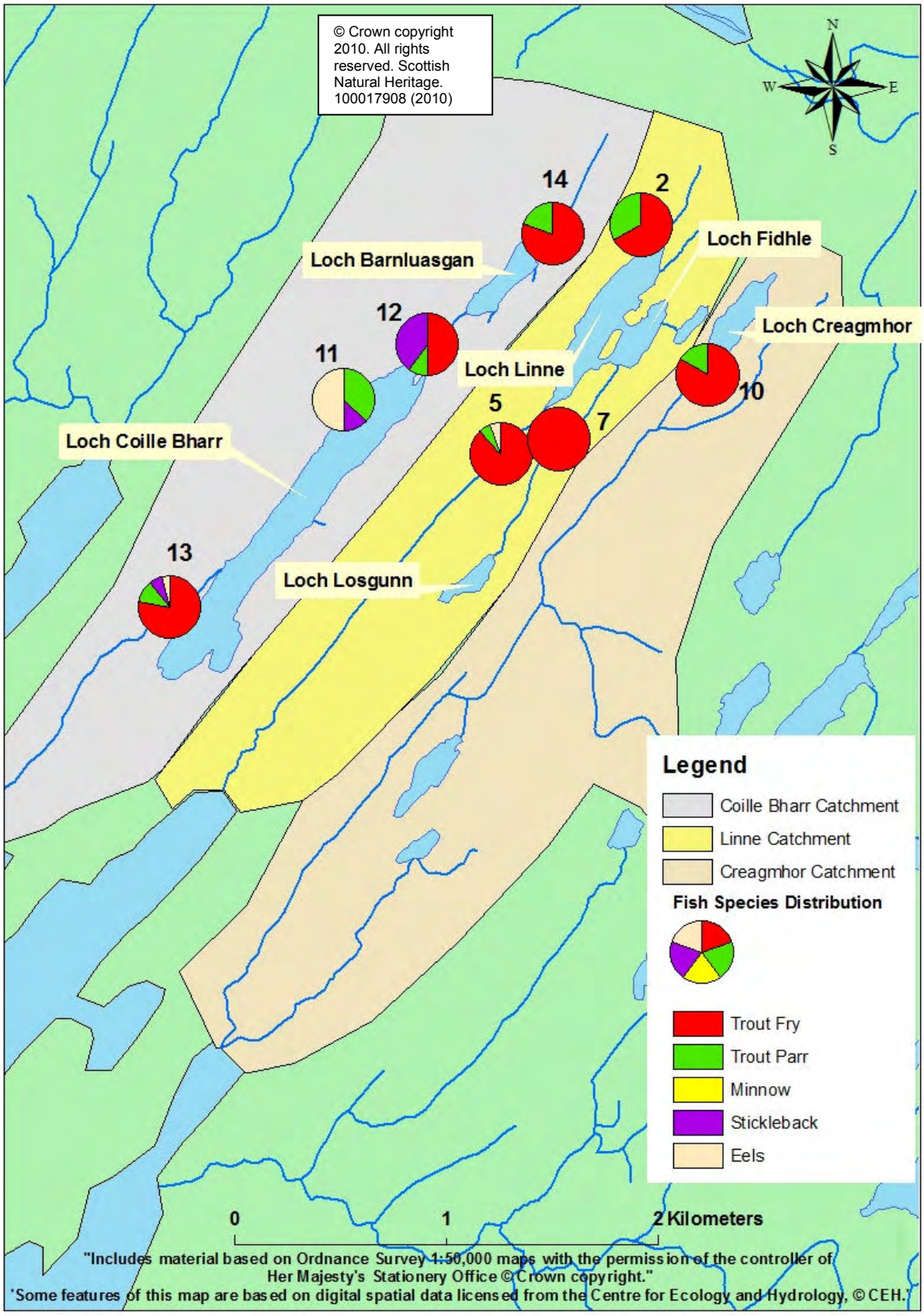
Table 3.1 Electrofishing survey results for brown trout (no. of fish per 100m²), 2008

Site No.	Fry (0+) est.	Fry 95% C.I.	Fry min. est.	SFCC Grade	Parr (1+&2++) est.	Parr 95% C.I.	Parr min. est.	SFCC Grade	Total est.	Total 95% C.I.	Total min. est.
1	0			F	0			F	0		
2			5.71	E			2.86	E			8.57
3	0			F	0			F	0		
4	0			F	0			F	0		
5	55.37	2.02	54.81	B			2.67	E	57.99	1.90	57.49
6	0			F	0			F	0		
7			17.86	D			0	F			17.86
8	0			F	0			F	0		
9*											
10	9.49	0.72	9.43	E			1.89	E	11.36	0.59	11.32
11	0			F			3.85	E			3.85
12			5.35	E			0	F			5.35
13	39.11	2.28	38.16	C	7.33	0.99	7.15	C	46.44	2.48	45.31
14			11.31	D			7.54	C			18.86

9* not sampled in 2008

Where present, minimum estimates of fry abundance ranged from less than 6 to 55 fry per 100m² of stream sampled. The highest densities of trout fry were found at sites 5 (grade B) and 13 (grade C). Lower densities of fry were found at sites 7 and 14 (grade D) and 2, 10, and 12 (grade E). Where present, minimum estimates of parr abundance ranged from less than 2 to 8 parr per 100m² of stream sampled. The highest densities of trout parr were found at sites 13 and 14 (grade C). Lower densities of parr (grade E) were found from four other locations; sites 2, 5, 10 and 11.

Figure 3.1 Fish distribution and relative abundance (minimum number per 100m²)



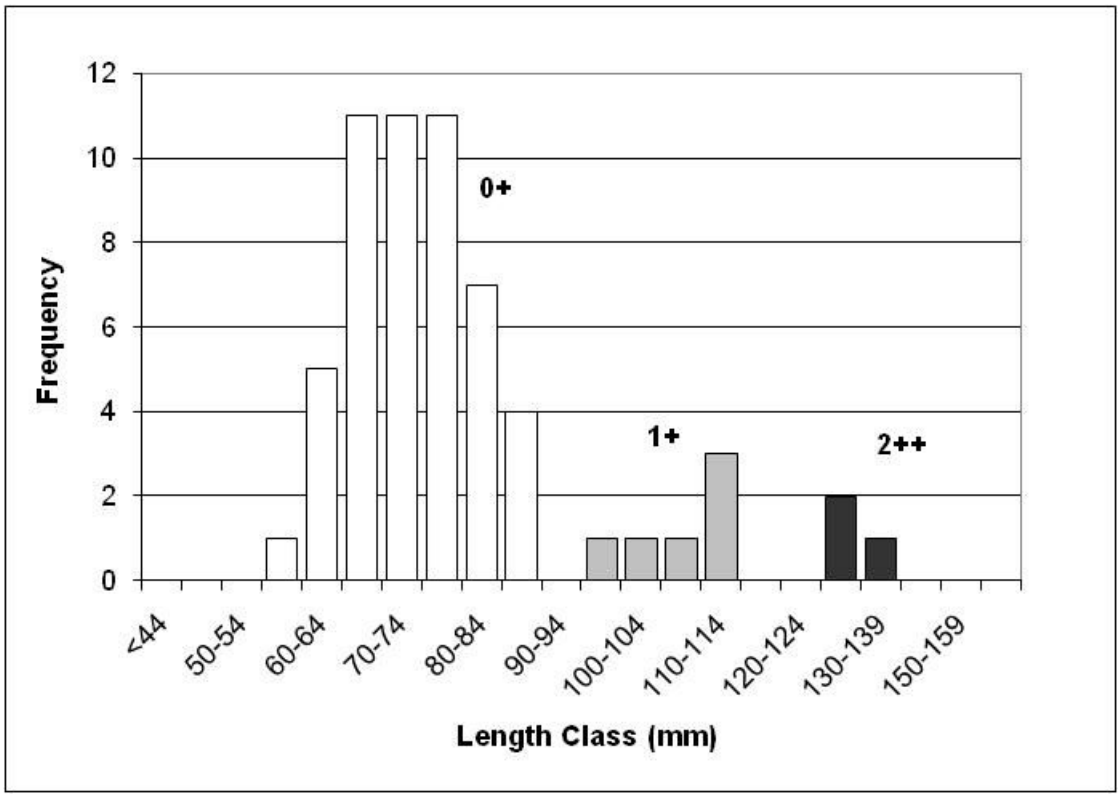
The mean length at age for trout is given in Table 3.2. An example of the length-frequency distribution for trout where all three age classes were found (site 13) is given in Figure 3.2.

Table 3.2 Frequency and length at age of brown trout (2008)

	fry (0+)			parr (1+)			parr (2++)		
Site	**No.**	**Mean Length (mm)**	**Length Range (mm)**	**No.**	**Mean Length (mm)**	**Length Range (mm)**	**No.**	**Mean Length (mm)**	**Length Range (mm)**
2	2	52	42-61	1	85		0		
5	40	67	47-80	2	97	93-100	0		
7	5	70	68-79	0			0		
10	5	57	51-70	1	103		0		
11	0			3	110	103-118	0		
12	6	81	70-94	0			0		
13	48	74	59-88	6	108	98-114	3	130.33	128-135
14	4	76	70-86	1	100		0		

A total of 110 trout fry (0+) were sampled at seven sites with the mean length ranging from 52mm at site 2, to 81mm at site 12. A total of 14 one-year-old trout parr (1+) were sampled at six sites with the mean length ranging from 85mm at site 2, to 110mm at site 11. Three trout parr of older than one year were sampled at site 13 with a mean length of 130mm.

Figure 3.2 Fish length (mm) at age frequency distribution at site 13 (2008)



3.1.2 Non-salmonid fish

Three species of fish other than trout were sampled at five sites (Table 3.3). European eel were sampled at three locations (sites 5, 11 & 13) and three-spine sticklebacks were sampled at three locations (sites 11, 12 & 13). One translocated species (non-native); minnow, was also sampled at three locations (sites 5, 7 and 12).

Table 3.3 Electrofishing survey results for other species (min. no. of fish per 100m²)

Site No.	Category	Eel	Length Range (mm)	Stickleback	Length Range (mm)	Minnow	Length Range (mm)
5	EM	4.0	110-220	0		1.3	72
7	EF	0		0		14.3	62-68
11	AF	5.1	115-230	1.3	52	0	
12	EF	0		3.3	30-38	8.2	40-72
13	EM	2.4	96-110	4.0	30-45	0	

Where present, minimum density estimates of European eel ranged between 2.4 and 5.1 per 100m² and stickleback ranged from 1.3 to 4.0 per 100m². Minnow abundance ranged between 1.3 and 14.3 per 100m².

3.1.3 Comparing fish abundance 2002 and 2008

The minimum density of juvenile trout sampled in the 2002 and 2008 surveys are compared between individual sites using grades of relative density (Table 3.4) according to the SFCC classification scheme.

Table 3.4 Classification of trout abundance for habitat category (2002 and 2008)

Site No.		Trout fry (0+)		Trout Parr (1+ & 2++)	
	Category	**2002**	**2008**	**2002**	**2008**
1	AF	F	F	F	F
2	AF	F	E	F	E
3	AF	F	F	F	F
4	AF	F	F	F	F
9	AF	F	*	F	*
11	AF	F	F	F	E
14	AF	F	D	F	C
6	EF	F	F	F	F
7	EF	**	D	**	F
8	EF	F	F	F	F
10	EF	F	E	F	E
12	EF	F	E	F	F
5	EM	B	B	D	E
13	EM	B	C	D	C

Site 9* not sampled in 2008 and site 7** not sampled in 2002

For interpretation, when compared to 185 other sites sampled in the region, grade F represents an absence of fish, grades D and E represent low to very low abundance respectively. Grades C and B represent moderate to high abundance respectively and grade A represents very high.

3.1.3.1 Afferent freshwater (AF) sites

In the seven survey sites sampled in afferent streams flowing into freshwater lochs (AF), trout fry were sampled in relatively low abundance at two sites in 2008; sites 2 (grade E) and 14 (grade D). Trout parr were sampled at three of the seven sites at low-to-moderate abundance in 2008; sites 2, 11 (grade E) and 14 (grade C). No fish were sampled at these sites in 2002.

3.1.3.2 Efferent freshwater (EF) sites

In the five sites sampled in efferent streams flowing between freshwater lochs (EF), trout fry were sampled in relatively low abundance at three sites in 2008; site 7 (grade D) and sites 10 & 12 (grade E). Trout parr were sampled at one of the five sites at low abundance in 2008; site 10 (grade E). No fish were sampled at these sites in 2002.

3.1.3.3 Efferent marine (EM) sites

In the two sites sampled in efferent streams flowing into the marine Loch Sween (EM), trout fry were sampled in moderate-to-high abundance at both sites in 2008; site 5 (grade B) and site 13 (grade C). The 2002 survey also observed trout fry at both these sites (grade B), indicating a slightly lower abundance of fry at site 13 in 2008 compared to 2002. Trout parr were also sampled at both sites at low-to-moderate abundance in 2008; site 5 (grade E) & site 13 (grade C). The 2002 survey also observed trout parr at these sites (grade D), indicating a slightly lower abundance of parr at site 13 and a higher abundance at site 5 in 2008 compared to that sampled in 2002.

3.1.3.4 Habitat characteristics at sampling sites

The information on in-stream habitat characteristics collected at electrofishing survey sites; the channel, water depth and flow type, in-stream substrates and riparian habitat are summarised in Table 3.5.

Table 3.5 Summary of habitat characteristics of electrofishing survey sites

	Site		Water Depth	Flow Type		In-stream Features	
No.	**Category**	**Wet width (m)**	**(% > 11cm)**	**Run/riffle (%)**	**Dominant substrate**	**Bed mobility**	**Fish cover**
1	AF	0.5	10	40	organic silt	stable	poor
2	AF	0.7	10	50	pebble/cobble	stable	moderate
3	AF	0.4	20	30	bedrock/gravel	stable	poor
4	AF	0.6	0	80	bedrock	stable	poor
5	EM	2.2	60	70	pebble/cobble	stable	good
6	EF	0.3	0	20	organic silt	stable	none
7	EF	0.7	80	5	organic silt	stable	none
8	EF	0.4	10	10	silt/sand	stable	none
9	AF	0.2	0	0	organic silt	stable	none
10	EF	1.0	70	10	gravel	stable	poor
11	AF	1.9	70	80	cobble/boulder	stable	moderate
12	EF	2.0	40	50	cobble/boulder	stable	poor
13	EM	3.7	70	70	cobble/boulder	stable	good
14	AF	0.7	70	20	gravel/pebble	stable	moderate

Riparian habitats at most sites consisted of native broadleaf trees, grasses and tall herbs, with the exception of two sites (8 & 11) which were dominated by the features of the general land use; commercial conifer forestry. The stream morphology at a number of sites (5, 7, 8, 12 & 14) appeared to be modified (straightened), probably undertaken to improve drainage of forestry plantations and to accommodate forestry track infrastructure. All in-stream substrates at survey sites appeared to be stable.

In-stream habitats were more variable with different characteristics within each of the habitat types; efferent marine (EM) sites (5 & 13) were the largest stream habitats; 2.2 and 3.7m wet width respectively, which had diverse flow characteristics; 60 and 70 % of water was over 11cm depth respectively and 70% of the flow type was of broken water run and riffle type. In–stream substrates consisted of stable pebble, cobble and boulder associated with productive salmonid fish habitats.

In-stream habitat at three afferent freshwater (AF) sites (2, 11 & 14) had a relatively moderate level of fish cover; pebble, coble and boulder, while in-stream habitat that had a relatively poor level of fish cover (small substrates) was observed at a mix of categories; three afferent freshwater (AF) sites (1, 3 & 4) and two efferent freshwater (EF) sites (10 & 12). In-stream habitat that had little or no cover for fish (organic sediments) was also observed at a mix of categories; one afferent freshwater (AF) site (9) and three efferent freshwater (EF) sites (6, 7 & 8).

3.2 Redd count survey

Approximately 2.3km of streams and 300m of loch shore were surveyed in three locations covering an area of 4,520m² of wetted habitat. A total of 40 spawning sites containing 136 redds were observed in the survey with variation in the relative estimates of the density of redds per 100m² in each of the locations (Table 3.6 and Figure 3.3).

Table 3.6 Spawning habitat survey results (density = minimum no. of redds per 100m²)

Site	Habitat surveyed			No. of redds				
	Width (m)	Length (m)	Area (m²)	No. of spawning sites	Large	Medium	Small	Density ($100m^{-2}$)
A	1.6	300	480	11	0	0	66	13.8
B	0.8	300	240	2	0	0	3	1.3
C	1.9	2000	3800	27	1	44	22	1.8

3.2.1 Redd distribution and abundance

Redds were observed in all of three survey sections (Table 3-6). The distribution of different sizes of redds are described below.

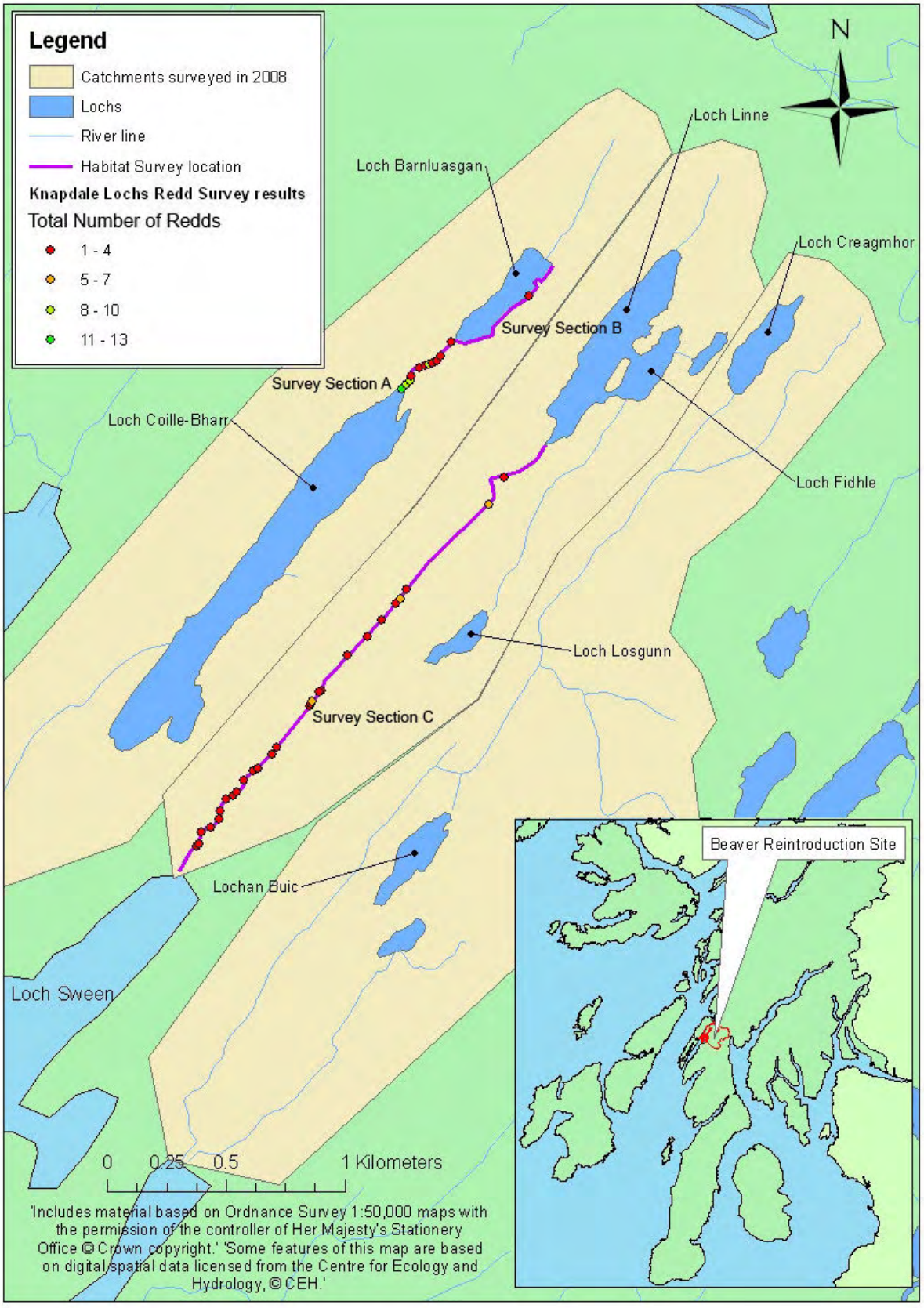
3.2.1.1 Small sized redds

A total of 91 small redds (<0.5m² area) were recorded during the survey and were distributed throughout all three survey sections. The number of small redds observed in relation to the area of habitat surveyed varied from relatively low at site B (three redds) and site C (22 redds) and relatively high abundance at site A (66 redds).

3.2.1.2 Medium and large sized redds

A total of 44 medium sized redds (>0.5 and <1m²) were observed at site C, but were not observed in sections A or B during the survey. One large or composite redd (>1m²) was observed in section C during the survey. The numbers of small redds observed in relation to the area of habitat surveyed varied from relatively low density at sites B and C (1.3 and 1.8 redds per 100m² respectively) and relatively high abundance at site A (13.8 redds).

Figure 3.3 Distribution of spawning habitat and redd density (no. of redds per 100m²)



4 DISCUSSION

The findings of the fish and habitat surveys are discussed below in relation to each other and the trial reintroduction of European beaver.

4.1 Fish distribution

The fish species sampled in the survey; brown trout, European eel and three-spine stickleback are amongst those expected in relation to their natural range and the recorded habitat types. The exception would be minnow (Maitland & Campbell, 1992), which are probably not native to this region of Scotland and are likely to have been translocated by anglers. The reasons for the translocation of minnow are the transport of live minnows to the water to use as bait, and the release of any minnows surplus to requirements, and attempts to establish populations of minnows in the belief that these will provide useful feeding for trout. The introduction of any fish into inland waters without appropriate license was recently made illegal.

The absence of Atlantic salmon from sampling sites accessible from the sea is likely to be due to the relatively small size of the catchments surveyed. They may not be sufficient to support the number of juveniles and smolts necessary to sustain a viable population, particularly when rates of marine survival are relatively low. Alternately, it is possible that juvenile salmon and other native species, such as flounder (*Platichthys flesus*) and lamprey (*Lampetra* spp.), may be present at low density in some locations but were not detected during this survey.

The absence of wide-spread species such as juvenile brown trout in some of the sampling locations is likely to be as a consequence of a number of potential factors; the accessibility of adult fish from favoured habitats (sea or lochs), the habitat suitability for recruitment of juveniles or the seasonal use of habitats (e.g. emigration of juveniles from the site prior to survey).

Trout and other species were not sampled at a number of sites in either the 2008 or the 2002 survey indicating that these sites may not have suitable or accessible habitat or fish were simply not present during the survey period. Further sampling at these and other sites is required to establish the factors controlling fish distribution.

Trout fry were recorded in four locations in 2008 where they were not found to be present in 2002, which may be an artefact of sampling error or reflect potential for seasonal variation in habitat use. The 2002 survey was undertaken in late December when water temperature was below the recommended 8ºC (SFCC, 2007), potentially reducing the effectiveness of the sampling technique and increasing the potential for sampling error. The 2008 survey, conducted in mid-October when water temperature was above 8ºC found fry in more locations than in 2002, but where present in both 2002 and 2008, fry numbers were relatively similar in sites 5 and 13. There is also potential for some habitats to be used for a limited period of time; such as spawning and early life-stage (fry) development of trout or diurnal use of habitats. Similarly, stickleback and minnow may also potentially utilise these habitats for recruitment in the summer months and possibly as shelter from larger fish on a seasonal basis, as will eels for feeding.

4.2 Fish abundance and habitat characteristics

The findings of fish and spawning habitat surveys are discussed in relation to the type of habitat sampled.

4.2.1 Fish abundance at efferent marine (EM) sites

The habitat conditions at the efferent marine category (EM) sites are generally favourable for salmonid fish (depth variation, stable flow and coarse in-stream substrates) with additional benefit from the stability of efferent water flowing from freshwater lochs. The freshwater lochs, acting as reservoirs, decrease the higher peaks of flow during spate events and reduce potential for dewatering of habitats during drought events. Additionally, the potential for improved access of larger sea-run adult fish at these sites is also likely to foster a higher abundance of juveniles in suitable habitats compared to that observed in sites not accessible from the sea.

When compared to SFCC classifications of West coast juvenile fish abundance, trout fry at the efferent marine sites were classed as moderate to high abundance. The wide distribution and size of redds observed during the spawning habitat survey of Loch Linne efferent streams also indicate that spawning activity is likely to be influenced by larger adults. These redds are potentially constructed by sea-run trout as these sites are easily accessed from the sea, although there does not appear to be any significant obstacle to restrict access to these same sites by resident trout from Loch Linne either. Eel, stickleback and minnow were also sampled from this type of habitat, but their abundance was much lower than that of juvenile trout. This is likely to be an artefact of the turbulent and relatively high flow conditions in these habitats that are preferred spawning and nursery habitat for trout.

4.2.2 Fish abundance at afferent freshwater (AF) sites

The habitat conditions at the afferent freshwater category (AF) electrofishing survey sites are generally less favourable for salmonid fish compared to other habitats sampled. Generally, with the exception of site 11, they share common characteristics; small wet width, shallow variable flow and fine in-stream substrates that are all likely to be a contributory factor to the relatively patchy distribution and low abundance of salmonid fish. The lack of sufficient flow carried by such small streams may not allow access to spawning adults (from freshwater lochs) in the autumn. Additionally, a higher potential for dewatering of juvenile habitat during drought events, is likely to influence fish survival and distribution on a seasonal or annual basis. Access issues may also be exacerbated by modifications to the watercourses, such as channel straightening and the presence of obstacles where tracks cross watercourses.

Eel and stickleback were sampled at one afferent freshwater site (site 11), which was the third largest watercourse sampled. The stability of flow present in a larger sub-catchment is likely to provide more stable habitat than smaller streams, but comparison between 2008 and 2002 data indicate that this site may display variation in the fish population year-to-year or only be utilised on a seasonal basis.

4.2.3 Fish abundance at efferent freshwater (EF) sites

Habitat data collected at efferent freshwater fish survey sites indicate that this type of habitat has been affected by channel modification (channel straightening and associated forestry drainage). In general, in-stream characteristics are not favourable for salmonid fish; such as relatively shallow flow with fine in-stream substrates, but relatively stable flow compared to the afferent freshwater category (AF) sites is potentially beneficial for maintaining wetted habitat during drought events.

Despite the patchy distribution and relatively low number of juvenile trout sampled in these habitats, the number of redds observed in the stream efferent of Loch Barnluasgan during spawning habitat surveys indicate that this type of habitat is of importance to loch-based

trout populations. Therefore it is likely that trout utilise this type of habitat, particularly for spawning and early fry development with few or no fish over-wintering in these habitats.

Stickleback and the highest abundance of minnow were sampled in this type of habitat indicating that the slower and less variable flow associated with much of this habitat type is suitable for these species. Where present, the density of minnow was similar or higher than that of trout at the efferent freshwater sites indicating that freshwater loch habitats host significant populations of minnow. It is likely that minnow that share such habitats with juvenile trout will compete for limited resources to the detriment of the productivity of native species (Larsen *et al.*, 2007).

4.3 Fish abundance and sampling error

The location and seasonal timing of sampling (i.e. late autumn and winter) undertaken as part of this study is unlikely to reflect the full range of habitats utilised by the fish species found in this survey. Some survey sites may not be located in the preferred habitat type for these species during the sampling period and others may have suitable habitat, but are not accessible. For instance, young-of-the-year trout are likely to disperse away from spawning sites over time after emergence from a redd in the late spring due to competition for limited resources and therefore the relative abundance of fry found at a site will be influenced by the relative distance of the survey site from the nearest spawning site and the timing of the survey.

5 IMPLICATIONS FOR THE MANAGEMENT

The information on fish distribution, abundance and spawning activity collected in the 2002 and 2008 surveys provide some very preliminary indication of the implications for the management of fish populations in relation to the trial reintroduction of beaver to the Knapdale area. However, a more detailed assessment will be provided at the end of the Scottish Beaver Trial once beavers have been on site for five years.

5.1 Fish species

The fish species sampled in the survey; brown trout, European eel and three-spine stickleback have value as part of local biodiversity, particularly brown trout and the migratory form, sea trout, which are listed as locally important species in the Local Biodiversity Action Plan (Argyll & Bute Local Biodiversity Partnership, 2002). There are also other fisheries related legislation in regard to the passage of migratory fish (sea trout) that may, or may not, have implications for management of dams created by beaver activity.

5.2 Fish distribution

Salmonid fish require access to a range of habitats during their life-cycle, including both freshwater and marine habitats in the case of sea trout. While limited research has been undertaken in areas where the distribution of beaver and migratory salmonids overlap, there is some reference to practical management of beaver in relation fish distribution (Halley & Bevanger, 2005). Therefore, it is possible that the accessibility of fish to habitats will be a significant management issue that may need to be addressed during the trial period.

The Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 requires the Argyll District Salmon Fishery Board maintain the natural range of Atlantic salmon and sea trout as part of its statutory duties and powers. There is potential for beaver to construct dams in watercourses where the data collected during the survey indicates that the habitat may be utilised by sea trout; the Loch Coille-Bharr and Loch Linne efferent streams. Brown trout have similar requirements to sea trout and connectivity between loch and stream habitats are essential to maintain the productivity of the loch-based population and the performance of the fishery. Currently there is little or no data to assess potential changes in fishery performance over the study period. Additionally, the loch-based fishery for brown trout receives supplemental stocking of adult trout sourced from outside of the catchment.

Therefore, identifying and managing issues on the basis of fishery performance is unlikely to be possible. Potential issues affecting fishery target species (brown and sea trout) arising from the reintroduction of beaver are consequently likely to be identified from the study of fish populations and their habitats if they occur.

Potential fish access issues arising during the trial period will require resources if such issues are to be managed effectively and data collected to illustrate the relative effectiveness of management solutions. This will be addressed through the regular monitoring of beaver activities (e.g. by the Scottish Beaver Trial field officers based at Knapdale) and liaison between SNH and its independent monitoring partners, Argyll District Salmon Fishery Board, the Scottish Wildlife Trust and the Royal Zoological Society of Scotland, and other relevant parties.

It will be important to observe beaver behaviour in relation to the construction of dams, investigate fish passage issues and measure changes in the distribution and abundance of each component of the fish community. The Scottish Beaver Trial is required to contact SNH as per licence condition 24 in all instances of dam construction; this information will be passed to Argyll Fisheries Trust. Identification of fish passage issues is likely to be

determined by the programme of river habitat monitoring being undertaken by the University of Stirling during the trial period.

The potential management activities and techniques required to resolve or manage fish passage issues are likely to require investigation which is outside of the remit of the current study.

5.3 Fish abundance and habitat characteristics

The recruitment of salmonid fish requires a range of habitat characteristics, particularly for the early phases; spawning, egg incubation and pre-emergent fry. The availability of spawning-grade substrates and the flow of oxygen-bearing water to sustain ova and yolk-sac fry during incubation are essential to maintain viable populations. The survey data gathered to date indicate that fish are using a wide range of habitats within the trial area, some of which appear to have been modified by land use. Therefore, it will be important to better understand the factors currently affecting the productivity of freshwater habitats at an early stage of the trial period.

6 CONCLUSIONS

Interpretation of the data collected by fish and spawning habitat surveys in 2002 and 2008 provide a number of conclusions to this early phase of the study.

6.1 Fish species

Fish surveys undertaken at 14 sites across three catchments sampled three native fish species; brown trout, European eel, and three-spined stickleback. One translocated species was also sampled; minnow. Other native species may also be present; lamprey and potentially Atlantic salmon, but they were not recorded by this survey.

6.2 Fish distribution

Brown trout were sampled from all three catchments surveyed, but were not present in all sites. Some of the sites where trout were not sampled may potentially be utilised outside of the sampling period. A number of survey sites appeared to be unsuitable for juvenile salmonid fish due to unfavourable habitat condition. Electrofishing data suggest that eel and minnow are present in two of the three catchments and sticklebacks in one, but this may be an artefact of the location and distribution of sampling and these species may be more widespread. Information from future loch-based sampling of fish populations, due to commence in 2010, will also contribute to the data collected in stream surveys.

6.3 Fish abundance

Where present, juvenile trout abundance generally varied between low and moderate levels when compared to the SFCC classification scheme which compares this data with data from sites of a similar stream width in the west of Scotland region. Low density populations were sampled at five sites associated with streams adjacent to freshwater loch habitats, while moderate densities were sampled at two sites that were accessible from the sea indicating that migratory ‘sea’ trout may utilise these habitats for recruitment.

6.4 Salmonid fish spawning habitat

Walkover surveys of a sub-sample of habitats observed that trout redds were widely distributed in stream habitats, but were only present in loch habitats at stream confluences. Redds were present at a high density where spawning habitat was accessible to adult fish and the area of suitable habitat was relatively small. Large redds were observed in habitats potentially accessible by sea trout.

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 in relation to filling knowledge gaps and future work.

7.1. Electrofishing surveys

The results of the electrofishing survey provided adequate data to identify the fish species present at sampling sites and an indication of their relative abundance at the time of survey.

7.2. Redd count surveys

The data collected in the limited spawning habitat survey successfully identified habitats that were being used for the recruitment of salmonid fish at the time of survey. This information also provided supporting information for the interpretation of electrofishing data. Although, a standardised SFCC survey protocol is not yet established for redd counting, an experienced surveyor may provide very useful information. Further use of the technique appears to have potential benefits for better understanding the full range of habitats required by salmonid fish to complete their life-cycle. There may be potential to develop a survey protocol through the partners of SFCC in future.

7.3. Future work

At present there are gaps in our understanding of a number of fish species and habitats.

7.3.1 Fish populations

In addition to the fish sampling already undertaken, repeat and additional electrofishing and redd surveys will be done in 2009. The methods will be reviewed during the Trial period to ensure the work is appropriately targeted. It is anticipated that this will continue to the end of the 2013 trial period to assess changes in fish assemblages and their relative abundance over time. Further details will be provided in the 2009 survey report. To provide comparative data for electrofishing surveys, data from a number of control survey sites will also be provided by Argyll Fisheries Trust over the study period.

7.3.2 Fish habitats

A range of other monitoring projects are underway as part of the Scottish Beaver Trial. They include:

Beaver ecology - Standardised monitoring protocols have been developed. Field data will be collected by the Scottish Beaver Trial field officers, and then provided to SNH and Oxford University Wildlife Conservation Research Unit for annual analysis and interpretation.

River habitat - Baseline data on the fluvial geomorphology and river habitat of the streams of Knapdale has been undertaken, and monitoring will be ongoing. The approach used is based on both a standard application of the River Habitat Survey methodology and a bespoke geomorphic assessment.

Hydrology - Stage boards and automatics loggers have been set up at Knapdale and monitoring will be ongoing.

Aquatic macrophytes - A baseline survey of macrophytes has been undertaken and monitoring will be ongoing.

Water chemistry - Monthly samples are being collected from nine sites around Knapdale. Laboratory analyses are being undertaken by SEPA.

Monitoring for woodland, public health, otter, Odonata and other elements are also being undertaken. Details for all the above will be published during the trial.

In addition to completing the spawning habitat surveys (redd counts) for all catchments within the trial area as part of this project, the additional monitoring projects listed above will also provide a wider understanding of the character of freshwater habitats within the trial area.

7.4 Assessment and review

Establishing baseline and temporal information with sufficient robustness to detect significant change in the character of fish populations and habitats as a result of beaver activity will require on-going assessment and review. Consultation with a number of centres of expertise will provide additional input to the survey design that will provide the best chance of achieving the aims of the work programme.

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9 APPENDIX I

9.1 Electrofishing Survey Site Photographs

Fig. 1.1 Electrofishing survey site 1

Fig 1.2 Electrofishing survey site2

Fig. 1.3 Electrofishing survey site 3

Fig. 1.4 Electrofishing survey site 4

Fig. 1.5 – Electrofishing survey site 5

Fig. 1.6 Electrofishing survey site 6

Fig. 1.7 Electrofishing survey site 7

Fig. 1.8 Electrofishing survey site 8

Fig. 1.9 Electrofishing survey site 9

Fig. 1.10 Electrofishing survey site 10

Fig. 1.11 Electrofishing survey site 11

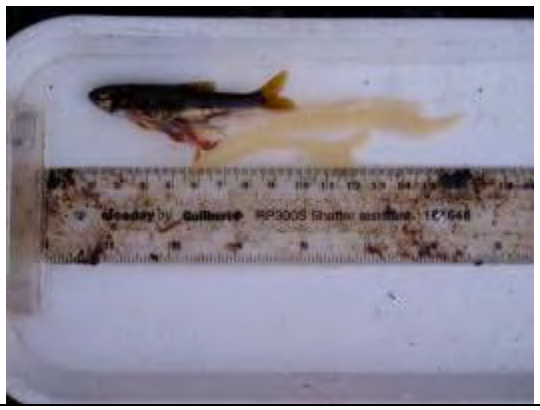
Fig. 1.12 Electrofishing survey site12

Fig. 1.13 Electrofishing survey site 13

Fig. 1.14 Electrofishing survey site 14

Fig. 1.15 Juvenile brown trout

Fig. 1.16 Minnow & parasite



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