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COMMISSIONED REPORT

Commissioned Report No. XXX

The Scottish Beaver Trial: Survey of Fish Populations 2012

(*ROAME No. F05AX701*)

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COMMISSIONED REPORT

Summary

The Scottish Beaver Trial: Survey of Fish Populations 2012

Commissioned Report No. XXX (ROAME No. F05AC701)
Contractor: Scottish Natural Heritage
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Background

Argyll Fisheries Trust is undertaking surveys of fish populations and redd counts as one of a number of monitoring projects investigating the effects of beaver activities on the natural environment during the Scottish Beaver Trial. Following the collection of baseline information in 2008 and 2009, monitoring in 2010 and 2011, more intensive surveys were undertaken at 12 sites in four locations during 2012. Two new sites were surveyed adjacent to existing sites in each location with the aim of increasing data resolution at sites where beaver activity may interact with fish populations.

Main findings

Surveys of fish populations and spawning activity were undertaken at two locations where recent beaver activity (tree felling and dam construction) may have affected the passage of fish between refuge habitat (lochs) and spawning habitats (streams). These surveys found no significant change to the species composition of fish or their number at these sites in 2012, compared to that found in previous surveys.

Surveys of fish populations and spawning activity were also undertaken at four locations where no recent beaver activity was known to potentially affect fish habitat. These surveys found no significant change to the number or species of fish found at these sites in 2012, compared to that found in previous surveys.

The following conclusions were reached:

The surveys undertaken in 2012 found no significant change to the number or species of fish found at sites where beaver have recently become active in tree felling and dam building and where no beaver activity had been recorded. Monitoring of these and similar sites will be necessary to assess potential beaver and fish interaction and inform management.

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1 INTRODUCTION

In 2008 the Scottish Government issued a licence to the Scottish Wildlife Trust and the Royal Zoological Society of Scotland to undertake a trial reintroduction of European beaver (*Castor fiber*) at Knapdale in Argyll. The five year trial is being monitored with a series of studies, including 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 the potential for European beaver to impact on migratory salmonid fish (Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*) and other native fish varies depending on geographical location, relief and habitat type (Rosell *et al*., 2005 and Kemp *et al*., 2010). 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). A recent review of scientific literature and expert opinion (Kemp *et al*. 2010) found that the impact of beaver on fish populations is spatially and temporally variable, and differs inter- and intraspecifically and that positive impacts were cited more frequently than negative impacts. In regard to the relationship of beaver to migratory salmonid fish, this study determined that the impact on abundance and productivity was considered to be positive, but the upstream and downstream movement of salmonids was considered to be negative. This five year study (2008 to 2013) aims to evaluate the response of fish populations in Knapdale streams within the trial area to the reintroduction of beaver at the trial site and compare them to similar streams outside of the trial area where beaver are not present.

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 help inform decision makers in regard to the potential for wider reintroduction across Scotland.

Previous fish surveys were undertaken at Knapdale in 2011 (AFT, 2012), 2010 (AFT, 2011), 2009 (AFT, 2010), 2008 (AFT, 2010) and 2002 (Kettle-White, 2002). Three families of European beavers were released at Knapdale Forest in May 2009. This report describes work undertaken in 2012, after the release, to assess the fish species, their distribution and their use of the range of aquatic habitats present in the trial area. This phase of the programme seeks to collect higher resolution information at fewer locations with the aim of increasing the resolution of information at sites where beaver activity may interact with fish populations.

2 METHODS

Two survey methods were employed to assess the fish populations and their habitat use in the freshwater streams in the Knapdale trial area; sampling of fish by electrofishing (October 2012) and assessment of spawning activity of salmonid fish by a walk-over survey (December 2012). The electrofishing survey re-sampled four sites originally investigated in 2002 (Kettle-White 2002), 2008 (AFT 2010a), 2009 (AFT 2010b) and 2010 (AFT, 2011) within the trial area and an additional two new sites in close proximity to these four sites.

2.1 Electrofishing surveys

A standard electrofishing technique was used to temporarily stun fish in the close vicinity of the operator, allowing fish to be retained and processed prior to release. The surveys were designed to investigate the relatively shallow areas of flowing water (< 1m depth) present in the study area at Knapdale which juvenile salmonid and other fish species 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 each survey site in recent years. The technique is also effective for non-salmonid species, although the shallow water habitats sampled may not reflect their preferences which may change on a seasonal basis. Data may therefore be less representative for such species.

Fish surveys were conducted 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 watercourse and lower voltage used in smaller watercourse 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) to provide information for interpretation of the fish data collected relative to the suitability of the habitat for fish. Measurements of water temperature and conductivity were taken at survey sites using a Hanna Instruments 98129 hand-held tester to identify water chemistry factors potentially affecting the effectiveness of the electrofishing survey method. This is in addition to information which has been recorded through the river habitat monitoring undertaken by Gilvear and Casas Mulet within the trial area (2010) 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) were utilised to estimate the density of fish present within the site at the time of the survey (Zippen, C. 1956). 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 were 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

Density estimates 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, or more; 2+ years, but have not yet been to sea) for salmon and trout. 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 categorised according to the SNH classification scheme (Godfrey, 2005) for West of Scotland Region (Table 2.1.1).

Table 2.1.1 Quintile ranges for juvenile trout (no. Fish per 100 m²) 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 Electrofishing survey sites

A total of 15 survey sites were sampled in three catchments in 2012 (summarised in Table 2.1.2), repeating two sites previously sampled in the Linne catchment (sites 4 and 9), two sites in the Coille-Bharr catchment (sites 14 and 17) and two sites in the Creagmhor catchment (sites 24 and 25). Two new sites were surveyed adjacent to each of the established sites in the Linne catchment (sites 4a, 4b, 9a, 9b) and the Coille-Bhar catchment (sites 14a, 14b, 17a and 17b). One new site was also surveyed in the Coille-Bharr catchment (site 16a) to assess the use of marginal loch habitat for recruitment by trout. One new site was surveyed in the Creaghmor catchment (site 24a) at the outflow of Lochan Buic. All sites were surveyed between the 4th and 10th of October 2012.

The new sites sampled were representative of the nursery habitat available to adjacent existing sites in an attempt to broaden the information on fish populations at locations where beaver activity has been noted during the trial period (Figures 2.1.1 and 2.1.2). Of the four categories of site previously surveyed; one site (site 16a) in afferent (in-flowing) streams to freshwater lochs (AF), six sites (4, 4a, 4b, 14, 14a and 14b) in efferent (out-flowing) streams to other freshwater lochs (EF) and nine sites (sites 9, 9a, 9b, 17, 17a, 17b, 25, 24a and 24) in efferent streams flowing into marine habitats from lochs (EM).

Table 2.1.2 Electrofishing survey sites summary (2011)

Site Code	Catchment	Category	Easting	Northing	Average width (m)	Conductivity (uS cm-1)
4	Linne	EF	179526	690498	0.9	37
4a		EF	179721	690685	0.7	37
4b		EF	179760	690741	1.4	37
9	Linne	EM	179306	690461	2.6	95
9a		EM	179213	690371	2.0	94
9b		EM	179209	690354	2.4	94
14	Coille-Bharr	EF	178896	690940	1.4	145
14a		EF	178859	690868	1.3	145
14b		EF	178925	690951	1.4	145
16a	Coille-Bharr	AF	178531	690631	2.5	149
17	Coille-Bharr	EM	177900	689865	2.9	137
17a		EM	177343	689810	3.6	137
17b		EM	177823	689785	2.5	137
25	Creagmhor	EM	179062	689241	2.3	132
24a		EM	179061	689113	1.4	113
24		EM	179702	689146	1.1	115

2.1.1 Beaver dam on loch Fidhle inflow

2.1.2 Felled trees on Loch Linne outflow

2.2 Redd count surveys

In December 2012 a walkover survey was undertaken for stream habitats in three catchments where electrofishing surveys had been undertaken in October. The aim of the survey was to identify the distribution and types of habitat utilised for recruitment by salmonid fish in the trial area and provide background information for interpretation of electrofishing survey data. 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). The location of active spawning sites (six figure grid references identified by hand-held GPS) and the number and relative size of redds observed were recorded (Figure 2.2.1). Information on site characteristics at each site was also recorded; stream width, in-stream situation of redds and other features. The size of the female fish making the redd is a major factor influencing the size of the redd, therefore the length of the depression (pot) of the redd was estimated and categorised; small (less than 0.5 m), large or a composite of a number of redds (more than 0.5 m). The location and area of habitat surveyed are given in Table 2.2.1 and the location of catchments in Figure 2.2.2.

Figure 2.2.1 Typical redd feature with light coloured excavated material at the tail

Table 2.2.1 Redd count survey site description

Catchment	Sub catchment	Type	Site Code	Survey Length (km)	Avg. Width (m)	Survey area (x 100 m²)
Linne	Losgunn	EF	LLOEF	1.09	0.5	5.5
	Linne	EM	LLEM	2.37	2.3	54.5
Coille-Bharr	Barnluasgan	EF	CBBEF	0.17	1.1	1.9
	Loch Coille-Bharr	AF	CBAF	0.02	1.5	0.3
	Coille-Bharr	EM	CBEM	1.72	2.8	48.2
Creagmhor	Creagmhor / Buic	EM	CMEM	1.13	2	22.6
		Total		**6.5**		**132.9**

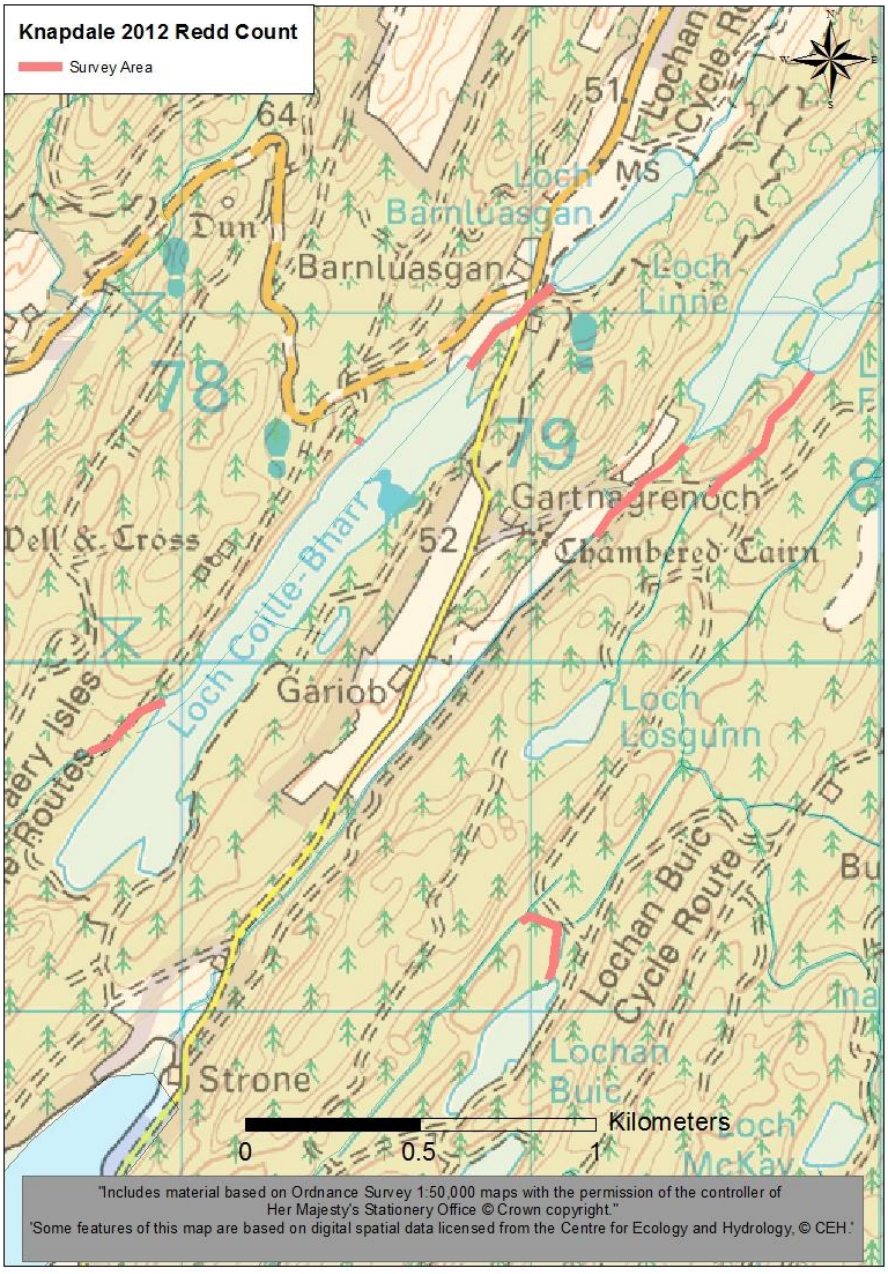

Figure 2.2.2 Redd count survey area 2012

3 RESULTS

3.1 Electrofishing survey

The results of electrofishing sampling of salmonid fish in each catchment surveyed are presented here. Results for non-salmonid fish species are given separately below.

3.1.1 Salmonid fish

Brown trout were found in all of the 16 electrofishing surveys conducted in October 2012. Fry (young of the year) were found at all sites with the exception of site 25 and parr (fish older than one year) were found at 10 sites. Atlantic salmon were not present at any of the sites surveyed. Estimates of trout abundance found are given as the number of fish per 100 m² of wetted stream bed (Table 3.1.1), classification (Figures 3.1.1 and 3.1.2) and length frequency (Table 3.1.2).

Table 3.1.1 Electrofishing survey results for brown trout (no. of fish per 100 m²)

Site	**Trout fry**				**Trout parr**			
No.	Min. Est.	Est.	95 % C.L (+/-)	Class	Min. Est.	Est.	95 % C.L (+/-)	Class
4	19.2			D	0			F
4a	10.5			D	0			F
4b	21.5	35.9	8.3	D	6.1	9.4	2.2	C
9	61.7	113.5	30.5	A	3.3			D
9a	62.9	97.8	24.0	A	15.7	16.16	2.9	A
9b	47.2			B	10.3			B
14	7.9			E	0			F
14a	7.9	10.6	3.95	D	5.9			C
14b	11.3	13.2	1.8	D	0			F
16a	38.5			C	16.5			A
17	54.0	70.1	6.7	B	2.3	4.5	7.8	E
17a	69.2			B	11.3			B
17b	67.2	95.4	5.4	A	4.8			D
24	10.1			D	0			F
24a	2.3			E	0			F
25	9.9	16.5	11.6	D	19.8	24.7	4.3	A
Mean	**30.71**				**5.94**			

Minimum estimates of trout fry abundance ranged from 2.3 to 62.9 fry per 100 m² of stream sampled. The abundance of trout fry were relatively low (class D and E) at all three sites in the Loch Fidhle inflow (sites 4, 4a and 4b), Coille-Bharr inflow (sites 14, 14a and 14b) and Lochan Buic outflow (sites 24, 24a and 25). More moderate numbers of fry (Class C) were found at the inflow site on Loch Coille-Bharr (site 16a). Higher abundance (Classes A and B) of fry were found at the Loch Linne outflow (sites 9, 9a and 9b) and Loch Coille-Bharr outflow (sites 17, 17a and 17b).

Minimum estimates of parr abundance ranged from 2.3 to 16.5 parr per 100 m² of stream sampled. When compared to fry, densities of trout parr were more varied between sites in each cluster surveyed, with relatively low abundance (classes D and E) found at four of the ten sites where parr were found. More moderate abundance (Class C) was found at two sites (4b and 14a) and higher abundance (classes A and B) at five sites.

The mean length of the 393 trout fry sampled ranged from 56 mm (at site 17a) and 86 mm (at site 24a). A total of 29 one-year-old trout parr (1+) were sampled at nine sites with the mean length ranging from 92 mm at site 16a to 113 mm at site 9b. Six older parr were found at three sites with mean lengths ranging from 151 to 161 mm.

Table 3.1.2 Frequency and length (mm) of brown trout at different age categories (yrs+)

Site	**Trout fry**			**Trout parr (1+)**			**Trout parr (2++)**		
No.	No.	Mean	Range	No.	Mean	Range	No.	Mean	Range
4	5	73	67-86	0			0		
4a	3	69	64-80	0			0		
4b	11	80	71-90	2	100		1	161	
9	83	64	49-82	3	94	90-101	0		
9a	38	67	41-86	7	97	90-103	0		
9b	23	58	40-86	1	113		4	160.3	150-180
14	5	78	74-81	0			0		
14a	5	70	64-77	3	95	91-103	0		
14b	7	84		0			0		
16a	7	73	63-83	3	92	90-97	0		
17	59	65	43-85	3	96	90-103	0		
17a	85	56	43-77	5	89	84-101	0		
17b	58	61	44-87	2	98	95-102	1	151	
25	0			0			0		
24a	1	86		0			0		
24	3	74	70-78	0			0		
Ttl. / Avg.	**393**	**70.5**		**29**	**97.1**		**6**	**157.4**	

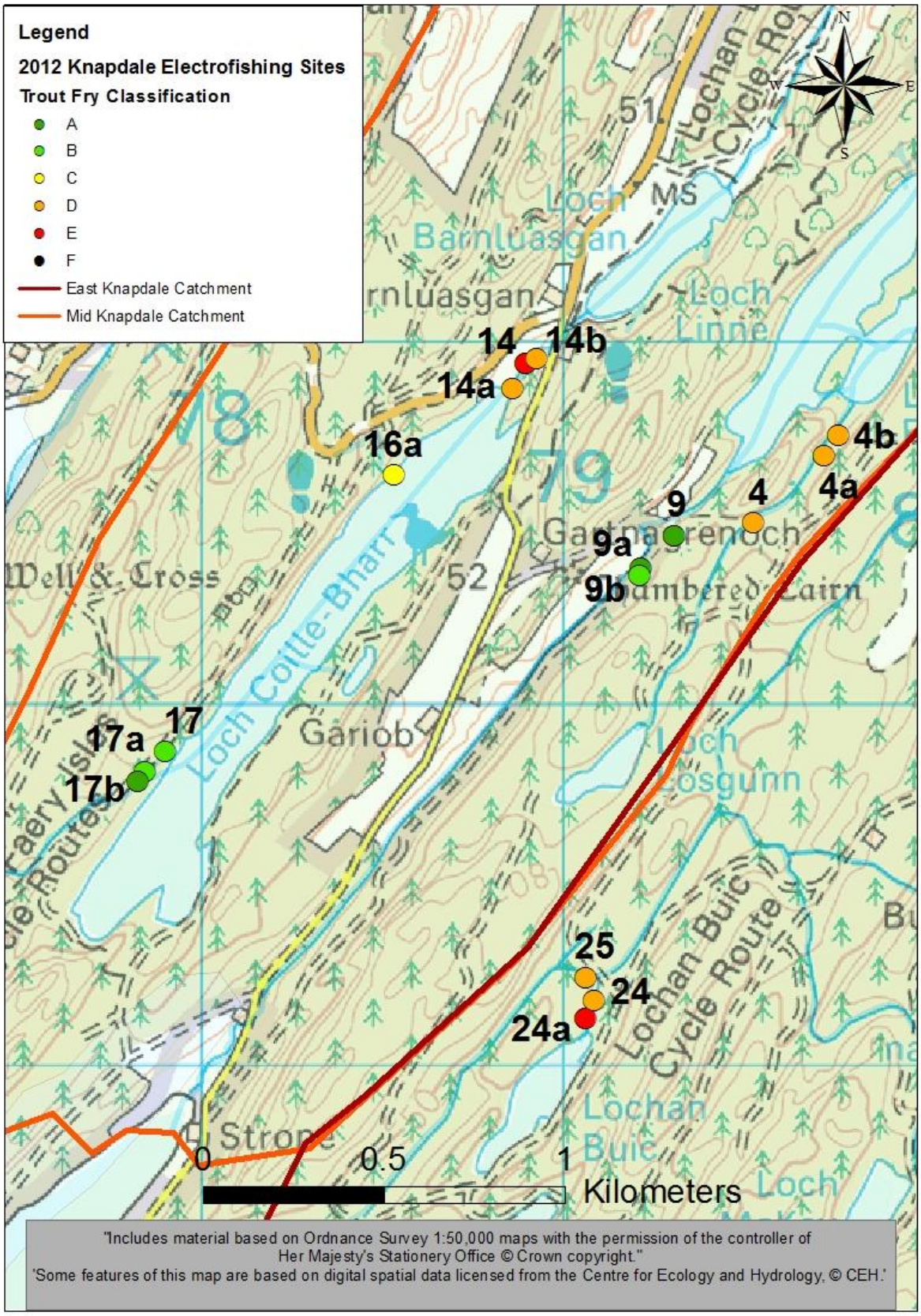

Figure 3.1.1 Classification of trout fry abundance

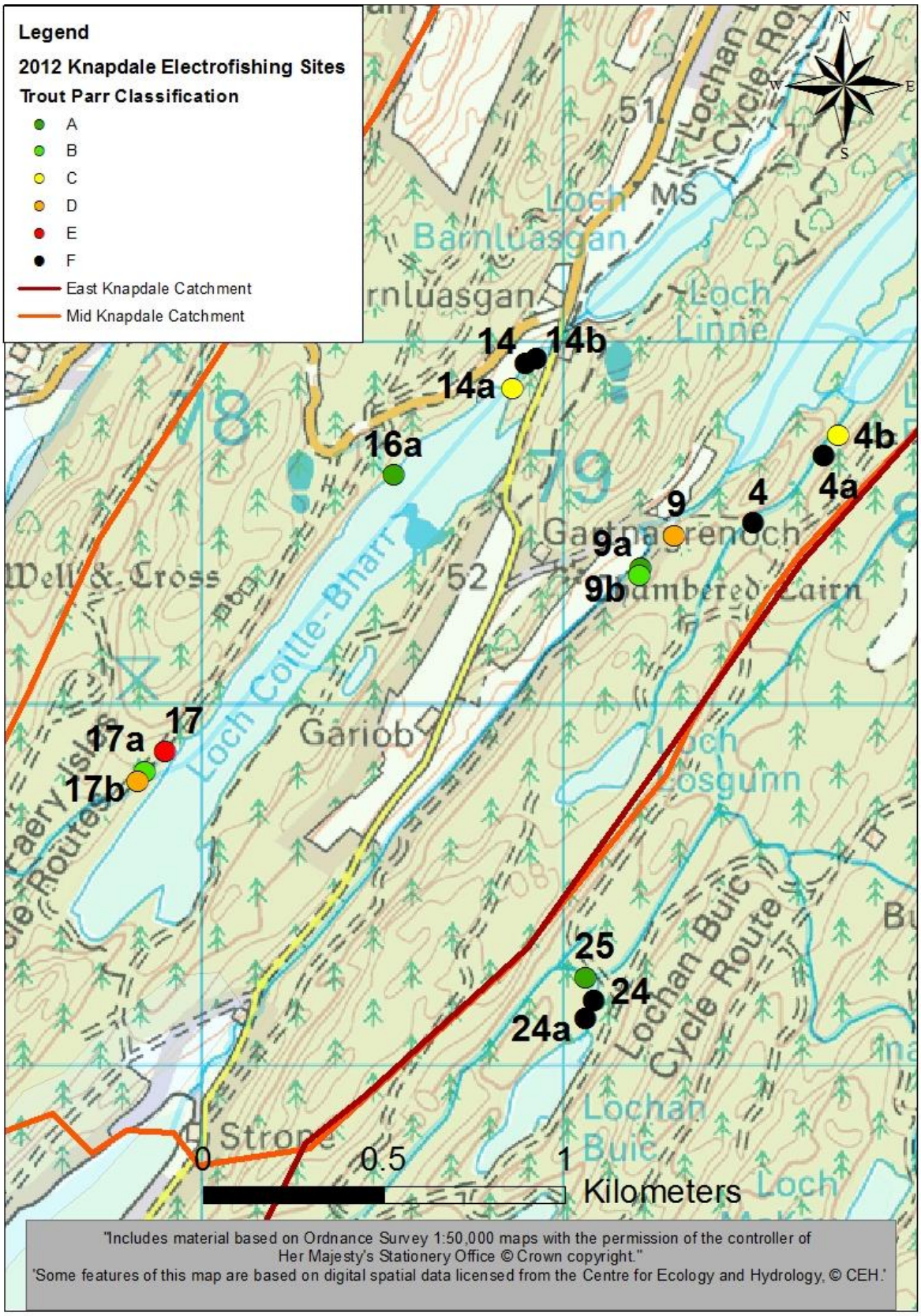

Figure 3.1.2 Classification of trout parr abundance

3.1.2 Non-salmonid fish

Other than trout, two other native species of fish were sampled at nine sites (Table 3.1.3). European eel were found at six sites (Figure 3.1.3) with minimum densities ranging from 1.6 to 9.6 per 100 m² and three-spine sticklebacks at three sites (Figure 3.1.4), ranging from 1.5 to 16.8 per 100 m². One translocated species (non-native); the European minnow, was also found at five locations (Figure 3.1.5) in the Linne and Coille-Bharr catchments ranging from 1.1 to 75.4 per 100 m².

Table 3.1.3 Electrofishing survey results for other species (min. no. of fish per 100 m²)

Site	**Eel**		**Stickleback**		**Minnow**	
No.	No.	Min. Density	No.	Min. Density	No.	Min. Density
4	0		0		0	
4a	0		0		0	
4b	0		0		0	
9	8	8.7	0		1	1.1
9a	1	2.3	0		0	
9b	0		0		5	10.3
14	1	1.6	0		2	3.2
14a	0		1	1.9	38	75.4
14b	0		0		0	
16a	0		1	5.5	0	
17	0		0		0	
17a	5	7.7	1	1.5	0	
17b	6	9.6	1	1.6	3	4.8
25	0		0		0	
24a	1	2.3	2	4.6	0	
24	0		5	16.8	0	
Ttl. / Mean	**22**	**5.3**	**11**	**5.3**	**49**	**18.9**

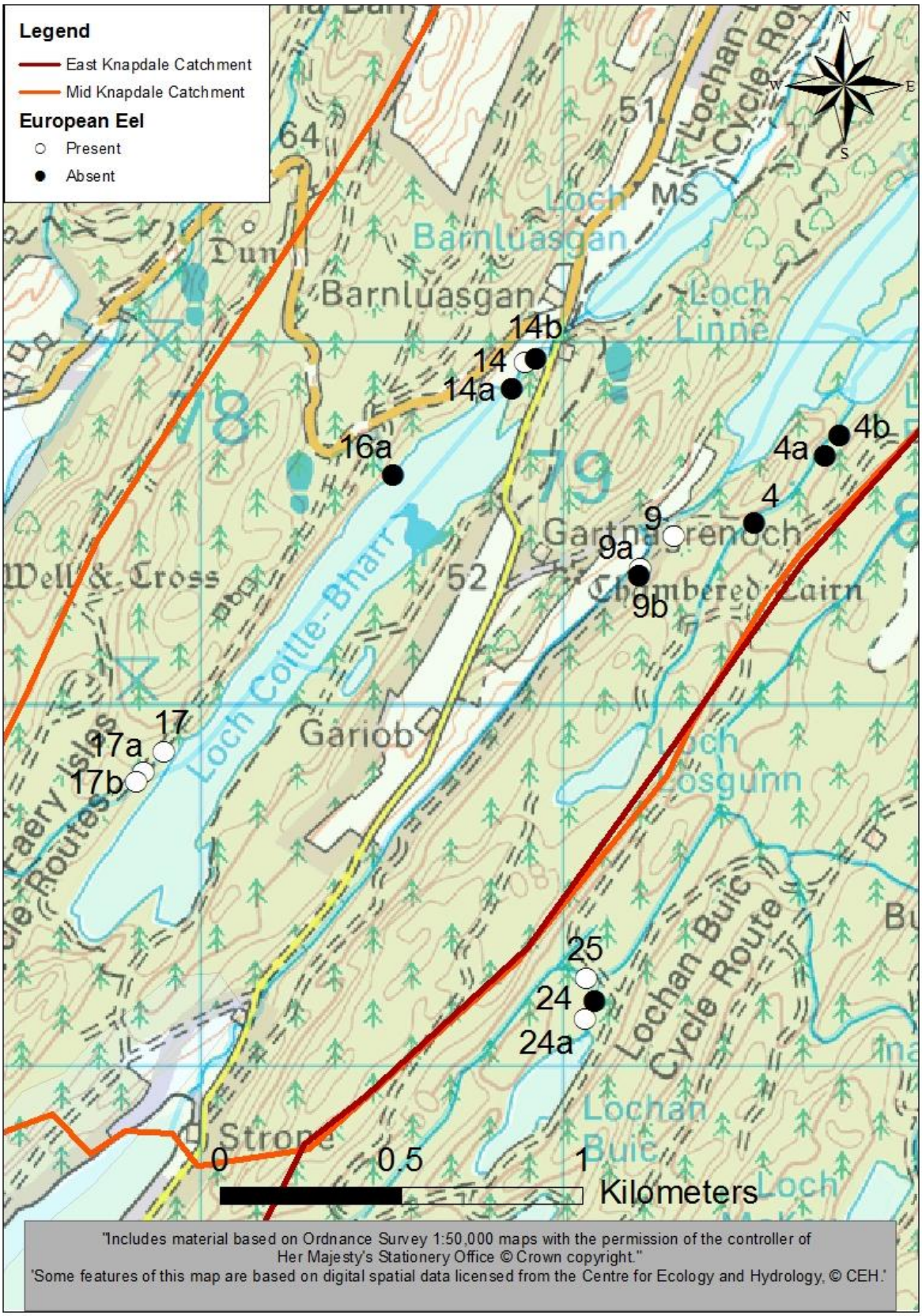

Figure 3.1.3 Distribution of European Eel 2012

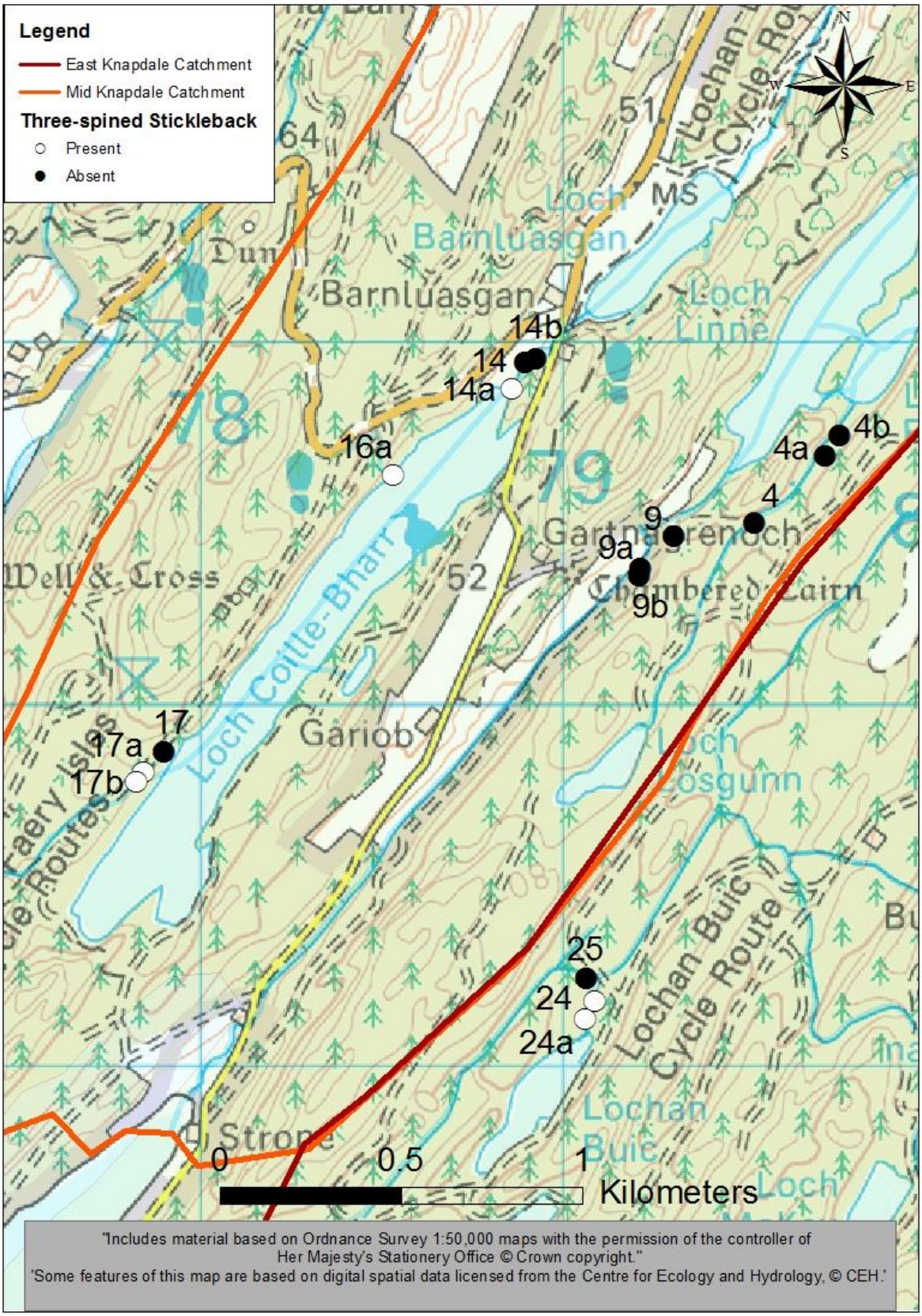

Figure 3.1.4 Distribution of Three-spine stickleback 2012

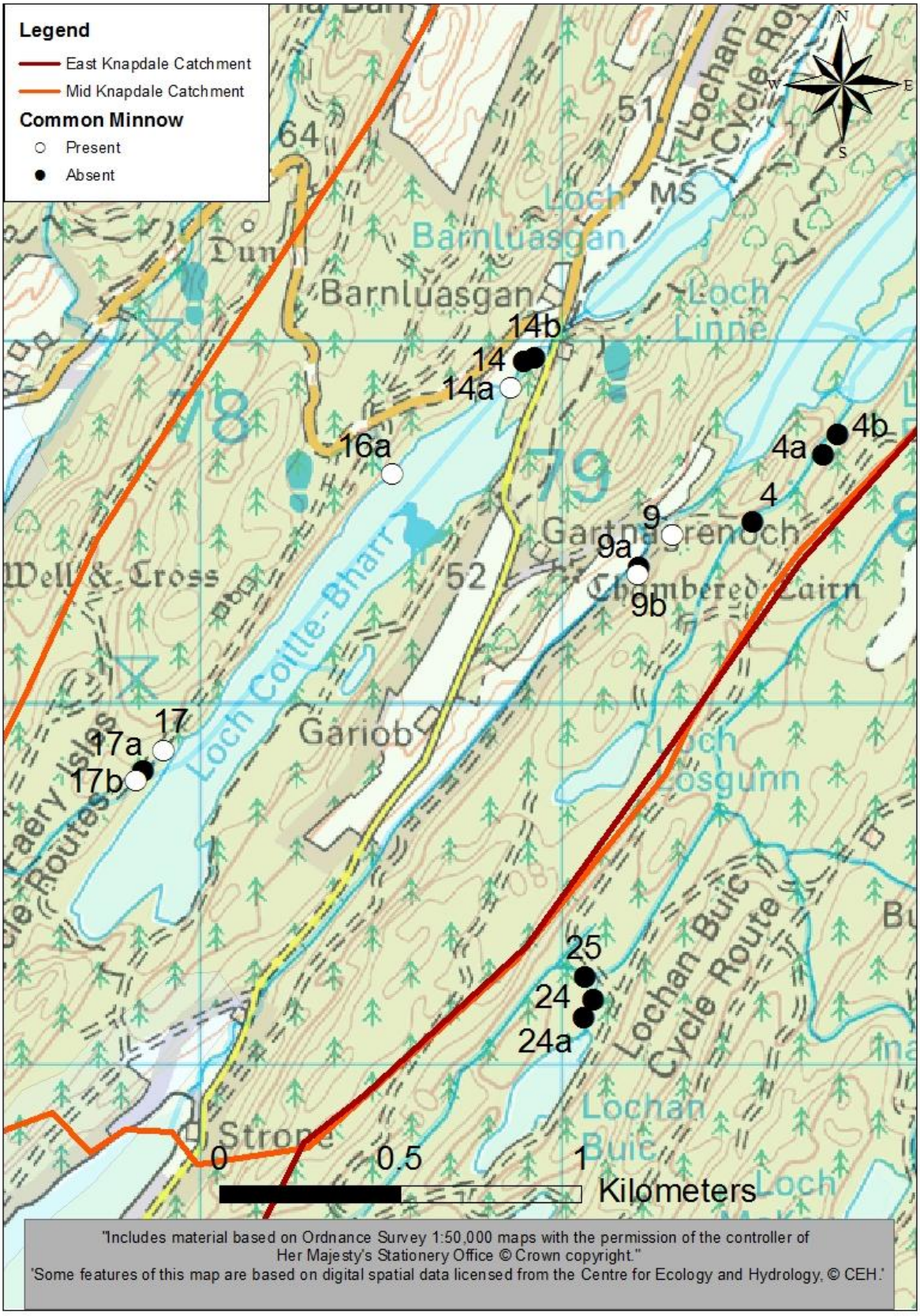

Figure 3.1.5 Distribution of common minnow 2012

3.1.3. Comparison of trout abundance 2008 to 2012

Comparison of the classification of minimum density of juvenile trout over time was possible at the six repeated sites between 2008 and 2012 (Table 3.1.4). For interpretation, when compared to 185 other sites sampled in the region, class F represents an absence of fish, class D and E represent low to very low abundance respectively. Class C represent moderate abundance and classes B and A represents high and very high abundance respectively. The data collected in 2002 at these sites are not compared with more recent data here as it was collected at a different time of year, which is likely to have affected fish distribution and abundance.

Table 3.1.4 Classification of trout abundance (2008 to 2012)

Site No.	Category	FRY					Parr				
		2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
4	EF		D	F	E	D		F	F	F	F
9	EM	B	B	B	B	A	E	E	F	E	D
14	EF		D	D		E		F	F		F
17	EM		D	D	D	B		D	E	D	E
24	EM		F	D	F	D		A	A	F	F
25	EM		F	D	F	D		F	B	F	A

Of the two efferent stream survey sites (sites 4 & 14) flowing between freshwater lochs (EF), trout fry were found at relatively low abundance (classes D and E), but no parr were found at these sites in any of the surveys.

At the four efferent marine sites (EM) flowing out of freshwater lochs into the sea, trout fry were found at relatively high abundance (classes A and B) in every survey at site 9 and at site 17 only in 2012. Lower densities of fry (class D) were found at the two sites in the Creagmhor catchment (sites 24 and 25) in 2012 and 2010 where none were found (class F) in 2009 and 2011. Conversely, low abundance of parr were found at sites 9 and 17, while relatively high abundance of parr were found at sites 24 and 25 in 2010, none in 2011 and again at high abundance in 2012 at site 25.

3.1.4 Habitat variables at sampling sites

Stream bed substrates found at electrofishing sites (Table 3.1.16) were mostly fine (silt and sand), averaging 54 % of habitat area and ranged between no fine sediment at site 16a to 100 % at the three sites surveyed downstream of Lochan Buic (sites 24, 24a and 25). Relatively small substrates (gravel and pebble) were also common, averaging 31 % of substrate found at all site and ranged between none at the Lochan Buic sites and one other sites (9a) to 80 % in the Loch Coille-Bharr inflow stream (site 16a). Larger substrates (cobble and boulder) were found at fewer sites, averaging 14 % of habitat area at nine sites where they ranged between 15 and 50 % of habitat area.

Water flow at electrofishing survey sites mostly consisted of glide and pool types, which were found at all sites surveyed, ranging between 20 and 100 % and averaging 74 % of all habitat area surveyed. Broken water flows (run and riffle) were found at 25 % of surveyed habitat (range 15 to 60 % at 11 sites) and torrential flow was found only at site nine (1 % of habitat).

Table 3.1.5 Summary of habitat variables at survey sites

Site	Substrate (%)			Flow (%)			Bank cover (%)	
No.	Fines	Gravel & Pebble	Cobble & Boulder	Run / Riffle	Glide / pool	Torrent	Left	Right
4	45	40	15	40	60	0	90	90
4a	60	40	0	15	85	0	90	90
4b	90	10	0	0	100		40	40
9	30	40	30	60	20	20	90	80
9a	30	20	50	60	40	0	70	60
9b	100	0	0	0	100	0	100	100
14	45	40	15	30	70	0	80	80
14a	30	70	0	25	75	0	90	90
14b	40	40	20	35	65	0	40	30
16a	0	80	20	20	80	0	90	90
17	50	30	20	40	60	0	80	80
17a	20	40	40	60	40	0	20	20
17b	30	50	20	15	85	0	20	20
24	100	0	0	0	100	0	20	20
24a	100	0	0	0	100	0	5	5
25	100	0	0	0	100	0	5	5
Avg.	**54.4**	**31.3**	**14.4**	**25.0**	**73.8**	**1.3**	**58.1**	**56.3**

Bank cover for fish at electrofishing survey sites mostly consisted of undercut banks, tree roots or draped vegetation. The proportion of the bank length (%) that provide cover for young fish ranged from 5 % at sites 24a and 25 at the Lilly Loch outflow to higher values of between 80 to 100 % at eight other sites.

3.2 Redd count survey

Approximately 6.5 km of streams were surveyed in six reaches of habitat in three catchments. A total of 30 spawning sites containing 86 redds were recorded in the survey. Summary results for each catchment surveyed are given below.

3.2.1 Redd count in the Linne catchment

A total of 18 small redds (<0.5 m pot length) and one large redd (>0.5 m pot length) were recorded at a density of 2.23 per 100 m² in the stream flowing between Loch Losgunn and Loch Fidhle and 0.04 per 100 m² in the outflow from Loch Linne (Table 3.2.1 and Figures 3.2.1 and 3.2.2).

Table 3.2.1 Linne redd count survey results

Survey reach	Spawning site			Redds (no.)				
	Type	No.	Area (m^{-2})	Large	Large Composite	Small	Total Redds	Density (per 100 m^2)
Losgunn	EF	5	16.0	0	0	17	17	2.23
Linne	EM	2	1.7	1	0	1	2	0.04
	Total	**7**	**17.7**	**1**	**0**	**18**	**19**	

3.2.2 Redd count in the Coille-Bharr catchment

A total of 64 small redds (<0.5m pot length), but no large redds (>0.5m pot length) were recorded in the Coille-Bharr catchment (Table 3.2.2). Redds were found at a density of 23.53 redds per 100 m² in the stream flowing between Loch Barnluasgan and Loch Coille-Bharr (Figure 3.2.3). Redd density was 0.01 redds per 100 m² in an inflowing stream to Loch Coille-Bharr and 0.39 redds per 100 m² in the outflow from Coille-Bharr (Figure 3.2.4).

Table 3.2.2 Coille-Bharr redd count survey results

Survey reach	Spawning site			Redds (no.)				
	Type	No.	Area (m^{-2})	Large	Large Composite	Small	Total Redds	Density (per 100 m^2)
Barnluasgan	EF	11	79			44	44	23.53
L. Coille-Bharr	AF	1	0.5			1	1	0.01
Coille-Bharr	EM	9	6.51			19	19	0.39
	Total	**21**	**86.0**	**0**	**0**	**64**	**64**	

3.2.3 Redd count in Lochan Buic outflow

A total of two small redds (<0.5m pot length) and one large composite redd (>0.5m pot length) were recorded in the outflow of Lochan Buic at a density of 0.13 redds per 100 m² (Table 3.2.3 and Figure 3.2.5).

Table 3.2.3 Redd count survey results for the Lochan Buic outflow

Survey reach	Spawning site			Redds (no.)				
	Type	No.	Area (m^{-2})	Large	Large Composite	Small	Total Redds	Density (per 100 m^2)
Creagmhor	EM	2	12.0	0	1	2	3	0.13

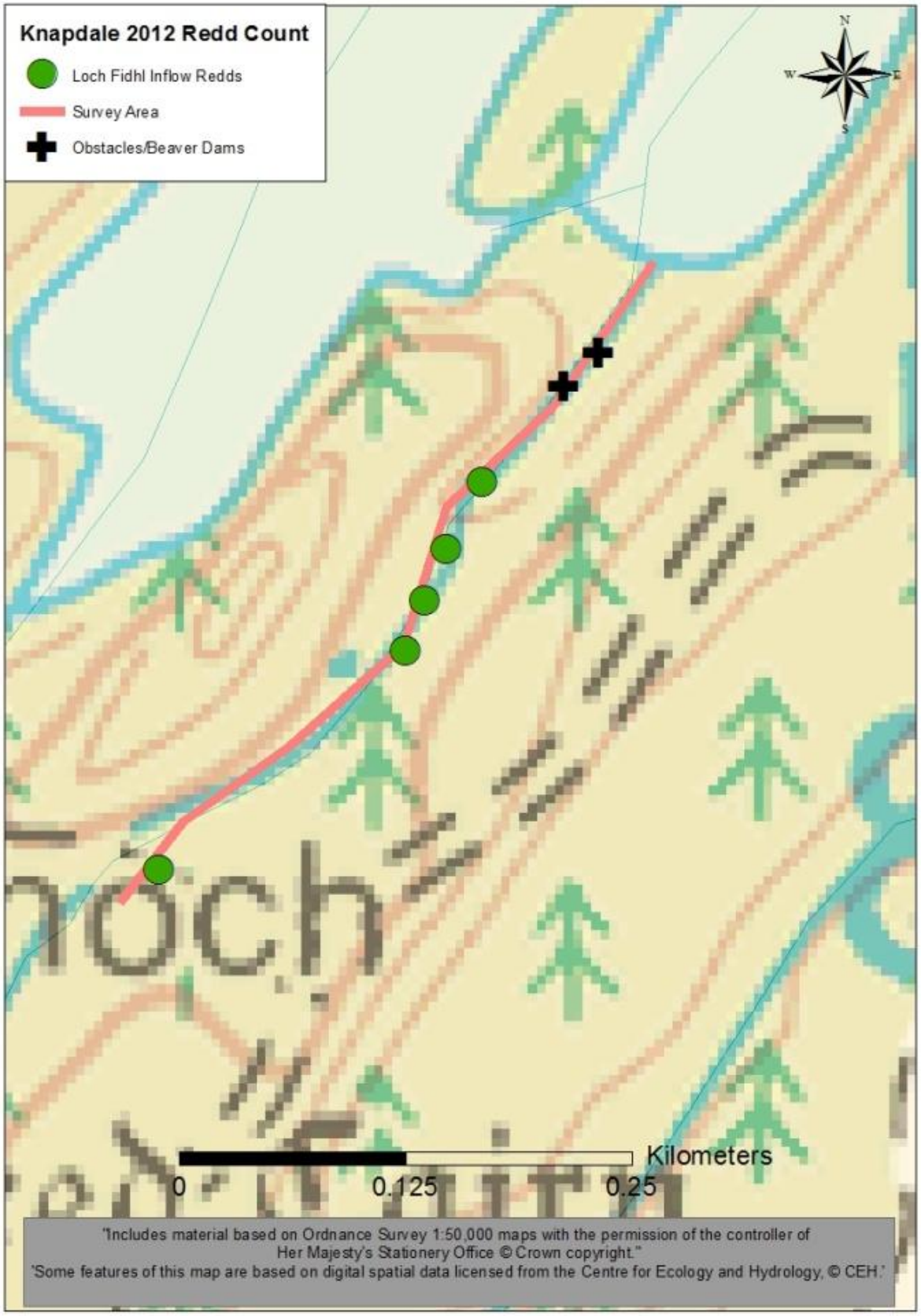

Fig. 3.2.1 Redd location in relation to beaver activity at Loch Fidhle inflow

Fig. 3.2.2 Redd location in relation to beaver activity at Loch Linne outflow

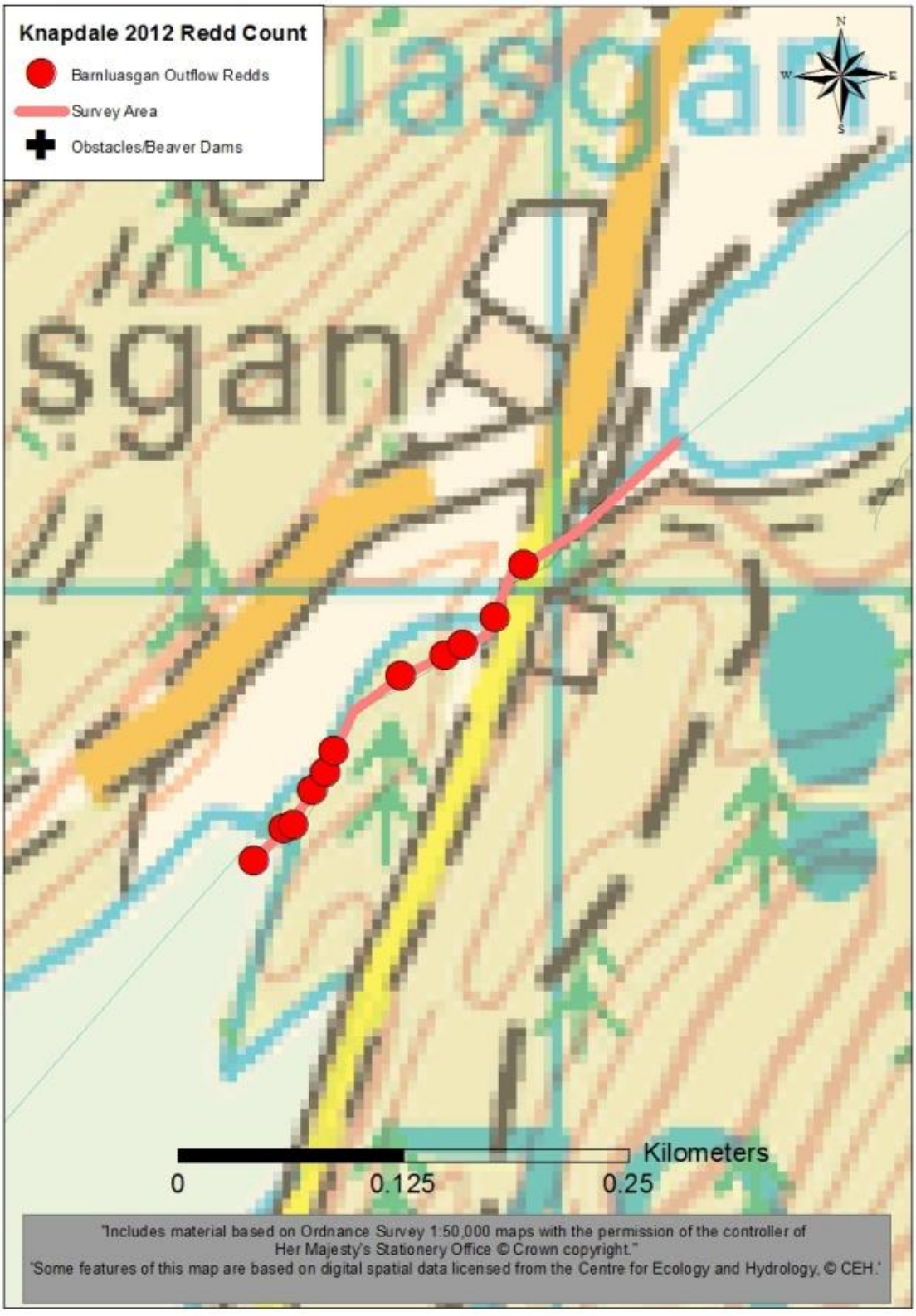

Fig. 3.2.3 Redd location at Loch Coille-Bharr inflow

Fig. 3.2.4 Redd location at Loch Coille-Bharr outflow

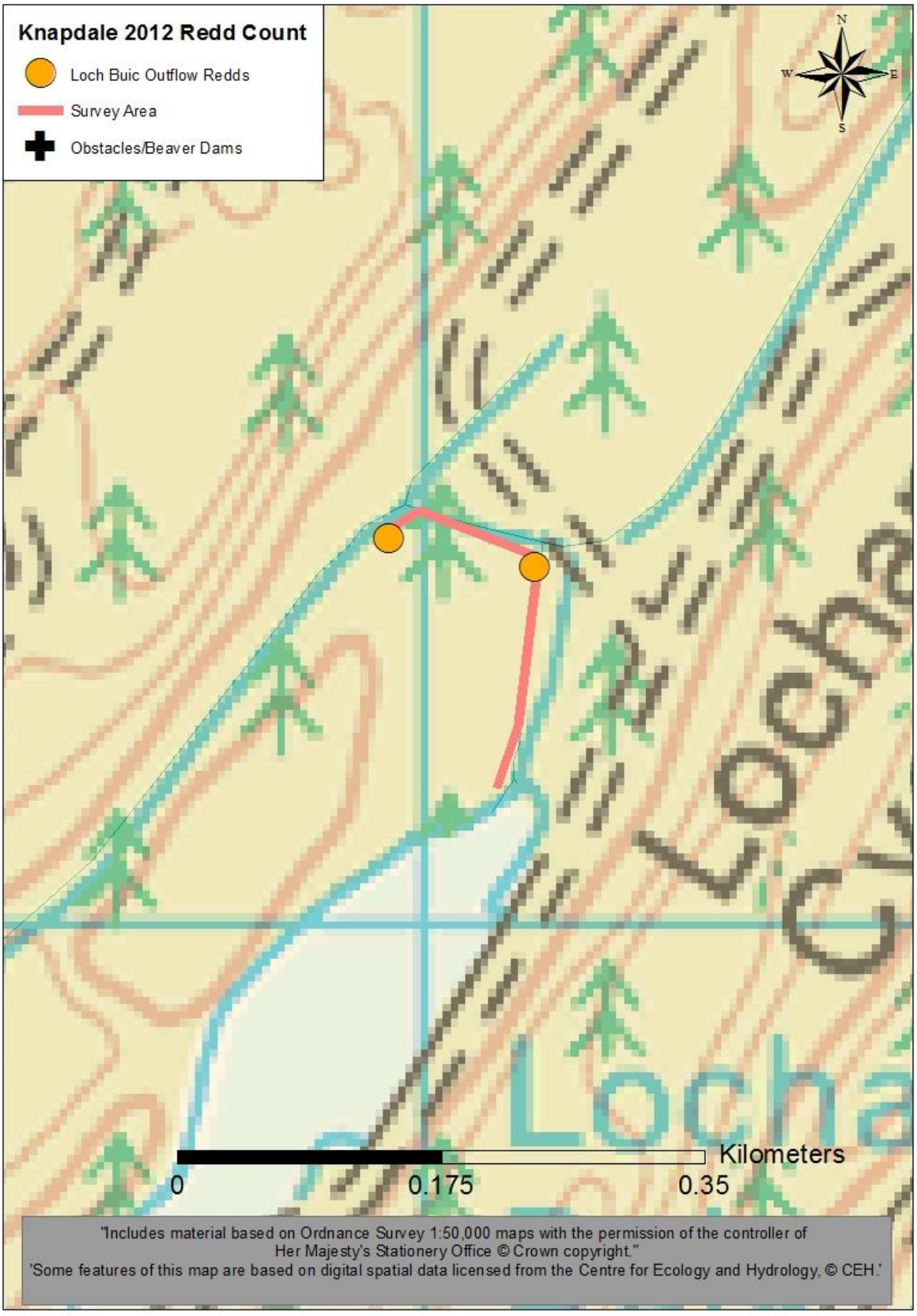

Figure 3.2.5 Distribution of spawning sites (Lochan Buic outflow)

4 DISCUSSION

The findings of the fish and redd count surveys are discussed below in relation to the survey locations and the trial reintroduction of European beaver.

4.1 Fish distribution and abundance

The fish species sampled in the sites surveyed in 2012; brown trout, European eel, three-spine stickleback and minnow are similar to that found in previous surveys undertaken in these habitats. The absence of species in some of the sampling locations was 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).

4.1.1 Loch Fidhle inflow (Linne catchment).

Studies in the stream flowing from Loch Losgunn to Loch Fidhle (sites 4, 4a and 4b) in efferent freshwater (EF category) habitat found some minor differences in fish distribution in 2012 compared to previous surveys. Previous redd count surveys (2009 to 2011) suggest that brown trout from Loch Fidhle migrate upstream to spawn in the autumn. Electrofishing surveys conducted in early October at site four found relatively low numbers of fry (classes D and E) in three of the four years when surveys have been undertaken (2009, 2011 and 2012) but no fry in 2010. An earlier survey undertaken in June 2011 found relatively high numbers of fry (class B), suggesting that recruitment of young trout may be significant at the site, but the majority may emigrate from the stream into to the loch after emerging from the redds (usually in May). Between 2010 and 2011, two relatively low beaver dams were constructed on the stream between Loch Fidhle and the spawning sites. The spawning and fish data collected in 2012 suggest that adult trout from Loch Fidhle have been able to migrate upstream of the beaver dams to spawn in 2011 and 2012.

The habitat in lower-most survey site (4b) immediately upstream of the upper beaver dam was general deeper than that found at the other two sites (which is likely be as a result of the dam). The higher number of fry found at this site and the only site where parr were found may be as a consequence of the creation of deeper water which are likely to be more preferable habitat than the shallower water found upstream.

4.1.2 Loch Linne outflow

Studies in the stream out-flowing from Loch Linne (sites 9, 9a and 9b in EM category) found little variation in fish distribution and abundance in 2012 compared to previous surveys. Previous fish and redd count surveys (2008 to 2011) suggest that brown trout from Loch Linne migrate downstream to spawn in the autumn, resulting fry may then emigrate upstream into Loch Linne. Since 2009, a number of trees have been felled by beaver across the stream between Loch Linne and the spawning sites downstream. The 2012 fish survey data suggest that trout fry numbers were higher compared to previous surveys, suggesting that trout are still able to access the site from Loch Linne. Similarly high numbers of fry and parr found in the two new sites surveyed in 2012 suggest that the area is of some importance to recruitment of loch trout.

4.1.3 Loch Barnluasgan outflow / Coille-Bharr outflow

Unlike sites surveyed in the Linne catchment in 2012, no beaver activity was found in the stream flowing between Lochs Barnluasgan and Loch Coille-Bharr (sites 14, 14a and 14b in EF category). The 2012 survey found a similar distribution of fish compared to previous surveys (2008 to 2011 at site 14b and 2009, 2010 and 2012 at site 14). Similar to previous surveys, a relatively low number of trout fry were found at all sites in all years with stickleback, minnow and eel also found in some surveys. Redd count surveys found a relatively high density of redds at these sites each year which indicate that although the habitat may be heavily utilised by trout from both Loch Barnluasgan (upstream) and Loch Coille-Bharr (downstream), some fry may emigrate from the site during the summer before fish surveys are undertaken in autumn.

4.1.4 Loch Coille-Bharr inflow

Studies undertaken previous to 2012 (2008 to 2011) in the stream flowing into Loch Coille-Bharr (site 16) indicate that the survey site is not accessible by trout from Loch Linnhe due to a waterfall close to its confluence with the loch. However, surveys found a low number of trout parr and a few small redds, which suggest that there is a resident trout population upstream of the waterfall. The surveys undertaken downstream of the waterfall (site 16a) in 2011 and 2012 found a number of redds (December 2011) and low-to-moderate number of fry in the restricted amount of suitable habitat between the loch and the waterfall (October 2012). These data suggest that this habitat may be of importance to the recruitment of trout in Loch Coille-Bharr, but the character of the habitat is influenced by the level of water in the loch. Higher or lower water levels in the loch may also influence water depth at the survey site and consequently influence the use of the site by spawning adult trout and subsequently by juveniles.

4.1.5 Loch Coille-Bharr outflow

Studies in the stream out-flowing from Loch Linne (2009-12 at site 17) indicate that trout are able to access the limited area of habitat from the Loch to the impassable waterfall further downstream. Surveys at the established site and the two new sites surveyed in close proximity all found relatively high numbers of trout fry (class A or B) in 2012. Redd count surveys also suggest that most of the available habitat is utilised for recruitment.

The comparatively wider variation in trout parr abundance found by the 2012 surveys indicate that older trout may emigrate back upstream into Loch Coille-Bharr where habitat is more suitable for larger, older fish. It may also however be possible for juveniles to migrate downstream over the waterfall, but this cannot be determined by this study. Similar to previous surveys, non-salmonid fish (European eel, stickleback and minnow) were also found to be widely distributed at one of the two new sites nearest to Loch Coille-Bharr.

4.1.6 Lochan Buic outflow

Previous studies (2009-12) undertaken at sites surveyed in the stream out-flowing from the Lochan Buic (sites 24 and 25) and the 2012 survey at a new site (site 24a) in close proximity indicate that while trout in Lochan Buic are able to access these sites, redd and fish numbers are relatively low compared to other sites sampled at loch outflows. The type of habitat found

at these sites; fine sediment bed with glide flow types within the stream and poor availability of bank-side cover from riparian vegetation provide little cover for fish and therefore is likely to influence the productivity of the habitat for fish.

4.2 Surveys and sampling error

The location of the fish sampling sites surveyed in this study are likely to have some influence on the findings of the study as they provide data for a relatively small area of habitat at a particular point in time. However, the similar results found at different sampling sites within the same location in 2012 suggest that the sites surveyed have been representative of the habitat available to fish. As implied by the results of the early summer surveys in 2011, the seasonal timing of surveys in the autumn is likely to reflect a lower abundance of juvenile trout than in early summer prior to due to density dependant mortality or dispersal of fish that compete for limited resources. There is also potential for non-density dependant factors such as droughts and floods to influence fish distribution and abundance (Elliot, 1993a) in any one year.

It is also possible for some use of habitats on a diurnal basis. Stickleback and minnow may 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. While surveys conducted in the autumn are likely to record higher abundance of adult trout as they migrate from loch and marine habitats toward spawning sites, no mature adults were found in the 2012 survey, indicating that no spawning activity had commenced in early October 2012.

The electrofishing surveys undertaken to date have been conducted in autumn when water temperature was close to, but not below the recommended minimum 8 ºC (SFCC, 2007). This may potentially reduce the effectiveness of the sampling technique and increasing the potential for sampling error compared to surveys undertaken in warmer temperatures.

Similarly the results of spawning habitat surveys may be affected by the timing of the surveys and ideally they would be undertaken once spawning has been completed, but the timing and duration of spawning activity may vary between different populations of trout and the environmental conditions in any one year. Therefore, the results of this survey may not fully reflect the actual distribution and frequency of redds in the catchments surveyed.

5 IMPLICATIONS FOR THE MANAGEMENT

While the information on fish distribution, abundance and spawning sites collected in 2012 was confined to fewer locations compared to previous years (2008 to 2011) it has begun to investigate potential implications for the management of fish populations in relation to the trial reintroduction of beaver to the Knapdale area. Since their introduction in 2008, the beavers appear to have had little influence on fish habitats until the two small dams were built on the burn flowing into Loch Fidhle from Loch Losgunn and a number of trees were felled on the outflow of Loch Linne. The increase in intensity of sampling at these and other similar sites adjacent to loch habitats is likely to further improve upon the baseline data and inform management of beaver activity and potential influence on fish habitat and fish populations.

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).

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 habitats to fish 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 to 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; particularly the Loch Coille-Bharr and Loch Linne efferent streams within the trial area and the afferent marine streams of Arichonan and Carsaig outside of the trial area. 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 are little or no data to assess potential changes in fishery performance over the study period. Additionally, the loch-based fisheries receive supplemental stocking of brown and rainbow trout that may or may not compete or reproduce with native populations and affect the distribution and abundance of fish measured as part of this study.

Therefore, identifying and managing issues on the basis of fishery performance is unlikely to be possible. Potential issues affecting native 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. 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 during the trial period.

6 CONCLUSIONS

The data collected by fish and redd surveys from 16 sites at six locations within the beaver trial site in 2012 provide a higher resolution of information at a range of sites where beavers have been active, and at sites where fish habitat may be affected if beaver become active.

6.1 Surveys at sites affected by beaver activity

Fish population and redd counts were undertaken at six sites at two locations where beaver have become active.

Cross-stream tree felling by beaver at the outflow of Loch Linne do not appear to have affected the movement of brown trout from loch Linne to their spawning and nursery habitat downstream.

Two small beaver dams made on the burn flowing from Loch Losgunn to Loch Fidhle do not appear to have affected fish spawning or juvenile recruitment upstream.

European eel, three-spine stickleback and minnow were also at sites where they had been found previous to beaver activity.

6.2 Surveys at sites not affected by beaver activity

Fish population and redd counts were undertaken at ten sites at four locations where no beaver activity has been found. Fish distribution and abundance at these sites appear similar in 2012 to that found in baseline and follow-up surveys (2008 to 2011).

6.3 Monitoring of beaver activity

While beaver activity in watercourses adjacent to loch habitats has potential to affect fish habitat, where limited activity (tree felling and dam building) has been found they do not yet appear to influence fish habitat or fish populations.

Although no changes to fish or their habitat have been found, on-going monitoring of fish populations at locations where beavers have become active and at similar locations where beavers may become active are required to inform management.

7 APPRAISAL OF METHODOLOGY AND FUTURE PROGRAMME OF WORK

The two methodologies utilised in the survey; electrofishing and walkover redd 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. Repeat sampling of sites are likely to provide more robust information on species distribution and variation in abundance. Further sampling at electrofishing sites where few trout fry were found may be undertaken in the early summer months to establish the potential for short-term habitat use by fry, further interpret factors controlling fish distribution and develop the sampling programme.

7.2. Redd survey

The data collected in the spawning habitat survey successfully identified habitats that were being used for the recruitment of salmonid fish at the time of survey and potential obstacles to adult fish access to spawning sites. This information also provided supporting information for the interpretation of electrofishing data. Although, an agreed survey protocol is not yet established for surveying salmonid spawning habitat or obstacle status, an experienced surveyor may provide very useful information. Further development 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

Fish studies at Knapdale has undertaken baseline sampling of fish populations in streams within the trial area in 2008 and expanded on these sites in 2009, including sites outside of the trial area. Repeat monitoring of these survey sites was continued in 2010 and 2011 to inform temporal changes in fish populations. Sampling of fish populations was also undertaken in three loch habitats in 2011. A more intensive sampling of fewer sites in 2012 at locations where beaver have become active and similar sites where beaver may become active in the near future has begun to focus on potential interaction between fish and beaver at the trial site.

The 2013 surveys will need to continue to assess any affect on fish populations at sites where beaver are known to be active as well as maintaining the monitoring of a core of study sites where no beaver activity is known to have occurred so that potential changes may be compared. Additionally, sampling of fish may also have to include new sites where beaver become active.

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 are being developed. Field data will be collected by a Field Officer, 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. 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.

–Aquatic macrophytes - A baseline survey of macrophytes has been undertaken.

–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 the completion of electrofishing and spawning habitat surveys (redd counts) for all catchments within the trial and a sub-sample of habitats outside of 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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