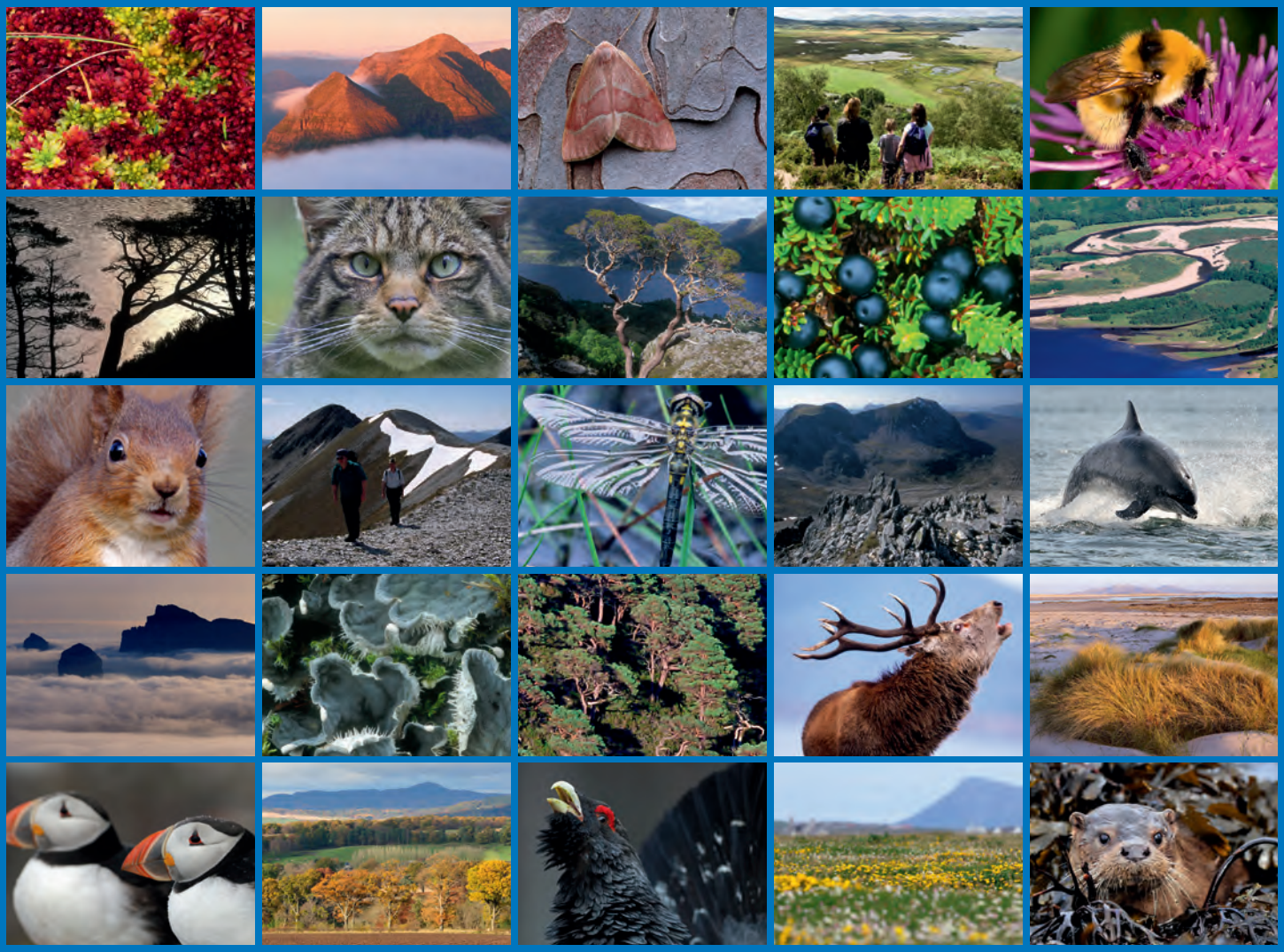
Scottish Natural Heritage
Commissioned Report No. 553

The Scottish Beaver Trial: Ecological monitoring of the European beaver *Castor fiber* and other riparian mammals – Third Annual Report 2012



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COMMISSIONED REPORT

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The Scottish Beaver Trial: Ecological monitoring of the European beaver *Castor fiber* and other riparian mammals – Third Annual Report 2012

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COMMISSIONED REPORT

Summary

The Scottish Beaver Trial: Ecological monitoring of the beaver *Castor fiber* and other riparian mammals – Third Annual Report 2012

Commissioned Report No.: 553
Project no: 7062
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Background

In 2008, the Scottish Government approved a licence for the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS), to undertake a five-year trial reintroduction of the European beaver *Castor fiber* after an absence of over 400 years. The aims of the trial include an assessment of the ecology of the beavers, and their impacts on the Scottish environment. The success or failure of the trial will be based on a number of specific criteria, which relate to the ability of the reintroduced population to sustain itself, the effects of the beavers on biodiversity, the economic effects of the beavers, and the cost of their reintroduction and ongoing management.

In order to effectively assess the Scottish Beaver Trial (SBT), Scottish Natural Heritage (SNH) is coordinating a monitoring programme, in collaboration with a number of independent organisations. A core element of this is the monitoring of the beaver population itself. SNH is, therefore, working in partnership with the Wildlife Conservation Research Unit at the University of Oxford (WildCRU) in order to ensure the monitoring of the beavers, and other riparian mammals present at Knapdale, is suitable and appropriate. WildCRU are responsible for independent analysis of data received on the ecology of the released beavers; this is the third of five annual reports planned over the duration of the Scottish Beaver Trial. The aim of this report is to report on and summarise the data gathered on the ecology of the beaver population and other riparian mammals, and to present analyses that address the relevant success and failure criteria of the trial, and that address key ecological questions relevant to the study of the ecology and biology of the European beaver in the Scottish environment. The current report collates ecological monitoring data to the end of the third year of the trial (to June 2012). A full assessment against these criteria will not take place until the end of the trial hence these findings are very much interim.

Main findings

- A total of fifteen beavers in five families or pairs were released during the first year of the trial, and one further animal during the second year of the trial. Three deaths, all males, were recorded during the first year, and a total of four animals went missing over the first two years of the trial. As of June 2012, of the 16 animals released over 2009 and 2010, nine were believed to be alive and present in the release area.

- A total of ten wild-born beavers have been recorded to date; two of these were predated as kits. Litter size has varied between one and three kits per reproducing pair. During the third potential breeding season of the trial (technically Year 4 of the trial), three of four beaver pairs successfully produced kits.
- The beaver population present at Knapdale is currently increasing slowly. Mortality of established animals appears to be low, and, although reproduction has been slow to establish, increases in litter size in 2012 (Year 4), and production of at least one kit by one of the more recently released pairs of beavers, suggests that reproductive rates may increase in subsequent years.
- For those animals that survived six months or more post-release, there has been no evidence of a decline in body condition; all of these individuals have either maintained their pre-release body weight, or increased in weight.
- Beavers at Knapdale currently remain in four discrete family groups, covering a total area of 422.8 ha, at a density of approximately one beaver family per 4 km of waterway edge.
- Use of GPS tracking and temperature-depth recorders (TDRs) were considered to be useful additional monitoring tools to provide further insights into the behaviour of beavers at Knapdale – detailed analysis of GPS data and TDR data will be included in future reports.
- Two sub-adults released at the start of the trial have apparently dispersed; one wild-born sub-adult also appears to have dispersed. SBT will actively seek records of beavers outwith the trial area during the last year of the trial, with a view to providing information on dispersal movements and distances travelled.
- Thus far, there is no evidence that beaver reintroduction has had a negative impact on the presence of otters in the area.

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For further information on the monitoring of the Scottish Beaver Trial see:
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This project is supported through a partnership of Scottish Natural Heritage and the University of Oxford Wildlife Conservation Research Unit as part of the monitoring of the Scottish Beaver Trial. The authors thank the Royal Zoological Society of Scotland (RZSS), the Scottish Wildlife Trust (SWT), and Forestry Commission Scotland for their help and cooperation. RZSS and SWT have also contributed funds to the overall monitoring programme.

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1. INTRODUCTION

1.1 Background

The European, or Eurasian, beaver *Castor fiber* became extinct in Scotland around the 16th century as a result of over-hunting. Over recent years the potential for restoring this species to the natural fauna has been investigated. These investigations have resulted in a suite of information with regard to the scientific feasibility and desirability of conducting such a reintroduction. Relevant documents published by Scottish Natural Heritage (SNH) can be viewed at www.snh.gov.uk/scottishbeavertrial.

The work undertaken is in line with obligations on the UK Government, under Article 22 of the European Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna (the 'Habitats Directive'), to consider the desirability of reintroducing certain species (listed on Annex IV), including European beaver.

The Species Action Framework, launched in 2007 by Ministers, and completed in 2012, set out a strategic approach to species management in Scotland. In addition, 32 species, including European beaver, were identified as the focus of new management action for five years from 2007. SNH worked with a range of partners in developing this work and further information can be found at www.snh.gov.uk/speciesactionframework.

In May 2008, the Scottish Government Deputy Minister for the Environment approved a licence to allow a trial reintroduction of up to four families of European beaver into Knapdale Forest, mid-Argyll.

The licence has been granted to the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS), who are managing the 'Scottish Beaver Trial'. The trial site, Knapdale Forest in Argyll, is owned by Forest Commission Scotland (FCS). Several families of animals were caught in Norway during 2008 and quarantined for six months. Three families were released in spring 2009, and a further two pairs[1] in May and June 2010. The release sites were Loch Coille Bharr, Loch Linne/Loch Fidhle, Creagmhor Loch and un-named Loch (south), also known as the 'Lily Loch'. The release is being followed by a five-year period of monitoring that will run until May 2014. SWT and RZSS have dedicated field staff in place to cover this period.

One of the objectives of the Scottish Beaver Trial, as set out in the original licence application submitted by SWT and RZSS, includes the 'study of the ecology and biology of the European beaver in the Scottish environment', which will, in part, fulfil another of the objectives, to 'generate information during the proposed trial release that will inform a potential further release of beavers at other sites with different habitat characteristics'.

The licence issued by The Scottish Government to the RZSS and SWT came with a number of conditions, a key one being that the monitoring of the project must be independently coordinated by SNH. As part of this process, SNH has, therefore, entered a partnership with the Wildlife Conservation Research Unit (WildCRU) at the University of Oxford to support, enable and report on the ecological monitoring of the beaver population and other riparian mammals[2] during the trial period. This is one element of a wider monitoring programme, coordinated by SNH, which includes:

[1] The fifth family was released, under agreement from the Scottish Government, as a replacement for the first family that failed to establish.

[2] The number of 'other riparian mammals' that we are able to monitor is limited by resources and therefore we chose to concentrate on the otter because it is a qualifying feature of the Taynish and Knapdale Woods Special Area of Conservation. We included American mink and water vole because field signs for these two species can potentially be detected while carrying out otter surveys, and thus

- Beaver health
- Terrestrial vegetation
- Aquatic/ semi-aquatic macrophytes
- Fish
- Odonata
- Water chemistry
- Hydrology
- Riverine geomorphology
- Socio-economics
- Public health
- Scheduled monuments

WildCRU does not have a lead role with any of the other monitoring projects listed above, but the various elements are coordinated so that data can be efficiently collected and shared by those involved with the monitoring programme.

1.2 Success and failure criteria

The licence application sets out *success criteria* for the project, some of which are specific to the ecology of the beaver (rather than the wider socio-economic and other environmental aspects of the trial), and thus are particularly relevant to the ecological monitoring work carried out. These are, that:

- **Survival of introduced animals is similar to that of successful reintroduction programmes elsewhere in Europe at a similar stage of population establishment.**
- **A stable or increasing core population is achieved within the limits of the study site.**

There are also *failure criteria.* The failure criteria specific to the ecology of the beaver are, that:

- **Mortality levels preclude establishment of a population.**
- **Significant and unsustainable damage is incurred by the ecosystem within the study site.**

1.3 Relevant objectives of the Scottish Beaver Trial

Specific *relevant objectives* of the Scottish Beaver Trial are to *'study the ecology and the biology of the European beaver in the Scottish environment'* and thus to *'generate information during the proposed trial release that will inform a potential further release of beavers at other sites with different habitat characteristics.'*

Further, although not stated explicitly initially as an objective of the ecological monitoring, for any reintroduction it is important to be able to assess post-release behaviour of animals. With both animal welfare and future success (of further releases, if the decision is made to reintroduce beavers) in mind, and given the disturbance that animals are subject to during capture, quarantine and release, it is crucial to be able to assess whether or not individual animals were negatively affected by the process, and how well they have adapted to their new environment. This question can be addressed by assessing the health of the animals and their stress levels, as well as various demographic parameters (such as survival and

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without the requirement for additional resources. The water shrew is designated as a Species of Conservation Concern in the UK but we are not aware of any water shrew records from Knapdale so this species was not included in the monitoring programme.

reproductive success), but behaviour is also key (partly because aberrant behaviours can be relatively easily detected).

An additional aim of the ecological monitoring project (Campbell *et al.* 2010 p3) is to *'ensure the methodology includes the collation of suitable data which will allow the refinement of the existing beaver population model commissioned by SNH (Rushton et al. 2002), thereby improving our ability to predict future trends in beaver populations should the trial support the case for further reintroductions.'*

1.4 Addressing relevant success/ failure criteria, and objectives of the trial

We have now changed the format of the annual reports for the ecological monitoring, in order to more clearly address the success/failure criteria of the trial, and the stated objectives and trial aims. Previous reports were organised around the methods used, as stated in the original methodological protocols (published as Campbell *et al.* 2010). Here, and in following reports, we initially provide a brief overview of the animals present at Knapdale, and a very brief summary of the monitoring methods, before the three main sections of the report that address beaver demographics, morphometrics and body condition, and, ecology and behaviour. The final section covers monitoring of other riparian mammals.

The success and failure criteria of the trial are addressed by analysis of beaver demographics, with the exception of an assessment of 'significant and unsustainable damage to the ecosystem' which is primarily being addressed by other monitoring partners, but is supported by the monitoring of other riparian mammals which is reported on here. Health of the beavers at Knapdale will be reported on by the Royal (Dick) School of Veterinary Studies, but a broad assessment of body condition is included here because of the obvious link between individual body condition and population demographics, and ecology/behaviour. The broader trial objective of studying the ecology of beavers in the Scottish environment, is addressed by assessing home range size and location of beaver families, spatial organisation, activity patterns, and habitat use, all of which are covered in the section on ecological data. Although, to what extent these findings will be *relevant at other sites with different habitat characteristics* is more difficult to assess (since spacing patterns or habitat use might differ in different habitats/environments), and may require wider comparisons with similar projects elsewhere in Europe – this particular project objective is not addressed in this report but will be considered, as far as is possible, in the final report at the end of the trial. To address the additional, but important, objective of assessing the behaviour of translocated beavers (above), we have added a number of methodological protocols that will allow a more detailed insight into the behaviour of released beavers at Knapdale that are additional to the original methodological protocols but that can be carried out alongside existing monitoring and without significant increases in either workload (for SBT) or animal handling (see sections 6.3 and 6.4).

This report covers monitoring of the ecology of released beavers and other riparian mammals to the end of the third year of the Scottish Beaver Trial (June 2012). Note that beaver families will now be referred to by their loch names for consistency with other monitoring projects (original names (numbers 1-5) are also given to allow cross-referencing to earlier ecological monitoring reports). Note that there has been some exchange of individual beavers between families over the trial period; Loch names in this report refer to beaver locations during Year 3 rather than their original site of introduction.

2. ANIMALS AT KNAPDALE

Between May 2009 and September 2010[3], a total of 16 beavers have been released. There are currently no plans to release more beavers in Knapdale for the duration of this trial, in accordance with amended licence conditions.

Table 1. Fate of beavers released in Knapdale, Argyll (2009 – 2012). Released animals known to be alive and present at the release site at the time of reporting are highlighted in grey.

Name	Sex	Age[a]	Family[b]	Release data	Release loch	Current loch (new family name)	Fate (as of June 2012)
Andreas Bjorn	M	5+	1	31/05/2009	Creagmhor Loch		Withdrawn from programme Dec 2009; died in captivity May 2010
Gunn Rita	F	5	1	31/05/2009	Creagmhor Loch		Missing[c]
Mary Lou	F	1	1	31/05/2009	Creagmhor Loch		Missing[c]
Frank	M	Unk	2	30/05/2009	Loch Linne	Loch Linne	Alive
Frid	F	Unk	2	30/05/2009	Loch Linne	Loch Linne	Alive
Biffa	M	2	2	30/05/2009	Loch Linne		Missing[d]
Biffa's brother	M	2	2	30/05/2009	Loch Linne		Dead (shortly after release)
Bjornar	M	Unk	3	30/05/2009	Loch Coille-Bharr	Dubh Loch	Alive
Katrina	F	Unk	3	30/05/2009	Loch Coille-Bharr	Dubh Loch	Alive
Millie	F	2	3	30/05/2009	Loch Coille-Bharr	Dubh Loch	Alive
Marlene	F	2	3	30/05/2009	Loch Coille-Bharr		Missing[e]
Tallak	M	5+	4	04/05/2010	Un-named (S) or 'Lily Loch'		Dead (approx 2 weeks post-release)
Trude	F	2	4	04/05/2010	Un-named (S) or 'Lily Loch'	Loch Buic	Alive
Eoghann	M	2	5[f]	23/06/2010	Creagmhor Loch	Loch Buic	Alive
Elaine	F	2	5[f]	23/06/2010	Creagmhor Loch	Lochan Beag	Alive
Christian	M	3	4[g]	21/09/2010	Loch Buic[g]	Lochan[h] Beag[h]	Alive

[a] Estimated age at time of release; post-mortem tooth sectioning revealed Andreas Bjorn to be > 7 years old, and Tallak to be > 15 years old (Frode Bergan, Telemark University College, unpub. data).
[b] Numerical 'family names' as used in previous reports.

[3] Scottish Government granted permission for the replacement of dead or dispersed adult beavers for the period up to May 2011.

[c] Gunn Rita disappeared in the second week post-release, her female yearling (Mary Lou) disappeared in mid-July 2009.
[d] Biffa was last seen in February 2011.
[e] Telemetry signals suggested that Marlene was on a nearby sea loch in August 2009, but this was not confirmed visually (she has not been seen since).
[f] The fifth pair of beavers was released as a replacement for the loss of Family 1 (Loch Creagmhor) with the aim of establishing a minimum of four potential breeding pairs in the release area by May 2011.
[g] Christian was released to provide a mate for Trude following the death of Tallak; he was released into Loch Buic where Trude had established a small burrow and was regularly observed feeding. (Christian was released at the far end of the loch at an artificial lodge where his scent had been placed prior to release - the two beavers paired up on the night of Christian's release and remained together until the end of Year 2.).
[h] Also known as Un-named Loch (N).

Table 2. Wild-born beavers in Knapdale, Argyll (2009 - 2012).

Name	Sex	Year of birth	Mother	Loch	Fate (as of June 2012)
Barney	M	2010	Frid	Loch Linne	Alive (2 years old)
2	?	2010	Katrina	Dubh Loch	Alive (2 years old)[1]
3	M	2011	Frid	Loch Linne	Alive (1 year old)
4	M	2011	Katrina	Dubh Loch	Predated as a kit
5	F	2012[2]	Frid	Loch Linne	Predated as a kit
6	?	2012[2]	Katrina or Millie[3]	Dubh Loch	N/A[5]
7	?	2012[2]	Katrina or Millie[3]	Dubh Loch	N/A[5]
8	?	2012[2]	Katrina or Millie[3]	Dubh Loch	N/A[5]
9	F	2012[2]	Trude[4]	Loch Buic	N/A

[1] Missing as of summer 2012; last sighting was on camera trap on 24/05/12.
[2] Preliminary data for Year 4 monitoring
[3] Maternity unknown (kits were lost before being captured and thus genetic testing not possible)
[4] Film footage suggested that this female was pregnant last year (2011), but no kits were seen; Elaine (the female beaver at Lochan Beag) was also thought to be pregnant this year, and there were signs that she was pregnant last year, but no kits have been observed
[5] Preliminary Year 4 data suggests that all three of these kits have been lost and are presumed dead.

3. SUMMARY OF ECOLOGICAL MONITORING TO DATE

3.1 Animals released

A total of fifteen beavers in five families or pairs were released during the first year of the trial, and one further animal during the second year of the trial. Three deaths, all males, were recorded during the first year (two of these deaths occurred shortly after release, the third animal was withdrawn from the trial due to ill-health approximately seven months post-release). A further three animals were also classified as 'missing' (fate unknown) by the end of the first year. No further deaths were recorded during the second year of the trial, but one further animal was recorded as missing. Two of the four missing animals were sub-adults (one was two years old and disappeared in the first month post-release, the other was three years old and disappeared two years post-release). No further deaths (of released animals) or missing animals were recorded in the third year. As of June 2012, of the 16 animals released over 2009 and 2010, nine were believed to be alive and present in the release area (see Table 1 above).

3.2 Wild-born animals

In both the second and third year of the trial, two kits were recorded (one per pair for each of the two pairs that successfully reproduced). Preliminary data from this summer (2012) suggest that five kits have been born to three pairs (the Dubh Loch pair produced three kits). As of June 2012 (the end of the third year of the trial), two wild-born sub-adults and one wild-born yearling were present in the population (as of October 2012, four kits were also known to be present – this will be fully reported on in the Year 4 report). Over the course of the trial, two kits have been predated (one in 2011 and one in August 2012). One of the wild-born sub-adults appears to have dispersed (at two years of age). See Table 2 (above).

3.3 Methodology

Detailed methodological protocols are given in Annex 1. Here we summarise briefly the methods currently utilised and the information obtained from each.

Annual trapping

SBT aim to trap all individual beavers at least once each year, which provides data on survival and animal health[4] as well as the additional opportunity to deploy GPS tags or other remote monitoring devices whilst minimising the number of times an animal is trapped. However, the male beaver on Dubh Loch (Bjornar) appears to be particularly difficult to trap and it is not always possible to trap all individuals each year (Christian, for example, has not been trapped at Knapdale since his release in September 2010, although he has been observed repeatedly on Lochan Beag (initially on Loch Buic), and SBT report that he appears to be healthy). A particular aim of the trapping is to capture and mark all wild-born animals to allow assessment of their survival and movements; to date, both wild-born animals on Loch Linne have been captured and marked with ear tags, but the wild-born animal on Dubh Loch was not marked and has now disappeared (probably dispersed).

Monthly observations

Monthly observations carried out by SBT, primarily for management purposes, also contribute information on survival and location. These data are incorporated into survival and home range analyses as appropriate.

[4] Animal health is reported on in detail by the relevant independant monitoring partner, the Royal (Dick) School of Veterinary Studies, but basic measures of body condition are included in the ecological monitoring.

Summer lodge/den counts

Systematic lodge/den counts were initiated in the third year of the project in an attempt to ensure accurate counts of kits are produced each summer. Counts were initially conducted from mid-July to end of August, but extended to the end of September for summer 2012 (technically the fourth year of the project) because some kits were first seen emerging from the den in mid-September last summer (2011). SBT report that lodge/den counts are not the most efficient method for counting kits and suggest that it offers no advantage over simply counting kits seen during normal monthly observations[5]. One possibility is the use of two to three infra-red cameras at lodges, rather than observers (who are limited by darkness). The use of infra-red cameras will be trialled next year (summer 2013), carried out alongside observational lodge counts to allow assessment of the relative efficiency of the two methods.

Field sign surveys

Seasonal field sign surveys continue to provide essential ecological information on the areas used by beavers (home range location and size) and their terrestrial habitat use, and provide continuity for the data collected thus far. The potential limitation of field sign surveys is that individual/family identity cannot be confirmed and although most field signs still occur in four relatively distinct clusters (reflecting the current four family groups) that may not remain the case throughout the trial. To address this potential issue over the remaining two years, camera traps will be deployed on an *ad hoc* basis, as necessary, to cover areas where use needs to be assigned to specific beavers.

GPS tracking

During the second year of the project, preliminary trials investigating the potential use of inexpensive GPS transmitters indicated that GPS tracking would be a feasible and potentially useful monitoring tool for recording nightly movements and verifying home range boundaries (defined on the basis of field signs). Therefore, further amendments were made to the ecological monitoring methods to include GPS tracking[6]. The GPS tags record for a limited duration (maximum 10 days) and therefore, given this limitation as well as the extra trapping effort required to deploy tags on animals and to retrieve the tag, the original aim was to obtain snap-shot data on all adult beavers but with effort spread over the remaining two full years of the trial. During initial deployments of GPS tags, one tag was lost and three tags were damaged by beavers chewing them (resulting in datasets shorter than 10 days). The success and potential usefulness of GPS tracking will continue to be assessed as Year 4 of the trial progresses.

Time-depth recorders

An additional new method introduced in the third year (2012) of the project was the use of time-depth recorders (TDRs). The use of these devices was opportunistic insofar as they are small, lightweight devices (31 mm length, 8 mm diameter, weight 2.7 g in air and 1 g in water) and can be deployed attached to GPS tags so that no additional animal handling was required and no additional time required of SBT staff (the devices themselves were supplied by the Wildlife Conservation Research Unit). These devices will potentially provide information on the extent to which beavers use the aquatic habitat; information that cannot be inferred from either GPS telemetry locations (fixes are not picked up in water and are too low resolution to be able to distinguish between a beaver at the edge of the loch and a

[5] Night-vision goggles were trialled but found not to be useful because identification of individual beavers was not possible.

[6] Observational methods were reduced since they were originally introduced to replace VHF tracking that was unsuccessful at Knapdale.

beaver on the bank) or by field signs. TDRs are capable of recording depth and temperature at 1 second intervals (for approximately six days), providing very detailed dive profiles, and thus will also provide additional 'non-essential' information on the diving behaviour of beavers at Knapdale. Whilst not part of the original essential ecological monitoring protocol, data will be presented here alongside nightly movements inferred from GPS telemetry locations, and observational data from the first two years of the trial, with a view to assessing the general behaviour of translocated beavers. To date, we have six datasets (from two female beavers in both summer and winter, and two male beavers in winter). Use of TDRs will continue as long as GPS tags are being used.

Behavioural observations

Behavioural observations (beyond the monthly observations referred to above) were not carried out in the third year of the study as they were judged to not add greatly to the field sign surveys and were time consuming to collect. There are currently no plans to repeat these observations during the existing trial.

Annual surveys for other riparian mammals

Annual otter surveys were carried out by SNH; these surveys are designed to detect substantial changes in otter presence or use of the site by otters. Since the literature on otter-beaver interactions suggests that a positive impact of the beaver release would be more likely than a negative impact, the surveys were not designed to provide high levels of statistical power to detect small changes in spraint density (which in any case is not related clearly to otter density), but rather to be able to detect a disappearance of otters (caused by beavers) or major decline or increase in their activity at beaver-occupied sites. Mink and water vole field signs are also recorded opportunistically.

4. DEMOGRAPHIC DATA

4.1 Survival of translocated animals

A crude estimate of minimum survival of released animals to the current time is given by the number known to be currently alive, still being monitored and present within the original release area (nine), divided by the total number of animals released (16). On this basis, we estimate minimum survival to the end of the third year of monitoring to be 0.56. This estimate includes only known survivors (missing animals are considered dead), and treats all released individuals equally, although, in reality, staggered releases over the first two years of the trial (Table 1) mean that some individuals have survived three years post-release whereas others have only, thus far, survived two years post-release. Interval estimates that calculate survival rates over specific time periods (i.e. one year post-release) and take account of the loss of animals to monitoring (i.e. those that are lost and for which fate is unknown) can be obtained using methods such as Kaplan-Meier survival analysis and the usefulness of these methods will be considered in future years.

As is common in reintroduction and translocation projects, the number of known survivors declined initially (due to immediate losses of animals, as a result of mortality – several stress-related (see below) - and dispersal from the release area). Most early losses of individuals occurred in the first two months post-release. Number of known survivors has tended to stabilise over time, with losses now being due to the occasional dispersal of animals that were released as sub-adults within their family groups (Fig 1).

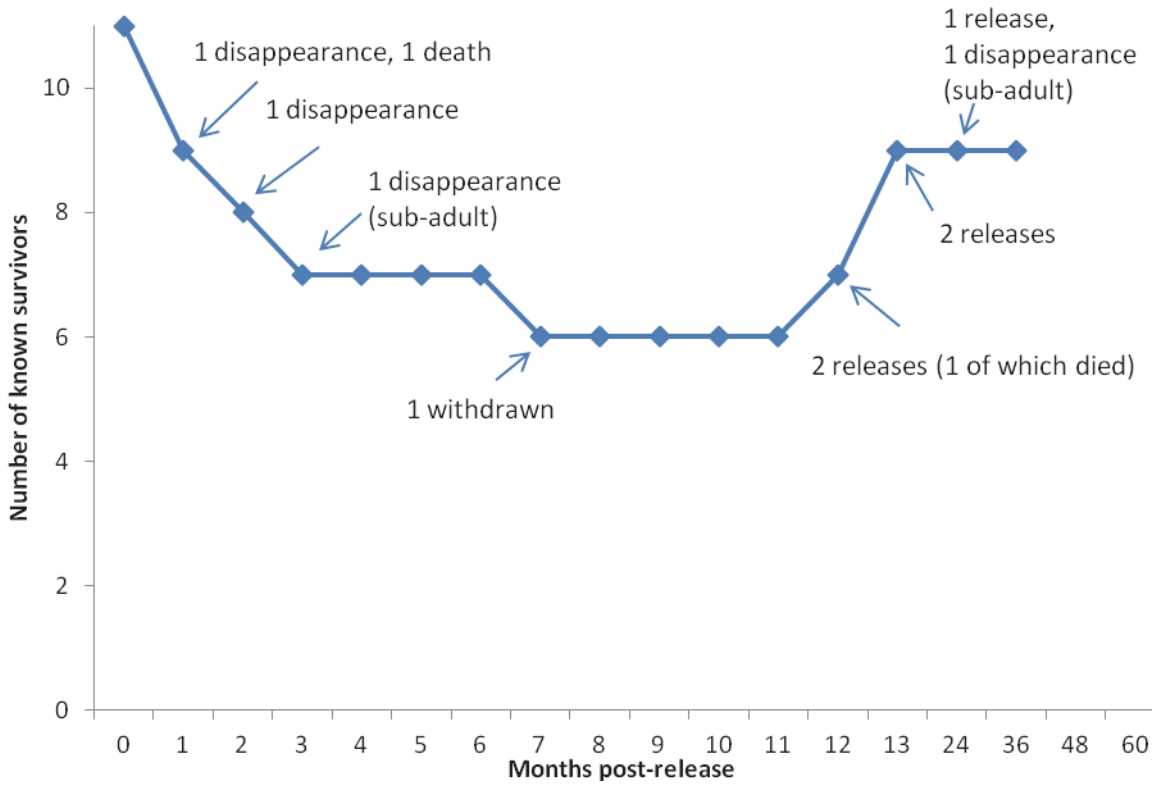


Figure 1. Number of beavers known to be surviving at Knapdale over time since initial release. Missing animals, in this case, are not counted and are presumed dead.

4.2 Population structure

Beavers were released in five 'family' groups; three families (released in 2009) included one to two sub-adults each, the other two families (released in 2010) were released as breeding

pairs (the subsequent discussion excludes the Creagmhor family, released in 2009 with one sub-adult, that did not settle and establish a home range at the site, see Table 1, and Harrington *et al.* 2011, 2012). Of the two families with sub-adults that settled at the release site, one sub-adult in each family – Marlene from the Dubh Loch family, and Biffa from the Loch Linne family - had dispersed by the end of the second year post-release[7] (one of the sub-adults – Biffa's brother from the Loch Linne family - also died shortly after release); only the Dubh Loch family still includes one of the released sub-adults – Millie[8] - at the end of the third year post-release (Table 3).

Breeding began in the summer of 2010. At the end of the third year (June 2012), the Dubh Loch and Loch Linne families had one wild-born sub-adult present each (the Dubh Loch sub-adult - dispersed during summer 2012) (Table 3). The Loch Linne family also has a yearling present (as of June 2012) (Table 3). The two pairs on Loch Buic and Lochan Beag would not have been expected to breed until 2011 as they were not released until 2010: one of the females – Trude from the Loch Buic pair - was suspected pregnant in summer 2011 (note that the male partners of each of these pairs exchanged places sometime between April and October 2011) but did not successfully produce kits; Trude produced one kit in summer 2012. There were signs that Elaine from the Lochan Beag pair was also pregnant in both 2011 and 2012, but kits have not yet been observed (as of October 2012).

The Loch Linne and the Dubh Loch families continued to successfully produce kits in 2012 (the Dubh Loch family produced three, the largest litter size[9] at Knapdale to date), the Loch Linne family produced one (that was predated). At the end of the third year of the trial, the four extant beaver families were composed of two to three adults, zero to one subadults, zero to one yearlings, and up to three kits (Table 3).

Table 3. Changes in beaver family composition (post-kit emergence) at Knapdale (2009 – 2012). Non-breeding beavers that are 2 years of age or older are considered sub-adults; breeding animals are considered adults. (This summary excludes the original Creagmhor family that failed to settle).

Family	2009[1]	2010	2011	2012	2013
Loch Linne	Adult male Adult female 2 sub-adults	Adult male Adult female 1 sub-adult 1 kit	Adult male Adult female 0 sub-adults 1 yearling 1 kit	Adult male Adult female 1 sub-adult 1 yearling 1 kit (predated)	
Dubh Loch	Adult male Adult female 2 sub-adults	Adult male Adult female 1 sub-adult 1 kit	Adult male Adult female 1 sub-adult 1 yearling 1 kit (predated)	Adult male 2 Adult females[2] 1 sub-adult[3] 0 yearlings 3 kits	
Loch Buic	-	Adult male Adult female	Adult male Adult female[4]	Adult male[5] Adult female 1 kit	
Lochan Beag	-	Adult male Adult female	Adult male Adult female	Adult male[5] Adult female[6]	

[1] as released.
[2] Millie (released as a sub-adult may now be the breeding female).
[3] This wild-born sub-adult (unconfirmed sex) went missing in the summer 2012.
[4] Suspected pregnant but no kits produced.
[5] Male partners exchanged places between the Loch Buic and Lochan Beag pair in early summer - autumn 2011
[6] Suspected pregnant but no kits observed yet (as of October 2012).

[7] Marlene disappeared the same summer of her release (see Table 1).
[8] Millie is now (at the end of Year 3) considered an adult; it is possible that she is the mother of the kits born at Dubh Loch in the summer of 2012 (Table 2, 3).
[9] Note that because kits are counted as they are observed emerging from the lodge, litter size at birth may be underestimated.

4.3 Reproduction

No reproduction was expected in Year 1 (summer 2009) because no females were released (in May 2009) pregnant; during Year 1, females of the Loch Linne and Dubh Loch families may have become pregnant following mating in the winter of 2009/10, and thus could have produced kits at the beginning of Year 2 (summer 2010) but the Loch Buic pair and the Lochan Beag pair had only just been released and so could not have reproduced. Thereafter, (from the winter of Year 2, with kits potentially produced at the beginning of Year 3 - summer 2011), four mature breeding pairs were present. Reproductive histories of each family are summarised in Table 3 (above). In the third year of the trial, 3 of 4 beaver pairs successfully reproduced, litter size ranged between 1 and 3 (mean = 1.67), and the reproductive rate was 1.25 (defined as the proportion of pairs that successfully reproduce x the mean litter size, Table 4). Throughout the trial, thus far, annual reproductive rate has ranged between 0.5 and 1.25.

Table 4. Beaver reproduction in Knapdale (2009-2012). Data are number of pairs that could reproduce (N), proportion of pairs successful (p.pairs), mean litter size of successful pairs (ml), reproductive rate (Rr); where reproductive rate is defined as p.pairs x ml, and litter size is the number of emerging kits (as in Nolet et al. 2005).

Year	N	p.pairs	ml	Rr
2009	0	-	-	-
2010	2	1.0	1	1.0
2011	4	0.5	1	0.5
2012	4	0.75	1.67	1.25
2013	4			

4.4 Survival of young wild-born animals

Of the total 4 kits born at Knapdale in the second and third years of the trial (2 born per year), 3 (0.75) survived to 1 year of age. Of the two yearlings present in the third year of the trial, both (1.0) survived to two years of age (although one dispersed at two years old, in summer 2012[10]).

4.5 Population growth

The number of beaver families present at Knapdale has remained constant at four, although the size of three of the four families has increased due to wild births, and a total of seven additional wild-born beavers[11] has been added to the population over the duration of the trial thus far.

[10] In future years, we will be unable to report survival of wild-born two year olds to adulthood because we will not be able to distinguish between dispersal (and subsequent loss to monitoring) and death of an individual.

[11] Including four surviving kits born in summer 2012 (technically Year 4 of the trial).

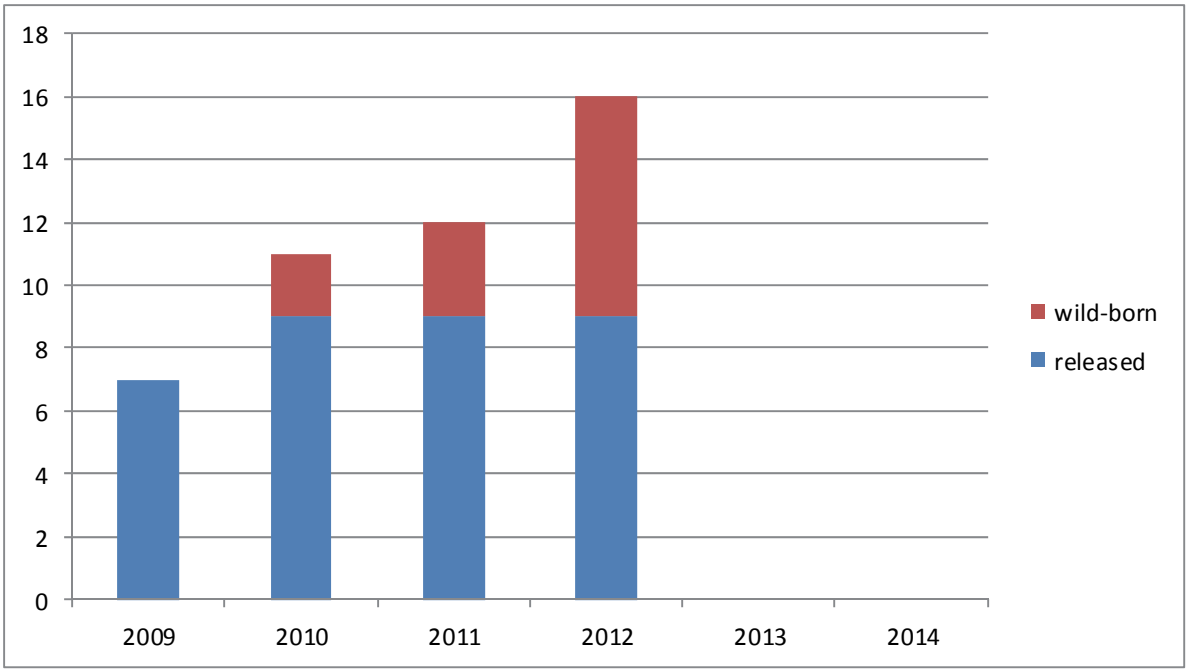


Figure 2. Total number of beavers present in Knapdale in August of each year.

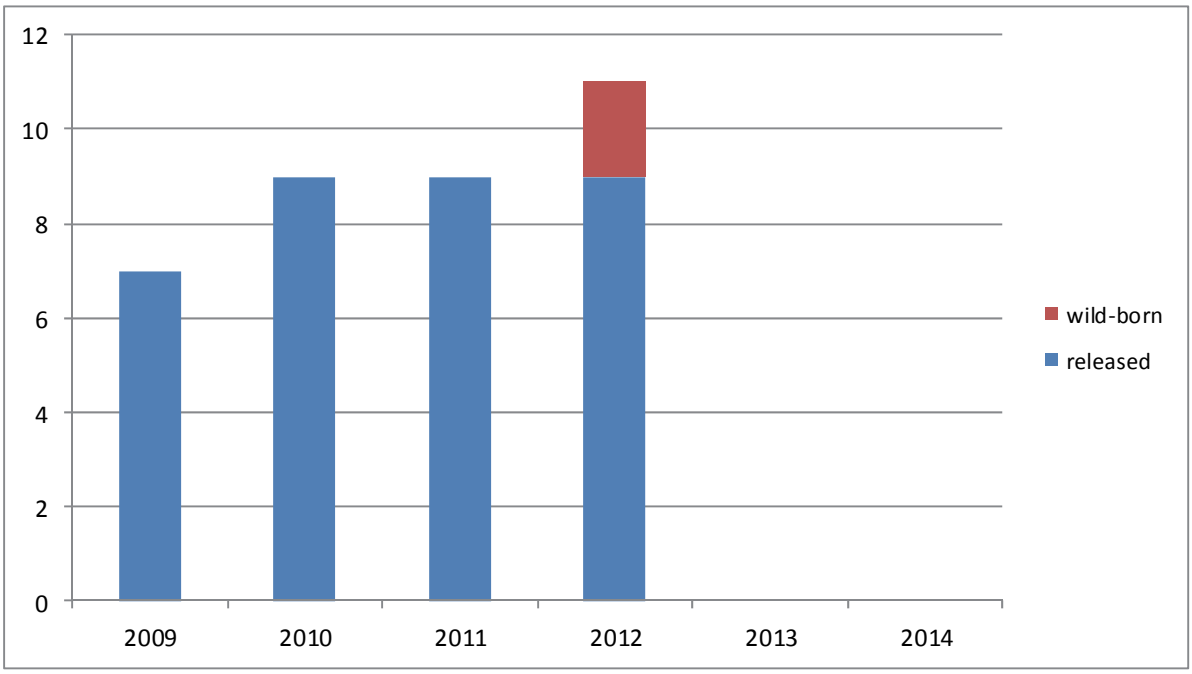


Figure 3. Total number of sub-adult and adult beavers (including all beavers two years of age or older, i.e. breeders and non-breeders in family groups) present in Knapdale in August of each year

A total of four sub-adults (three released, one wild-born) appear to have dispersed, but the low numbers and the fact that they (presumably) left the occupied area in different years mean that the chances of individual beavers (of opposite sex) meeting and forming new families is low. The two most recent presumed dispersals were the released sub-adult male

– Biffa – from the Loch Linne family (last seen in February 2011) and the wild-born sub-adult, of unknown sex, from the Dubh Loch family (missing since the summer of 2012).

4.6 Mortality

Of the total 16 animals released, three deaths were recorded (all during the first year of the trial, and all male), equating to a post-release mortality rate of 0.19 (or approximately 20%). Andreas Bjorn was found in poor body condition and withdrawn from the programme in December 2009 (seven months post-release) and died five months later in captivity of heart failure. Tallak died a couple of weeks post-release and post mortem results suggest that he did not feed, most likely due to an individual failure to cope with the stress of change in environment (S. Girling, RZSS, pers. comm.). Andreas Bjorn and Tallak were both older males (at least 7, and at least 13, years old, respectively, Frode Bergan, Telemark University College, unpub. data[12]). The only younger (two year old) male to die post-release, died overnight on the day of release; this animal was found to have lung, liver and kidney congestion suggestive of sub-acute circulatory failure[13] (G. Goodman, pers. comm.). Beaver health is being monitored by the Royal (Dick) School of Veterinary Studies, and further details will be available in a separate report at a later date.

Of the 9 kits born at Knapdale (to date, October 2012), two were predated (one in summer 2011 and one in summer 2012). This equates to a total kit mortality rate of 0.22; and yearly kit mortality rates of 0.5 and 0.2, respectively. It is not clear, however, whether the one predation rate observed per year thus far is likely to increase proportionally with an increase in the number of kits produced, or whether they were both rare chance events.

4.7 Population persistence

Towards the end of the trial we will carry out simple population viability modelling using VORTEX in order to make preliminary assessments of likely persistence of beavers at Knapdale, based on current population size and population growth rates observed during the trial.

4.8 Comparisons with beaver reintroductions elsewhere in Europe

Although there have been a number of beaver reintroductions throughout Europe (reviewed in Halley and Rosell 2002; Dewas *et al*. 2012), few documents reveal data in sufficient detail to make comparison with the Knapdale population. The best documented reintroduction of beavers is the Biesbosch population reintroduced to the Netherlands between 1988 and 1991 (Nolet and Baveco 1996; Nolet *et al*. 2005). The beaver population in the Biesbosch experienced low reproductive rates in the initial years of establishment (due to low quality food associated with climatic changes). For comparison, annual reproductive data for the Biesbosch population were as follows: proportion pairs that successfully bred = 0.25-0.77; mean litter size (per successful pair) = 1-3.33; reproductive rate (mean juveniles/pair – for all pairs) = 0.5-1.46. Thus far, the proportion of pairs that successfully bred at Knapdale compares favourably (current range 0.5 – 1.0, with 0.75 pairs breeding this year); mean litter size is currently lower than in the Biesbosch (current range 1-4, but the birth of a litter of 3 kits this year (2012) may suggest that this parameter will increase in future years – see above 4.3); reproductive rate across all pairs at SBT is currently comparable, or slightly higher than in the Biesbosch (current range 0.5 – 1.25, see Table 4 above).

[12] Animal age was confirmed by cementum analysis of teeth taken from the carcasses; from a welfare point of view it would be ideal to know the age of the animals before the decision was made to trap them from the wild for translocation but this was not possible in this case.
[13] There was no evidence of infection or degenerative disease (G. Goodman, pers. comm.).

During Year 4, we will seek further comparative data, from reintroductions elsewhere in Europe and, in future reports will attempt to draw further more detailed comparisons with these, as far as possible, and with the wild source population in Norway (if comparative data are available).

4.9 Questions relevant to the success/failure criteria of the trial

Here we outline some initial thoughts on the questions posed at the beginning of the report. We will not be able to draw proper conclusions until the end of the trial and stress that these notes are preliminary and based on an incomplete dataset. The current early stage of the release, and the fact that some of the animals are still only in the second year post-release, mean some of the demographic parameters could change as the trial progresses and hence whilst presented for information, we are not yet able to draw any conclusions on these key questions.

Are survival/mortality/reproductive rates similar to that of successful reintroduction programmes elsewhere in Europe at a similar stage of establishment?

Survival (of translocated animals) appears to be influenced predominantly by early post-release mortality. Early losses of animals (within seven months of release, most within two weeks) were relatively low (20%) (compared with reintroductions in general), but considerably higher than losses of 2% reported by Bajomi (2011) for the release of 234 beavers in Hungary in the late 1990s (which led to an established population of an estimated 700-900 animals over c. 16 years). Mortality of established animals, however, appears to be low.

The proportion of pairs successfully breeding compares favourably with the Biesbosch population, but litter size and overall reproductive rates are similar (and reproduction at Biesbosch was known to be low). In general, beaver reproduction at Knapdale has been slow to establish, due in part to some animals not being present until 2010, as well as new pairings (see Table 1), and, possibly, inexperience (for some beaver pairs – the Loch Buic and Lochan Beag pair) or even old age of the mother (which may be applicable to Katrina – the adult female released at Loch Coille Bharr/Dubh Loch - and perhaps also Frid, on Loch Linne). Successful production of kits by three of the four beaver families present in the summer of 2012, and the emergence of a litter of three kits suggests that reproductive rates may increase over the following years.

Is the core population stable or increasing?

The beaver population present at Knapdale is currently increasing. The number of adults is increasing slowly, but limited growth of the sub-adult and adult population would be expected over the duration of the trial because of the length of time required for a wild-born beaver to reach sub-adulthood and the small number of families (see Fig 2, 3, above).

Are mortality levels likely to preclude establishment of a population?

Mortality of established animals appears to be relatively low thus far. All beavers appear to be in good health (Roisin Campbell-Palmer, *pers. comm*.), which suggests that the population will grow. The beaver population currently appears to be growing slowly, due largely to a slow start to reproduction (above).

4.10 Data requirements

The low numbers of beavers released mean that estimation of population parameters (particularly age-specific survival of wild-born animals, and reproductive rates) at Knapdale

will be imprecise and may be biased by the large influence of possible chance events (e.g. predation of kits) or demographic effects (e.g. age of the breeding females). To improve our knowledge of beaver population dynamics in a Scottish context, further study of reproductive rates in particular from the larger beaver population in the Tay catchment, would be useful to compliment the SBT data. Although the Tayside population differs from the Knapdale population insofar as there was no pre-release monitoring, there are no details on the size of the founder population, and we are unable to infer anything about early population growth and population establishment on the Tay, the current Tayside population may provide very useful cross-sectional information on dynamics of an established population.

The trial will end in May 2014 and therefore, summer 2013 will be the last year of reproductive data as part of the trial. Hence by the end of the trial only three years of breeding data will be available for all four pairs.

5. MORPHOMETRIC DATA

We report here basic measures of body condition; detailed data on the health of the beavers at Knapdale will be reported on by the Royal (Dick) School of Veterinary Studies.

Thus far, for surviving animals, there has been no evidence of a decline in body condition post-release.

Pre-release and two year post-release morphometric data were available for four individuals (Table 5). Pre-release data were missing for two individuals. Four individuals were not captured during 2012; all of these individuals have, however, been regularly observed and were deemed by field staff to be in good body condition. Biffa, Trude and Eoghann were captured and measured at approximately six months, one year and one year post-release, respectively (see Harrington *et al.* 2011). Data over all years will be collated in the final report.

For those animals that were captured and measured two years post-release, all either maintained their body weight or gained weight (weight gain ranged between 0.9 and 8.9 kg) between release and two years post-release (although it is difficult to make direct comparisons between years because measurements were taken at different times of the year, for logistical reasons, and beaver body weight can fluctuate significantly between seasons). Changes in tail thickness between release and 2 years post-release appeared to be minor (range: -0.47 – 0.76).

Table 5. Pre- and post-release morphometric data for 10 beavers released at Knapdale that survived ≥ six months post-release. Post-release data are two years post-release for all individuals. Data are weight (kg), head-body length (cm), tail thickness[a] (cm).

Animal	Age (years)	Sex	Pre-release	Two years post-release
Frid	(adult)	Female	19.4, 77.5, 2.33	20.3, 74.5, 2.19
Frank	(adult)	Male	12.1, 77.0, 2.36	21.0, 81.0, 1.89
Biffa	2	Male	10.9, 64.0, 1.56	Animal missing
Bjornar	(adult)	Male	Data missing	20.4, 79.5, 2.64
Katrina	(adult)	Female	15.9, -, -	19.5, 78.0, 2.30[e]
Mille	2	Female	Data missing	21.4, 76.0, 2.49
Trude	2	Female	9.1, 66.0, 1.5	Not captured in 2012
Eoghann	2	Male	13.5, 75.0, 1.62	Not captured in 2012
Elaine	2	Female	12.5, 70.0, 1.67	16.2, 75.0, 2.43
Christian	3	Male	16.5, 80.5, 1.85	Not captured post-release

- Data missing

[a] Measured as the mean of four separate measures taken from four standard points on the tail (details in Campbell *et al.* 2010).

6. ECOLOGICAL DATA

6.1 Density of beavers within the release area

The four beaver families currently cover a total area of 422.8 ha, incorporating seven lochs (of which six are utilised; currently only Losgunn (the small loch north of Loch Buic) appears to remain unused by beavers) (Figure 4). The current 'beaver range' incorporates approximately 21.5 km of loch or river bank of which all, minus 4.2 km, appears to be used by beavers. Considering all loch/river bank length available within the occupied range, this equates to a density of c. 0.22 beaver families per km of waterway edge (or, on average, one beaver family per 4 km of waterway edge).

Beaver range size, and the length of loch/river bank length, was calculated in ArcGIS 10.0 (www.esri.com). Beaver range size was estimated based on the smallest convex polygon[14] that enclosed all beaver locations (observations and field signs – field methods in Annex 1) recorded in Year 3. The length of loch/river bank length within the beaver range was measured as the length of waterway edge within that convex polygon.

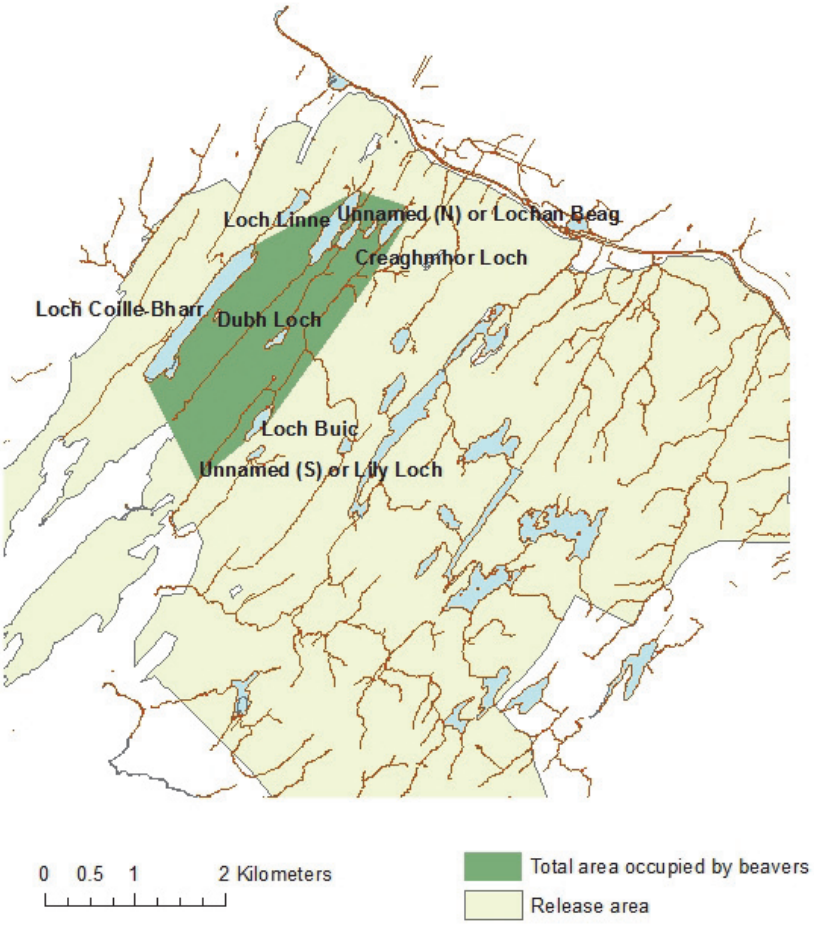


Figure 4. Area occupied by beavers at Knapdale, Argyll, in Year 3 of the trial. Note that 'Unnamed' (S) or Lily Loch now fall outside the occupied area. © Crown copyright and database rights 2013 Ordnance Survey 100017908.

[14] Generated using the Minimum Bounding Geometry function in ArcGIS.

6.2 Number and size of territories formed

Beavers currently remain in four discrete family territories, although there have been changes in the membership of those territories over the last year (see Table 1 above). There have been some minor shifts in focus of activity (see Figures 5 - 8 below), but otherwise all families, with the exception of the Loch Buic family, continued to use their release area. Territory sizes in Year 3 were broadly similar to those of Year 2.

To estimate territory size we used both observational locations and field sign locations (see Annex 1). Territory sizes were estimated at the family level; we did not estimate individual territories (see Harrington *et al.* 2011). At the time of writing this report, two families had been released three years previously, two other families (released as pairs) were released only two years ago (see Table 1 above).

Year 2 territory sizes were calculated in Ranges 7 (www.anatrack.com). On the basis of preliminary analyses in Year 1 (Harrington *et al.* 2011), we considered 100% restricted edge polygons (REPs)[15] (using a restriction distance of 0.2) to provide the most appropriate estimate of territory area. For comparability with other studies of beavers, and in accordance with Herr and Rosell (2004), we also calculated 100% minimum convex polygons (MCPs), and measured the length of waterway edge within the polygon defined by the MCP to provide an estimate of the length of river/loch bank used over the year. Loch/river bank lengths were calculated in ArcGIS 10.0 (www.esri.com). Year 3 locations were overlaid on Year 2 home range polygons in ArcGIS and territory sizes recalculated if there appeared to be any significant change in the area used between Year 2 and Year 3.

In all cases, field signs were inferred as belonging to a particular family on the basis of location – this is currently possible at Knapdale because the majority of field signs occur in relatively clear clusters. Outlying field signs, which were few, were not included in home range polygons. Observational locations were only used in Year 3 analyses if individual identity had been confirmed.

[15] Minimum convex polygons (MCPs) are the smallest polygon that can be drawn around a set of locations where the external angles are all greater than 180º. 100% MCPs include all locations within the polygon; they are a widely used technique and are therefore particularly useful for comparisons among studies. The area and shape of MCPs are heavily influenced by outlying locations and restricted edge polygons (or concave polygons) may provide a better method if MCPs include large areas that are not visited by the animal (e.g. a patch of unsuitable habitat). REPs are constructed by drawing lines between edge locations in the same way as for MCPs except that lines are only drawn if they are shorter than a selected fraction of the range width (the 'restriction distance'; 0.2 in this case), resulting in a concave range where linkages between edge locations are long. The restriction distance, in this analysis, was selected as the smallest distance that did not result in fragmentation of the range (as used by Harrington and Macdonald (2008)).

Loch Linne family (previously Family 2)
This family is in their third year post-release.

Data available for Year 3: 303 field signs (all field signs occurred within 40 m of the Year 2 home range polygon), 46 observations.

Individual beavers present during Year 3: one adult male (Frank), one adult female (Frid), one yearling-sub-adult (Barney), and one kit.

Territory size was estimated in Year 2 as 24.7 ha using REP (or 27.3 ha using MCP, which contained 3.7 km loch bank). There did not appear to be any significant change in territory size or location from Year 2; nor did there appear to be any significant increase in the length of waterway used (Fig. 5).

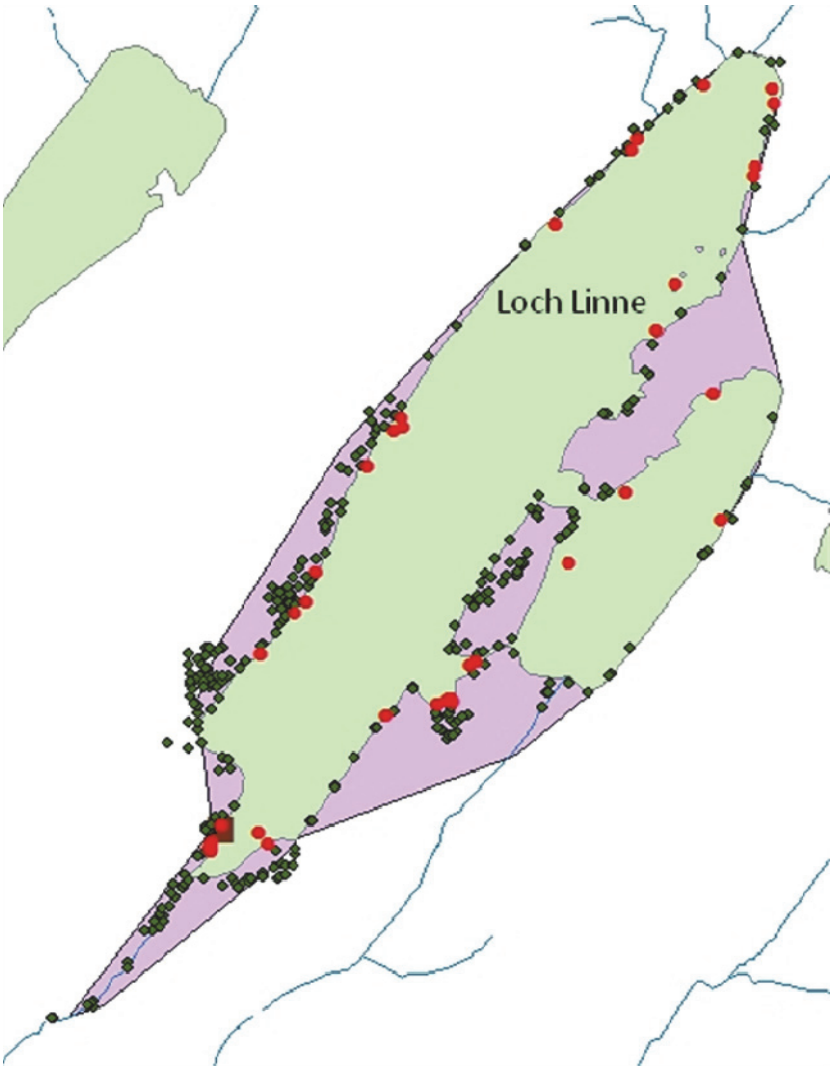


Figure 5. Schematic of the Loch Linne family territory in Year 2 and Year 3 of the trial. Year 2 home range polygon (REP_0.2) shown in purple, Year 3 locations in red (identified observations) and dark green (field signs). The original release area is indicated by the brown square. The pale green areas are the lochs. This family exclusively occupies Loch Linne (the second largest loch in the release area) and a small section of the stream to the south-west of the loch. © Crown copyright and database rights 2013 Ordnance Survey 100017908.

Dubh Loch family (previously Family 3)
This family is in their third year post-release.

Data available for Year 3: 357 field signs (all field signs occurred within 40 m of Year 2 home range polygon), 111 observations.

Individual beavers present during Year 3: one adult male (Bjornar), two adult females (Katrina and Millie), one yearling.

Territory size was estimated in Year 2 as 41.9 ha using REP (or 48.3 ha using MCP, which contained 4.5 km loch bank). There did not appear to be any significant change in home range size or location from Year 2 to Year 3; nor did there appear to be any increase in length of waterway used (Fig. 6).

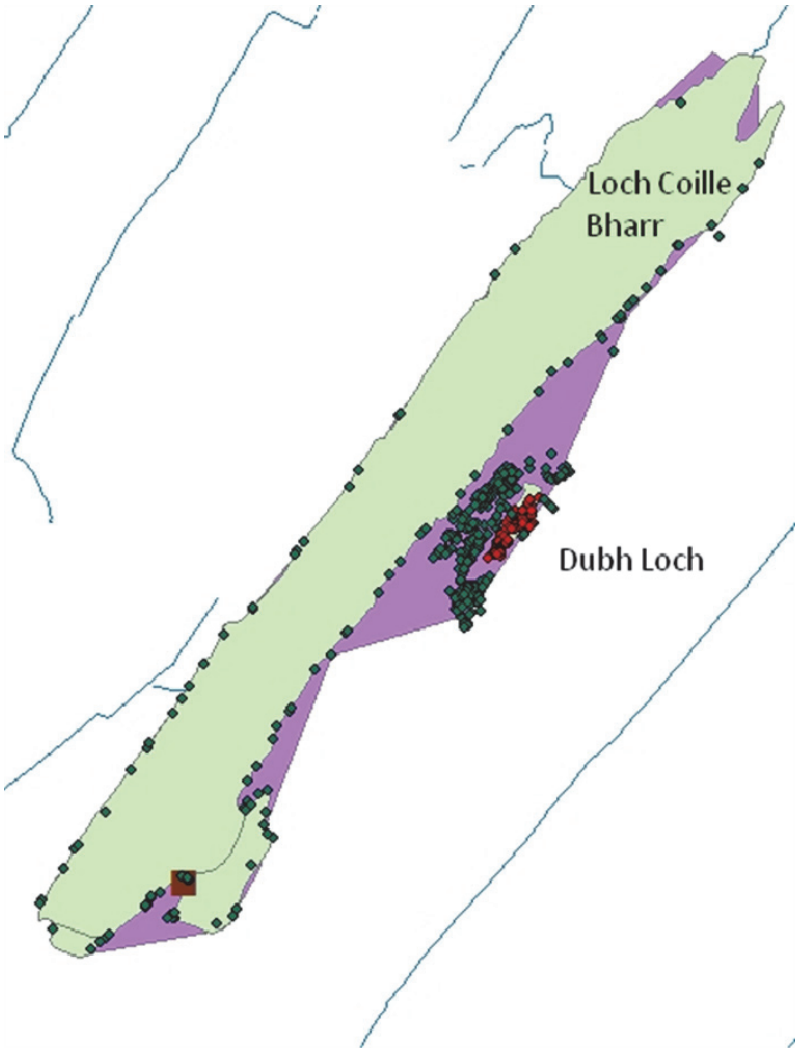


Figure 6. Schematic of the Dubh Loch family territory in Year 2 and Year 3 of the trial. Year 2 home range polygon (REP_0.2) shown in purple, Year 3 locations in red (identified observations) and dark green (field signs). The original release area is indicated by the brown square. The pale green areas are the lochs; although beavers were only ever actually observed on the Dubh Loch in Year 3, and there was particularly intensive activity (as evidenced by field signs) around Dubh Loch, fresh field signs were also found around the entire perimeter of the larger Loch Coille-Bharr (the largest loch in the release area) in both Year 2 and Year 3. © Crown copyright and database rights 2013 Ordnance Survey 100017908.

Loch Buic family (Trude and male partner) (previously Family 4)
This family is in their second year post-release.

Data available for Year 3: 158 field signs (all field signs occurred within 40 m of Year 2 home range polygon), 37 observations of Trude, 15 of Christian, 14 of Eoghann.

Individual beavers present during Year 3: one adult male (Christian up to 17/10/2011, Eoghann from 11/10/2011), one adult female (Trude).

Territory size was estimated in Year 2 as 14.0 ha using REP (or 25.0 ha using MCP, which contained 3.0 km loch bank). There was some apparent change in the area used since Year 2 (see Figure 7): the Un-named (S) or 'Lily Loch' appears to no longer be used. However, potential changes in the length of waterway used are unclear because it is currently not possible to confirm whether field signs on the stream to the north-west of Loch Buic belong to the Loch Buic family or were left by another dispersing (sub-adult) beaver (possibly Biffa, originally from Loch Linne). Year 3 territory size was estimated as 10.8 ha using REP_0.3[16] (or 15.2 ha using MCP), both of which are clearly over-estimates[17] since they include a large amount of unused area between the loch and the stream (shown for REP in the schematic below). The length of loch/river bank used in Year 3 was estimated as 1.66 km including only the loch banks and the stretch of river that connects the two lochs, or 2.26 km including all rivers within the MCP.

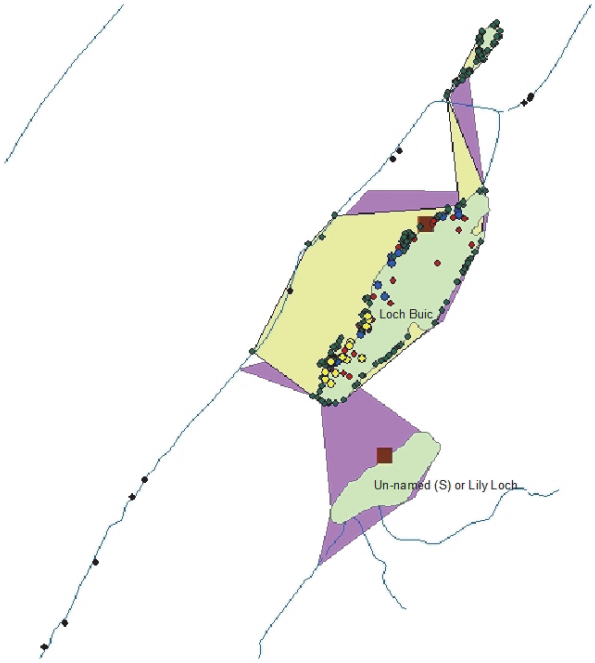


Figure 7. Schematic of the Loch Buic family territory in Year 2 and Year 3 of the trial. Year 2 home range polygon (REP_0.2) shown in purple, Year 3 home range polygon (based on REP_0.3) in yellow, observations of Trude in red, Christian in blue, Eoghann in yellow, field signs (within 40 m of the Year 2 home range polygon) in dark green, additional outlying field signs (of unknown origin, and therefore not included in the home range polygon) in black. The original release area is indicated by the brown square. The pale green areas are the lochs. © Crown copyright and database rights 2013 Ordnance Survey 100017908.

[16] REP using a restriction distance of 0.2 resulted in a fragmented range so a restriction distance of 0.3 was used in this case.
[17] Year 2 territory size estimates were also likely over-estimates for the same reasons.

Lochan Beag family (Elaine and male partner) (previously family 5)
This family is in their second year post-release.

Data available for Year 3: 190 field signs (within 100 m of Year 2 home range polygon, note that in this case a few additional field signs fall outside this area but clearly belong to the same family – these were included in the Year 3 territory), 33 observations of Elaine, 20 of Eoghann, 11 of Christian.

Individual beavers present during Year 3: one adult male (Eoghann up to 16/09/2011, Christian from 06/11/2011), one adult female (Elaine).

Territory size was estimated in Year 2 as 7.8 ha using REP (or 9.5 ha using MCP, which contained 1.5 km loch bank). There was some apparent increase in the size of the territory and in the length of waterway used in Year 3 due to the extended use of Lochan Beag (see Figure 8). Year 3 territory size was estimated as 10.2 ha using REP_0.2 (or 11.6 ha using MCP, which contained 1.8 km loch bank). Although the female beaver was observed predominantly on Lochan Beag, and there was particularly intensive activity (as evidenced by field signs) around this lochan, fresh field signs were also found around the entire perimeter of the larger Loch Creagmhor where the female – Elaine - was originally released.

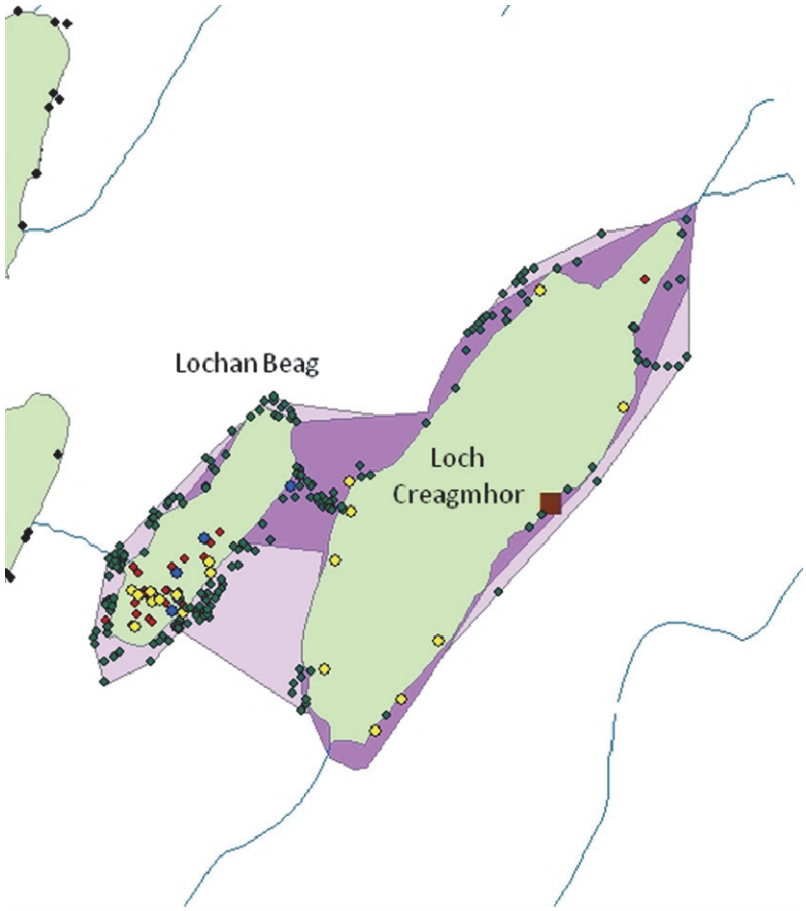


Figure 8. Schematic of the Lochan Beag family territory in Year 2 and Year 3 of the trial. Year 2 home range polygon (REP_0.2) shown in dark purple, Year 3 home range polygon (based on REP_0.3) in light purple, observations of Elaine in red, Christian in blue, Eoghann in yellow, field signs in dark green. The original release area is indicated by the brown square. The pale green areas are the lochs. Field signs shown on the banks of Loch Linne are attributed to another family; despite close proximity, the two lochs are separated by steep terrain and therefore the two families are not believed to overlap. © Crown copyright and database rights 2013 Ordnance Survey 100017908.

Territory sizes reported here are in line with territory sizes reported for beavers by Herr and Rosell (2004) and lie within the range of territory sizes (0.5–12.8 km) reviewed by Macdonald *et al.* (1995).

Seasonal home ranges
In last year's report (see Harrington *et al.* 2012), we carried out a preliminary analysis of seasonal home ranges, and suggested that winter home ranges might be smaller than those used in other seasons. However, for all families, the presence of outlying points in winter suggested that perhaps the difference is in the intensity of use rather than the area used *per se*. Seasonality in the areas used by beaver will be explored further in the final year of the trial when data from multiple years and seasons are available.

6.3 Beaver activity and the use of GPS

The original ecological monitoring protocols (see Campbell *et al.* 2010) specified that we would provide data on nightly movements of beavers. However, the discontinuation of VHF telemetry in the first year of the project meant that this was not possible (since we are unable to describe detailed individual movements from either observations – according to current protocols - or field signs). In Year 2, in an attempt to investigate alternative affordable replacements to the discontinued radio-telemetry, SBT proposed a trial to assess the feasibility of using inexpensive GPS transmitters (i-Got-U tags) sold commercially as 'route trackers', to monitor animal movements. In consultation with SBT and SNH, we made the decision to adopt the use of i-Got-U tags to obtain further information on beaver behaviour and movements at Knapdale. Tag deployment can be combined to some extent with annual trapping of animals to minimise workload for SBT, as well as animal handling required (with animal welfare in mind) (see Annex 1). Given the short deployments possible with these tags (maximum 10 days), the data obtained will provide a short but detailed insight into beaver behaviour at Knapdale[18] (that could potentially be compared with comparable behavioural data from Norway), this type of detailed behavioural data is of relatively low priority to the overall aims of the ecological monitoring but is important to be able to assess whether the translocated beaver population is behaving as it would be expected to, with a view to assessing how well the population has settled at Knapdale, and how the animals responded to the translocation process.

The use of i-Got-U tags for animal tracking is a novel method and thus requires preliminary tests to assess their accuracy and potential usefulness prior to deployments as part of the trial.

Is GPS tracking a useful monitoring tool?
Preliminary trials and accuracy testing in Year 2 suggested that both inter-fix intervals (most, >90%, successive fixes were achieved within 30 minutes or less, given a programmed inter-fix interval of 15 minutes) and accuracy of locations obtained (median errors 5-19 m, maximum errors 23-75 m) were adequate for the purpose of the ecological monitoring of beavers at Knapdale.

Initial trial deployments on two animals revealed that GPS locations were not obtained from inside the lodge, but this could be viewed as beneficial because it will be useful for assessing activity periods and emergence times. Trial deployments on two animals showed that beavers did not to use their entire home range over the 8-9 day deployment period, therefore GPS data will be most useful for assessing nightly movements, and temporal activity patterns (although it may be helpful in refining home range boundaries in some

[18] Precision is not sufficient for habitat analysis (e.g. to distinguish between use of loch bank and use of water).

cases). Relative imprecision will mean that GPS data will not be suitable for finer-scale analyses, such as habitat use (but that was not the primary aim).

GPS deployments

The original aim was to GPS-tag all adults over two years, with half the animals tagged in early summer and half in late autumn[19] (ensuring that there was even coverage of males and females in both seasons), each individual tracked for approximately two weeks. Ideally, all adults would be tracked in both seasons and the feasibility of this was to be reviewed as the project progresses. It was agreed that the other sub-adults or non-breeding adults would be tracked opportunistically if the opportunity arose.

In all cases, GPS were set to record over 24 hours, with 15 minute inter-fix interval.

To date, 12 GPS tags have been deployed (including 2 in the initial trial) (Table 6). Three of the four GPS tags deployed in Year 3 were retrieved successfully but two of these were damaged[20] which limited the data obtained from them (see below).

Table 6. GPS deployments on beavers at Knapdale to date.

Animal	Date of deployment	
Frank	22/02/11	TRIAL
Frid	02/03/11	TRIAL
Eoghann	24/10/11[1]	YEAR 3
Trude	25/10/11	YEAR 3
Frank	19/06/12[2]	YEAR 3
Frid	18/06/12[2]	YEAR 3
Millie	03/07/12[3]	YEAR 4
Millie	23/10/12	YEAR 4
Christian	21/11/12	YEAR 4
Frank	29/11/12	YEAR 4
Frid	29/11/12	YEAR 4
Elaine	03/12/12	YEAR 4

[1] tag lost.
[2] tag damaged; limited data obtained.
[3] tag damaged; no data retrieved.

Some animals are easier to trap than are others, and, thus far, for example, SBT have been more successful obtaining GPS data for the pair of beavers on Loch Linnne - Frank and Frid – than for some other individuals. Currently GPS tagging is carried out as and when it fits into SBT's current field work schedule, and when it can be coordinated with existing annual trapping of animals. The use (and success) of GPS tagging and deployment protocols will be reviewed as Year 4 progresses.

Preliminary analysis of GPS data

Here we present data from the three datasets obtained in Year 3. Table 7 summarises the quality of the data obtained (in terms of the number of locations recorded, and the actual inter-fix intervals achieved[21]) – data quality was generally high and in accordance with the

[19] Although the ideal situation would have been to track animals over winter, the animal welfare implications of trapping animals in winter, and the difficulties posed to fieldworkers, meant that a more feasible solution would be to limit 'cold season' tracking to late autumn. Alternative methods of inferring activity times and/or movements in winter should be considered in future.
[20] Tag damage appears to be caused by other beavers chewing the tags (this is a risk for any social animal that engages in social grooming).
[21] A GPS tag may fail to obtain a location when the animal is underwater or in thick vegetation – when this occurs the tag will continue to attempt to obtain a location until it is successful, thus some inter-fix

trials performed on Frank and Frid (the Loch Linne pair) in 2011. Similarly high quality data for Trude (on Loch Buic) suggests that the method will be successful across the lochs occupied at Knapdale, although the success of GPS tracking on Dubh Loch, where vegetation cover is generally higher, still needs to be assessed.

Table 7. Quality of GPS data obtained from three deployments on beavers at Knapdale. Inter-fix intervals are described as the proportion of fixes that are less than, or equal to, a specified time.

Animal	**Total no. locations**	**Inter-fix intervals**		
		≤ 15 mins (n)	**≤ 20 mins**	**≤ 30 mins**
Trude	391	0.55 (378)	0.85	0.90
Frank	158	0.39 (157)	0.87	0.92
Frid	38	0.29 (35)	0.74	0.86[1]

[1] One large 3 hour inter-fix interval between 21.24 and 00.25 suggests that the animal was probably inactive during this period.

Table 8 summarises individual beaver activity patterns (in terms of time of emergence from the lodge, time of return to the lodge and the time spent out of the lodge) for those individuals GPS-tracked thus far. Larger sample sizes are required to assess the generality of activity patterns – however, for the three datasets examined to date, it appears that the time that beavers emerge from the lodge, and return to the lodge, are variable, and not necessarily closely tied to the hours of darkness.

Table 8. Beaver activity patterns at Knapdale as inferred from GPS data for 3 beavers GPS-tracked during Year 3

Animal	**No. days tracked**	**Emergence time**	**Return time**	**Active time (hrs)**
Trude	11 (October)	18.35 - 20.36 pm	05.43 - 07.37 am	c. 10-13
Frank	4.5 (June)	18.54 – 20.46 pm	03.55 - 06.13 am[2]	c. 8-9
Frid	2 (June)	16.53 – 18.29 pm	02.01 - 02.24 am	7.5 [1]

[1] Only measured on one night.
[2] On one night this animal appeared to remain active until 12.57 am.

GPS locations in relation to home range boundary are shown for Trude in Figure 9. In this case, GPS data reveal the importance of the small lochan to the north of Loch Buic and also confirm that the stream to the north-west of Loch Buic is used by this pair.

Detailed measurements of nightly movements of all beavers GPS-tracked will be included in next year's report.

intervals will be longer than 15 minutes, and the proportion of inter-fix intervals that exceeds 15 minutes (and the actual duration of the inter-fix intervals) provides an indication of the ability of the tag to record the beavers movements precisely. (Accuracy of the locations obtained is a different issue that can only be assessed using stationary tests).

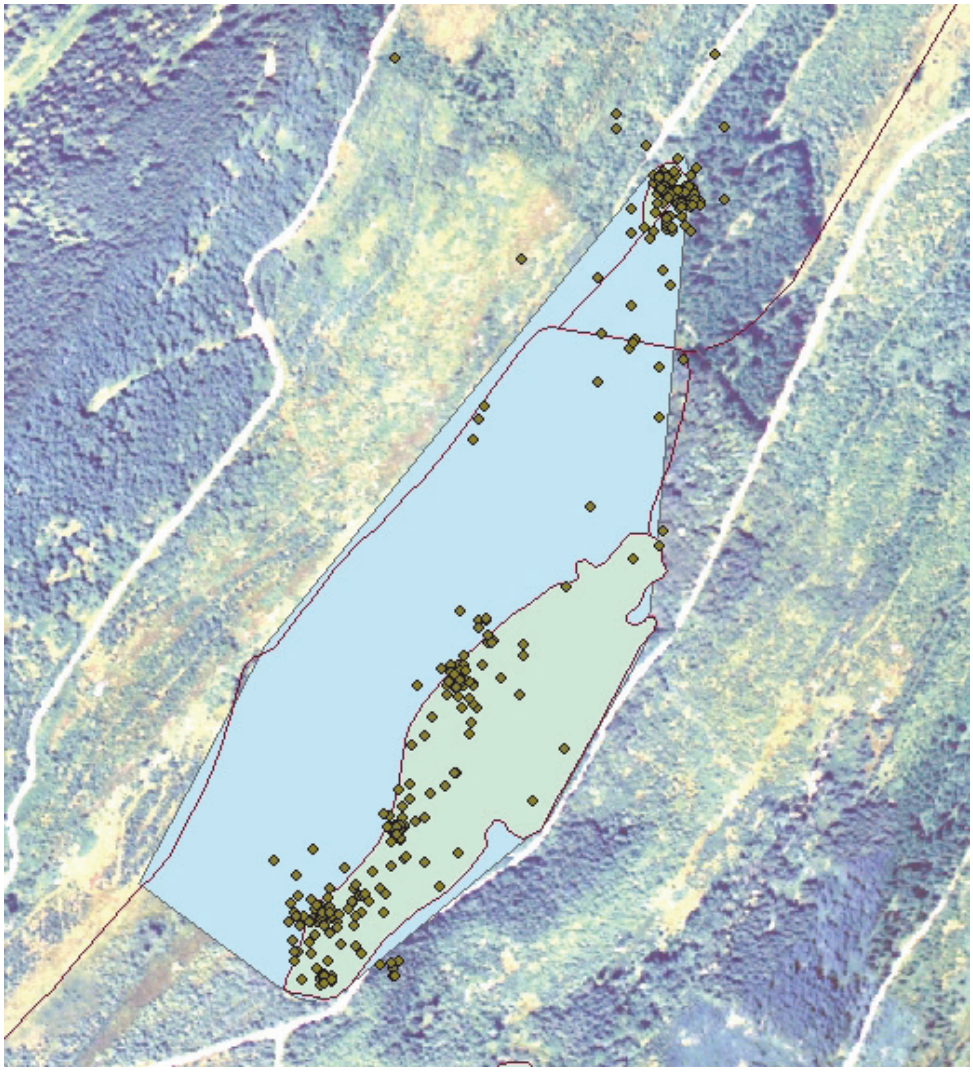


Figure 9. GPS lcoations for Trude, October 2011, shown against the Loch Buic family Year 3 home range as inferred from observational and field sign locations (shown here as a minimum convex polygon, in blue). The Loch is shown in pale green. Data licensed to Scottish Natural Heritage under the PGA, through Next Perspectives.

6.4 Habitat use

In last year's report we assessed terrestrial habitat use within the beaver's home range at the level of the beaver family/pair, as indicated by the location of field signs (see Harrington *et al.* 2012). We focused specifically on the use of deciduous woodland types (as defined by the dominant species present[22]). In general, preferences were hard to assess because of the small number of families and the variation in deciduous woodland habitat available within each of these four beaver home ranges.

The most dominant deciduous tree species within all beaver home ranges was downy birch, *Betula pubescens*; all beaver families appeared to use woodland dominated by this species in proportion with (or slightly less than) than its availability. There was some evidence that the Loch Linne family (Family 2) preferred (insofar as proportional use was greater than proportional availability) woodland dominated by downy birch and eared willow, and avoided (proportional use less than proportional availability) sessile oak; the Dubh Loch family (Family 3), however, and in contrast, appeared to show some preference for areas dominated by sessile oak. The Lochan Beag family (Family 5) occupied a less diverse deciduous woodland and appeared to use it in proportion to its availability; and, we were unable to assess deciduous woodland preferences for the Loch Buic family (Family 4) because only one dominant species type – downy birch– was present within their home range.

A more detailed assessment of annual and seasonal habitat use within the home range will be included in later reports as more data become available. The slight shifting of territory boundaries by some beaver families/pairs (particularly the Loch Buic family) will also allow an assessment of territory location, which will be included in later reports.

The beaver ecology monitoring no longer collects data on the size, number (or proportion), or the species of felled trees because this is covered by monitoring carried out by the James Hutton Institute (JHI) of the effect of beavers on riparian woodland (Moore *et al.* 2011). Comparisons between these two separate monitoring exercises will also be covered in future reports.

Use of Time-Depth Recorders (TDRs) to provide information on aquatic habitat use

One question that still remains, regarding habitat use, is: to what extent do beavers use the aquatic habitat? Field signs are not usually detected in the water, although macrophyte 'mats' are sometimes observed. The resolution of GPS locations mean that it will not be possible to distinguish between a beaver on the land at the edge of the bank and a beaver in the water at the edge of the loch (above). Detecting aquatic habitat use from GPS data is also complicated by the fact that a fix will only be obtained if a beaver in the water is at the surface, but not all 'surfacing events' will be recorded due to the 15 minute fix interval. Although beavers are observed foraging in the water, observational data are the most labour intensive of all monitoring methods and obtaining long duration data on focal animals is difficult and subject to bias due to observers disturbing the animal.

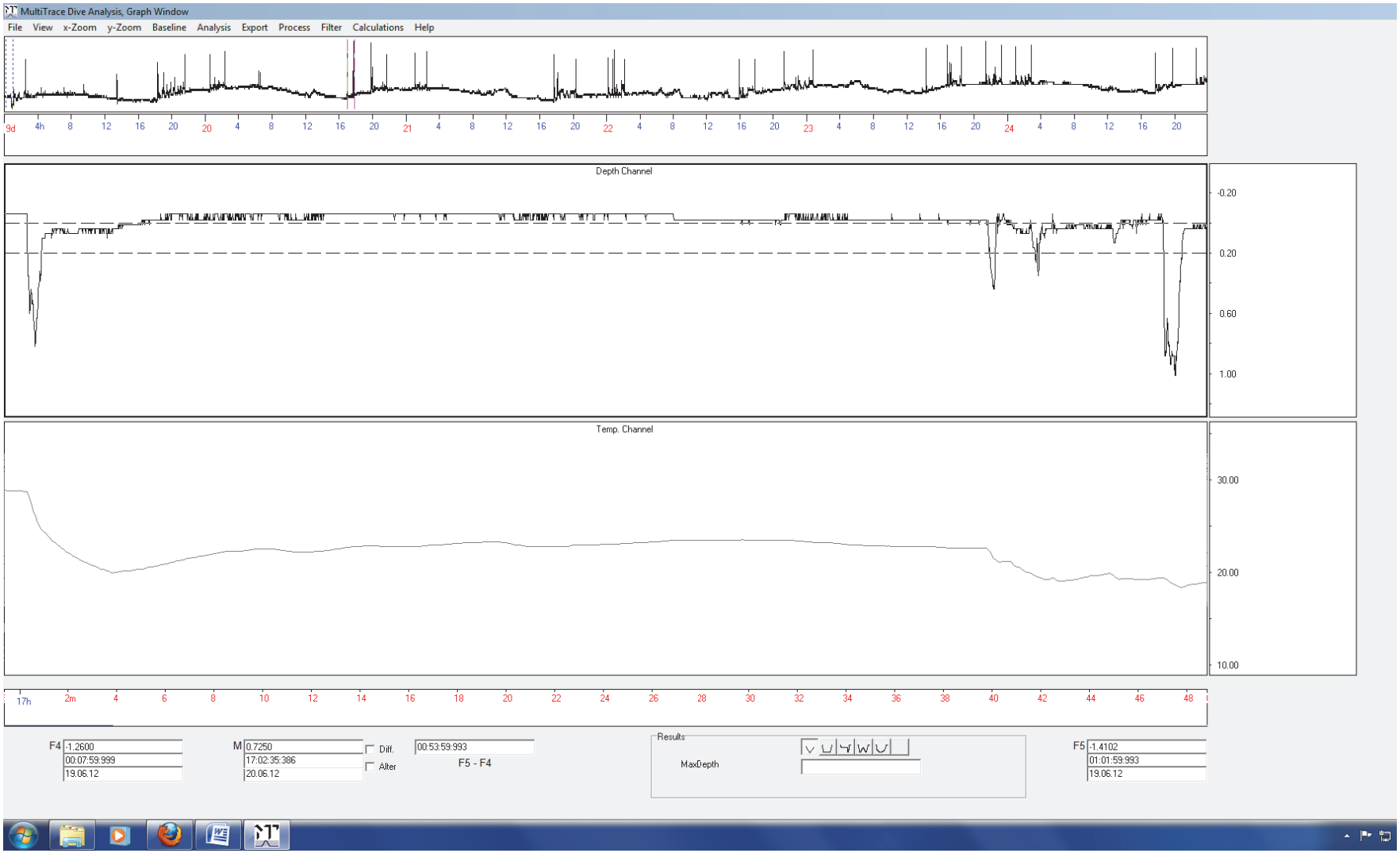
TDRs record depth and temperature at second intervals (for approximately 6 days), and provide very detailed dive profiles. Although it may not be possible to distinguish between foraging dives and travelling dives, or dives approaching the entrance to the lodge, dive data will provide information on the amount of time spent in the water, which, coupled with known activity periods from the GPS data, will allow us to infer the proportion of 'active time' that beavers spend in the water (as well as biological data on dive depth and duration, and patterns of diving activity). Whilst this level of detailed behavioural data (on one particular

[22] using the Knapdale woodland deciduous 2005 dataset (Brandon-Jones *et al*. 2005) [updated in 2011].

aspect of the beaver's behaviour) is not a key ecological question, deployment of TDRs does not require any additional resources if they are deployed alongside GPS tags and thus allows opportunistic study of beaver diving behaviour. Data obtained from TDRs may allow a better understanding of beaver behaviour at Knapdale, and will provide unique, 'non-essential' data on beaver diving behaviour, as well as potentially allowing comparisons with the diving behaviour of wild beavers in Norway.

Six TDRs have been successfully deployed and retrieved to date (two during Year 3 and four during Year 4). Full analysis of these datasets will be included in future reports. Figure 10 illustrates the type of data obtained from the TDRs.

a)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19.06.12
M 0.7250
17:02:35:386
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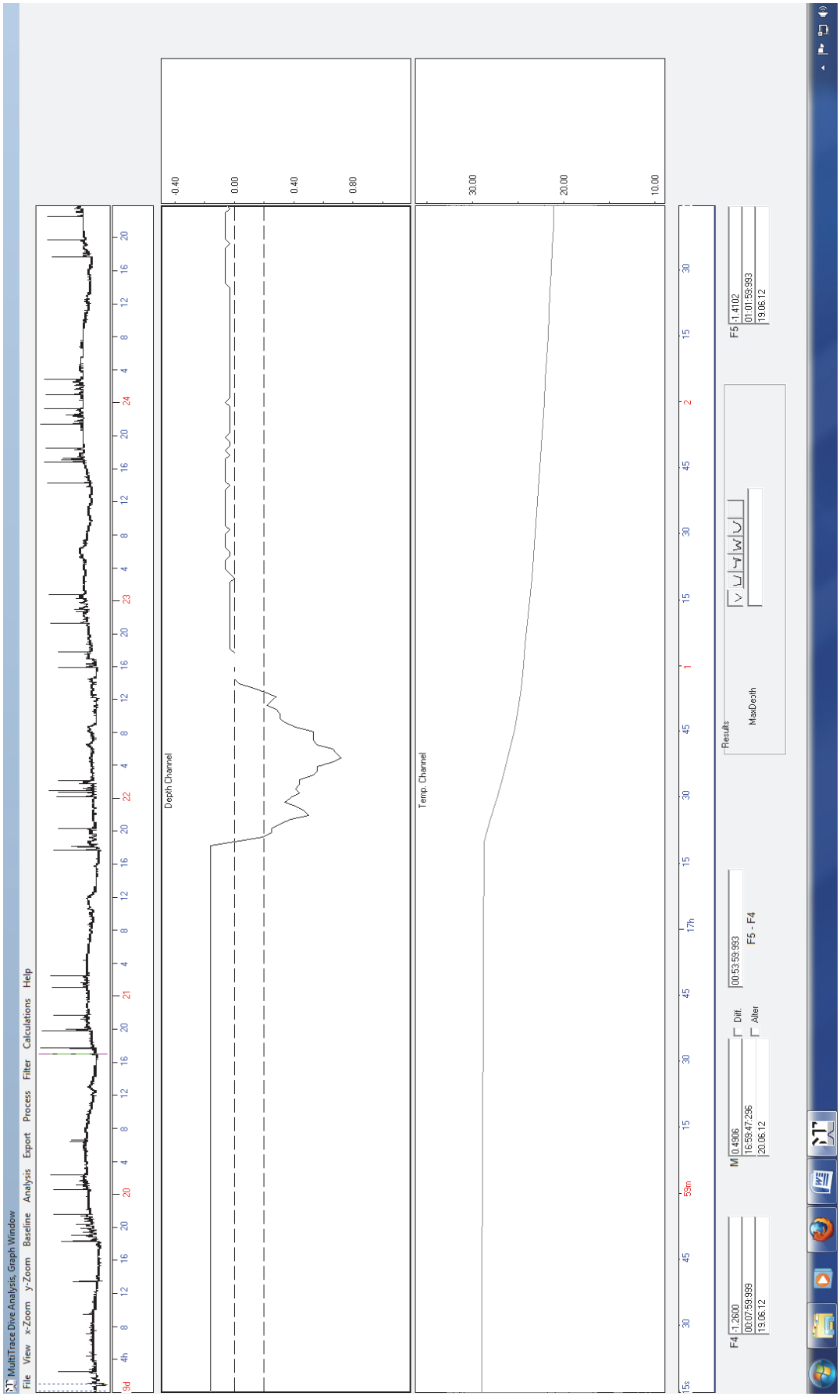
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M 0.4906
16:59:47.296
20.06.12
Diff.
Alter
00:53:59.993
F5 - F4
F5 -1.4102
01:01:59.993
13.06.12

b)

Figure 10. Screen shots illustrating TDR data viewed in MtDive[23]. The top window shows the entire 6 day dataset (depth data). The two larger windows show the depth data (middle window) and the temperature data (bottom window) zoomed in to show a series of 4 dives over approximately 48 minutes (a) and a detailed dive profile within a 4 minute series of data (b). Dives are defined, in this case, as depths of greater than 0.2 m (indicated by the two dashed lines that mark 0 depth and 0.2 m depth respectively).

6.5 Dispersal by sub-adults

In the first two years of the project, two dispersal events of a subadult away from the natal group were recorded. One was dispersal of a two year old female (Marlene) in the Dubh Loch/Loch Collie Bharr family, and the other a two year old male (Biffa) in the Loch Linne family.

Marlene was tracked via VHF telemetry south-west to a watercourse in the vicinity of the Fairy Isles and then to a nearby sea loch in August 2009. She has not been seen since.

Biffa remained with Family 2 for almost two years (1 year, 10 months) post-release. He was last seen in February of 2011.

During Year 3, the wild-born two year old (unknown sex) in the Dubh Loch family also appears to have dispersed. That animal has not been seen since summer 2012.

Dispersal of beavers from the release site constitutes important ecological information that will be crucial to management of the Knapdale population, and to assessing how beaver populations elsewhere might spread if the decision is made to reintroduce beavers to the rest of Scotland. However, although we are able to report the proportion of sub-adults that leave their family group and at what age this occurred (assuming that these individuals have dispersed and not died), we are currently unable to estimate dispersal distances or to otherwise describe dispersal movements (except through anecdotal information on beaver signs or sightings outside the release area). In an attempt to improve this information SBT will actively seek reports of beaver signs in Argyll outwith the trial area in the final years of the trial.

[23] A bespoke software program developed for analysis of TDR data by Jochim Lage, Jensen Software Systems.

7. OTHER MAMMAL MONITORING

One of the qualifying features of Taynish and Knapdale Woods Special Area of Conservation (SAC) is the Eurasian otter (*Lutra lutra*) (which is also a UK BAP priority species and a European Protected Species). To demonstrate that the trial reintroduction of beavers into the SAC will not negatively impact on this particular qualifying feature or on UK BAP priority species, otter presence in the area is being monitored over the duration of the project.

Thus far, there is no evidence that beaver reintroduction has had a negative impact on otters in the area.

A brief summary of the monitoring is presented here; for full details see Annex 2.

7.1 Methods

Survey methods are based on Strachan (2007) and were undertaken by SNH. Surveys were carried out within the release area and, for comparison, in a separate and independent control area (of similar habitat to the release area but located far enough outside the release area to minimise the chance of a single otter territory overlapping both the release area and the control area). Supplementary data on the presence of mink (*Neovison vison*) field signs (and water vole [*Arvicola amphibius*] field signs) were also recorded. Further additional data on the presence of mink were provided by SBT from their mink control activities; SBT also provide incidental species data recorded on an *ad hoc* basis during camera trapping and other activities (including visitor sightings).

Twenty 100 m linear sites (10 in the release area, all on catchments used by beavers, and 10 in the control area) were surveyed annually in the autumn (mainly October and November) in 2009, 2010 and 2011 (results from the 2012 autumn survey was part of the fourth year of monitoring and will be presented in the next annual report). Survey sites were selected amongst three broad habitat types (inland watercourse, freshwater loch outflow, coastal watercourse outflow/shoreline - see Harrington *et al.* 2011), with the additional specification that the two national otter survey sites within the release area – unnamed burn near Gariob Cottage, OS grid ref. NR781891 and the burn near Loch Barnluasgan, OS grid ref. NR789910 – were included amongst the ten sites to allow the use of survey data from earlier national otter surveys. The same sites were surveyed each year (Fig. 11).

Sites were surveyed by searching the entire length of the 100 m site and recording the following field signs: sightings (actual animals seen), total number of otter spraints[24], number of otter resting places, presence of tracks/runs etc., total number of mink scats found, presence of mink tracks, other evidence of mink (including local reports), total number of water vole latrines, presence of water vole burrows and feeding signs.

Spraint surveys are not suitable for assessing habitat use by otters but were considered sufficient to monitor for broad changes in otter presence, distribution and relative abundance.

Ten mink rafts are monitored by SBT at monthly intervals for management purposes (to inform any mink removal work required); these also provide potentially useful data on the presence and relative abundance of mink in the area.

[24] Spraint samples were only collected if species identification was uncertain. Samples were, otherwise, considered to be of limited use for further non-essential research, due to low numbers encountered and poor quality (i.e. not sufficiently fresh to allow DNA analysis).

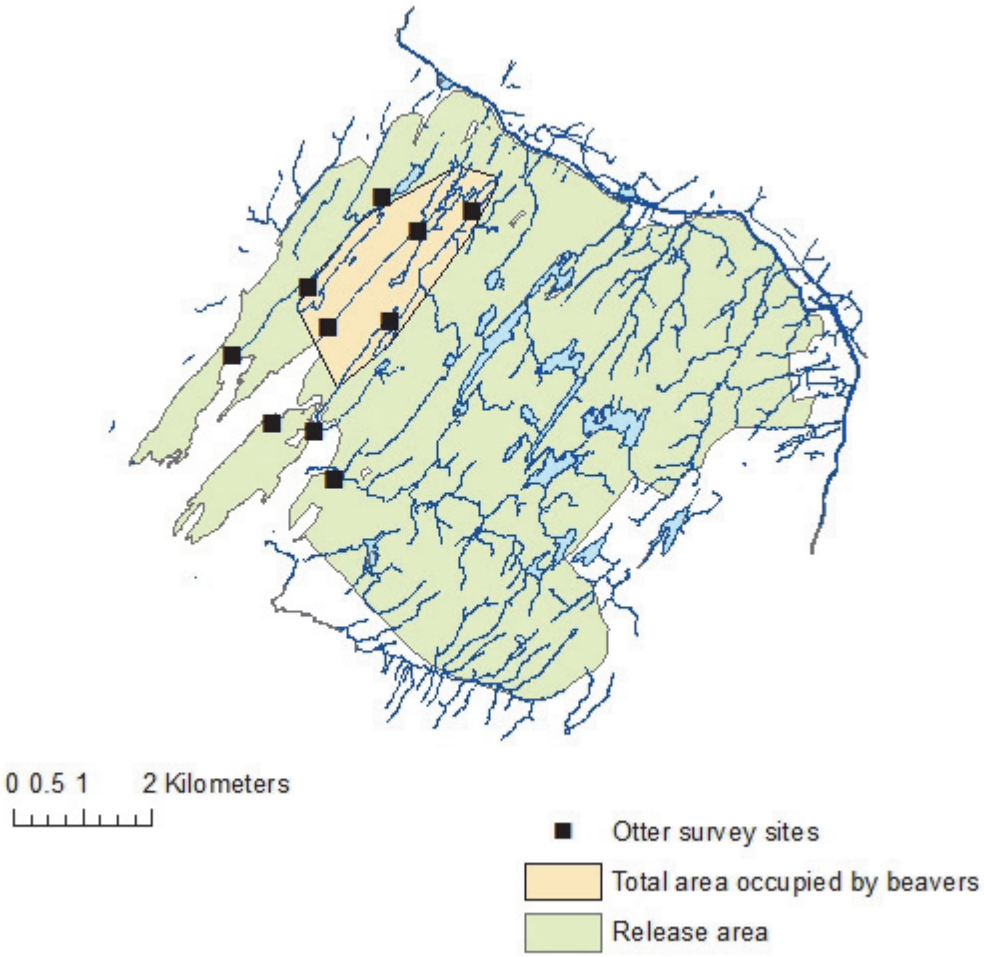

Figure 11. Otter survey sites within the release area, Knapdale, Argyll. The same sites are surveyed each year. 10 additional 'control' sites are surveyed outside the release area. See Annex 2. © Crown copyright and database rights 2013 Ordnance Survey 100017908.

7.2 Results

Otters

Evidence of otter activity (mostly spraints or footprints/otter paths) was recorded at eight survey sites (80%) in each of the trial area and the control area in Year 1, in seven sites (70%) in each in Year 2, and in seven sites (70%) in the trial area and six sites (60%) in the control area in Year 3. This is slightly lower than the overall mean number of positive sites recorded across the SNH Argyll & Stirling Area during the 2003/04 national survey (89.13%). However, weather conditions (particularly high water levels) and delays in the timing of the survey in all three survey years meant that otter (and mink) presence may have been underestimated (see Annex 2). Statistical analysis revealed no significant difference over time between the trial and the control area (Annex 2). However, interestingly, in Year 2 and Year 3, the *quantity* of spraint found at some of the positive survey sites within the release area was substantially greater than at any of the positive sites in the control area (perhaps suggesting a higher level of overall otter activity within the release area). It is not currently clear whether this difference reflects habitat differences (and relative suitability for otters) between the two areas, or whether it is due to the presence of beavers.

SBT report observing otters swimming around the lodges on Loch Linne and Dubh Loch (total sightings = 4 in Year 2, 2 in Year 3). Otters have been captured by camera traps at a beaver foraging trail and a beaver canal on Lochan Beag and Loch Buic (total camera captures = 3[25]). Otter tracks have been recorded on mink rafts on seven occasions (2 in year 2, 5 in year 3). Only one direct interaction between beavers and otters has been recorded, during which two beavers were seen swimming towards an otter, the beavers splashed and then swam away – there was no other evidence of aggression or of close physical contact.

Mink

In Year 1, mink signs were recorded at one of the survey sites in the control area, and a further three sites had 'possible' mink presence (one in the release area and two in the control area). In Year 2, mink were confirmed at one site, and possibly present at one other (both in the control area). In Year 3, there were unconfirmed mink signs at three sites (Annex 2).

SBT recorded mink tracks on rafts on two occasions in Year 1, 10 occasions in Year 2 and on one occasion in Year 3. Two mink were shot as part of control operations for this non-native species in Year 2.

Water voles

No evidence of water voles was found during any of the three survey years, but this is not surprising given the late autumn/winter survey dates and the heavily-shaded habitat at many of the locations. No other signs of water vole have been recorded at Knapdale before or during the trial.

7.3 Concluding remarks

That there is no evidence of an effect of beavers on otter presence is not surprising. Indeed, given the important ecological role that beavers play in influencing the hydrology of their habitat and experience from elsewhere in their European range, negative impacts from beavers on any of these other riparian mammals are considered unlikely.

Mink abundance in the area appears to be relatively low. Although it is possible that beaver activity may influence local mink activity (mink are known to use beaver lodges as den sites, and beaver ponds for foraging, elsewhere in Europe and in North America [as are otters], e.g. Knudsen 1962; Sidorovich 2011), control methods for this non-native species are well established and are already in place at Knapdale.

It is likely that the nature of the survey sites and the timing of the survey are not suitable for providing supplementary data on water vole presence within the release area (however, this was not the main aim of the survey).

[25] Camera traps were only used extensively in Year 3.

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ANNEX 1: METHODOLOGY PROTOCOLS

These procotols follow the general format as used in the original methodology protocols in Campbell *et al.* (2010), with a brief overview of each method as it applies to the trial, an outline of the workplan and the data required, as well as a summary of the key information provided by each method. These are revised protocols following amendments made during the first and second year of the trial in consultation with SNH and SBT.

Note on reviewing of methods: Over the first year of the trial some changes were made to the original monitoring protocols as specified in Campbell *et al.* (2010) and these were outlined in the first annual report (see Harrington *et al.* 2011). During the second year of the project, preliminary trials investigating the potential use of inexpensive GPS transmitters indicated that GPS tracking would be a useful monitoring tool (see Harrington *et al.* 2012). Therefore, further amendments were made to the ecological monitoring methods, including a renewed emphasis on radio-telemetry (GPS) and, accordingly, decreased emphasis on observational methods (put in place in 2010 as a replacement for VHF telemetry). Field sign surveys continue to provide essential ecological information and provide continuity for the data collected thus far. In addition, in the third year of the project, we included the use of temperature-depth recorders (TDRs) to provide further information on the general behaviour of beavers, and specifically on their use of the aquatic habitat. SNH and WildCRU will continue to review these methods throughout the trial, in close discussion with SBT, and any further changes will be identified in future reports.

Trapping

Overview

The preferred technique is the Norwegian method of trapping from a boat because it allows targeted captures, and reduces individual recaptures and overall capture time. Trapping from a boat will, therefore, be used on all lochs where it is possible (current areas include Loch Linne, Loch Buic, Loch Collie-Bharr and Creagmhor). However, on some of the smaller lochs use of a boat is not feasible and, therefore, cage traps will be used at those sites (e.g. Dubh Loch, and Lochan Beag). Animal welfare is paramount in terms of suitable trapping method and duration of trapping effort, and thus, cage trapping at a specific location will cease if an individual is recaptured three times within a one-month period. Trapping should resume in an attempt to capture animals not yet trapped after a period of not less than two weeks, but not more than two months. All animals should be uniquely marked with both PIT tags and ear tags (using a variety of tags depending on circumstances). Argos tags, which the SBT initially used specifically for beaver management purposes rather than the ecological monitoring will no longer be fitted. VHF telemetry is not currently part of the revised methodology but may be used for management purposes.[26]

Over the first year of the project the most important outcome of the trapping data was the health and survival of individual released animals. In future years, identification of wild-born young will also be needed to allow assessment of their survival and description of population dynamics. Therefore, it should be a high priority to capture and mark any new, unmarked young animals. Every known animal should be trapped once per year. Trapping of new wild-born kits should be an additional priority. The weight of all animals captured should be recorded as well as standard body metrics (body length, tail length, width and thickness).

Work plan

The precise timing of the annual trapping is not critical and can be fitted in with other activities (but must be recorded so that methodology can be accurately

[26] ARGOS telemetry is not part of the ecological methodology protocols; VHF telemetry is not currently part of the revised methodology but may be used on 'new' animals and subadults likely to disperse for management purposes – data should still be provided to SNH and WildCRU so that its use (and potential relevance to ecological monitoring) can be further reviewed at a late date; new protocols for GPS telemetry are detailed below.

reported). However, the earlier in the monitoring year trapping is carried out the more time is available for capturing animals not yet caught. Further, to allow assessment of annual variation in body condition (estimated from animal weight and body metrics), the timing of trapping should be relatively consistent over consecutive years of the; project (i.e. within the same season). Late February to late spring when females may be pregnant should be avoided for intensive trapping efforts with Bavarian cage traps. Trapping for kits should, ideally, be carried out as close to emergence time as possible so that early losses (mortality rates of kits in the first few months post-emergence) can be estimated. In the event that kits lose their ear tags, they should be recaptured, and new eartags fitted, as soon as possible.

Data — Data detailing the number of traps used and number of hours the traps are open (to allow calculation of trap effort) to be entered into the existing trapping spreadsheet[27]; trap locations of captured animals also to be recorded.

Key information provided

Survival of known individuals (yearly)
Body metrics for assessment of overall body condition
Reproductive rates (number of females breeding and number of kits per breeding female)
Population size and density within the release site
Age structure of the population
Dispersal (number or proportion of animals dispersing)[28]

Observations (visual checks)

Overview — Observational data offer a non-invasive alternative to repeat trapping of animals and observations can thus be considered as 'recaptures' in a capture-mark-recapture (resight) analysis (to determine survival and population size). Observation locations of the beaver can be used instead of radio-telemetry 'fixes' to determine territory sizes and, potentially, habitat use. It may also be possible to carry out detailed behavioural observations of focal animals[29]. The use of observations to assess survival and/or population size is dependent on the ability to identify individuals. Locations of unidentified beavers can, however, be analysed at a family level to assess family territory (home range) sizes and/or habitat use. The use of observational locations in analyses of home range size or habitat use are potentially subject to bias because animals are most often observed on the water and cannot be seen through the thick vegetation when they are ashore; biases can, however, be overcome to some extent by combining observational locations with field-sign locations (below). However, these methods are hugely resource-intensive and, therefore, given the biases inherent in these data and the fact that field signs appear to be

[27] trap effort = total trap effort = number of traps x hours that the traps are open

[28] Whether dispersal is 'natural' dispersal of young sub-adults leaving the parental group, or 'dispersal from the release site' by newly-released adults, the proportion of animals dispersing can only realistically be estimated from the disappearance (lack of captures and observations) of animals from the site. Further, in the event of a disappearance, it will not always be possible to determine whether the disappearance was due to dispersal or to mortality. Some information on minimum distances moved will be obtained from reports of field signs outside the release area

[29] Behavioural observations of focal animals are not currently included in the monitoring protocols. Observations of beavers in Knapdale were, during the early phases of the release, somewhat problematic because newly-released beavers appeared to be disturbed by the presence of observers and/or the lights used by observers. Further, the behaviour of newly-released beavers is likely to differ in unknown ways from 'normal' behaviour of established animals.

adequate to describe home range outlines (and that additional information on animal movements will now be provided by GPS – see below), we have decided that observational locations are no longer necessary for essential monitoring (as suggested in last year's report – see Harrington *et al.* 2011). Monthly observations of identified individuals remain important for estimates of survival, family group size and composition, dispersal of sub-adults and population size. Observations of lodges/dens to assess the number of wild-born kits are described separately below.

Spotlights should be used for observations in the dark if animals have been habituated; SBT have been habituating beavers to spotlights and should continue this with new wild-born animals.

Workplan — Observation sessions should be carried out monthly as part of the monthly visual checks carried out by SBT for management purposes. **Revised protocols require only one record of each animal per month.** Locations of all animals observed should be recorded, and, if an unidentified animal is seen, animal sex and/or approximate age class (i.e. adult or young) should be recorded.

Data — Observational records should be entered into the existing observation trial database.

Key information provided

Survival of known individuals (monthly)[30]
Population size and density within the release site
Family size and composition
Sociality of the population[31]
Dispersal (number or proportion of dispersing animals) (see footnote 5 above)
Territory locations[32]

Lodge/den counts

Overview — Observing and counting individual animals as they emerge from the lodge or den in the evening provides additional estimates of family group size (Rosell *et al.* 2006), and, most importantly, if carried out during the period when kits emerge from the den, can provide information on the presence of kits, and estimates of the number of kits. During these observation periods it is sufficient to count the number and age-class (adults, yearlings and new kits) of all animals seen as they emerge from, and return to, the lodge or den. Observation periods should be as long as possible initially to maximise the likelihood of seeing animals as they first emerge from the den in the evening – the timing of observation periods can then be refined (and potentially shortened) in future years, as necessary. A number of repeat observations of each lodge/den should be made to increase the likelihood of observing all animals present (Rosell *et al.* 2006).

Observations of lodges or dens could potentially be carried out either by observers directly or indirectly using remote video. Currently, direct observations by one or two observers are considered most reliable, and this is the method that will be used at Knapdale. The potential usefulness of remote

[30] Dependent on identification of the animal
[31] Dependent on observations of two or more animals together or of observations of multiple animals leaving the same lodge/den
[32] Recorded locations of identified individuals will provide verification that known beavers are present within home ranges mapped on the basis of field sign distribution.

infra-red video cameras at lodges/dens (as either a replacement or supplementary method) may be investigated if time and resources allow.

Workplan — Fortnightly evening observations (from 8-12 pm) of all active lodges or dens, where the presence of pregnant females is suspected, should be carried out when kits emerge (from mid-July to the end of September[33]).

Data — Counts of animals at lodges/dens should be entered into a separate spreadsheet with columns for lodge/den location (name of loch and grid references), date, numbers of observed adults, 2-year olds, yearlings and kits, so that there is a row for each evening observation for each lodge/den.

Key Information Provided

Reproductive rates (number of breeding females and number of kits per breeding female)

Field sign surveys

Overview — A lot of useful information can be gained from field-sign surveys. These surveys can be used to locate dams, lodges and dens, territory borders and areas of high foraging activity. Assessment of habitat use based only on field signs is biased towards use of woody vegetation (there are few obvious signs of foraging on herbaceous or aquatic vegetation), but field signs can be supplemented by other more difficult and/or labour intensive methods (e.g. direct observations, telemetry or other types of dataloggers – see below) to provide a more complete picture of beaver foraging-habitat use.

Field signs (and their locations) should be recorded during foot or boat surveys along loch and river banks. Surveyors should walk (or travel by boat) until a field sign is observed. If it is a single field sign, record its location (and other associated data). If it is a patch of the same type of field signs, record the location in roughly the centre of the patch (and record any other information for that patch as a whole)[34]. If there are more than one type of field sign record both with the same location. For activity and foraging signs only one location (for either a single field sign or a patch of field signs) per 10 m length of bank needs to be recorded[35]. Field signs that should be recorded include: dwellings (lodges and burrows), construction (dams and canals), feeding signs (food caches, tree/branch cutting, feeding stations, foraging trails and grazed areas), and signs of other activities (tracks, droppings, scent mound or marking) (see Table A1.1). For feeding signs, only fresh signs (i.e. those left within the last 3 months) should be recorded; for other field signs (e.g. lodges, burrows, or scent mounds), only those with evidence of recent (within the last 3 months) use should be recorded. Dams can be recorded repeatedly although additional notes on recent maintenance activity and/or deterioration should be recorded in the database, and photographs should be taken to show changes over time. To

[33] One kit was first seen emerging from the den in mid-September (in 2011 – preliminary Year 3 data), which was later than originally expected and therefore, the period for den counts has been extended from mid-July - end of August (see Harrington *et al.* 2011) to mid-July - end September.

[34] The only complication that should arise will be if field signs become so prominent that they are essentially continuous (over more than 10 m) along the loch/river bank – if that becomes the case, record locations at 10 m intervals (e.g. for a 12-15 m stretch of feeding signs, record the first point midway within the first 10 m and then the second midway in the section that extends beyond 10 m.

[35] It is not necessary to predetermine the 10 m survey sections – this can be done retrospectively at the analysis stage to monitor e.g. changes over time in the proportion of survey sections containing foraging signs.

assess accurately whether a field sign is fresh or not, or been used recently, will require a degree of expert judgement, but assessments may be assisted by using an effective marking system to mark field signs when they are first recorded[36]. During Year 1 of the project a marking system was developed using natural wool to distinguish old (previously recorded) field signs from fresh field signs – this system is currently believed to be effective and so should be continued. Search effort for all surveys should be recorded.

Any reported or observed field signs (e.g. during searches for lost animals) outside the release area should also be recorded to provide information on dispersal.

Workplan — A strip of up to 40 m away from the water's edge around each loch/river known to contain beavers, as well as surrounding riparian corridors within the trial area (as shown in Fig. A1.1), should be searched for field signs each season (Spring = Mar, Apr, May, Summer = June, Jul, Aug, Autumn = Sept, Oct, Nov, Winter = Dec, Jan, Feb).

Data — Data should be entered into the existing revised field-sign file in the beaver trial database. For field signs recorded outwith the release area, any relevant explanatory notes should be added to the comments field (for example, known or suspected animal identification, any associated trapping efforts, animal now known or believed to be dead/alive, animal now rescued and returned to the release area).

Key information provided

The number and location of dams and lodges built
Territory locations, as well as number and size of territories
Territorial marking behaviour
Terrestrial habitat selection within territories

Table A1.1. Field signs recorded (revised January 2011)

Type	Feature	Including
Dwelling	Burrow	
	Lodge	
Construction	Dam	
	Canal	
Feed Sign	Food cache	Underwater stores of cut saplings and branches outside the lodge/burrow
	Tree/branch cutting	Felled trees/saplings Cut tree stumps Gnawed trees Cut branches Stripped branches/sticks
	Feeding stations	
	Foraging trail	

[36] Markers used need to be able to persist in the environment for 1 to 2 months, but also not distract from the aesthetics of the area since Knapdale forest is located within a National Scenic Area open to visitors.

	Other	Grazed area = cropped (by beavers) ground vegetation Acquatic macrophyte mats
Activity	Tracks	
	Scent mound or marking	Single mark, or recent marking of a larger, frequently used mound etc.

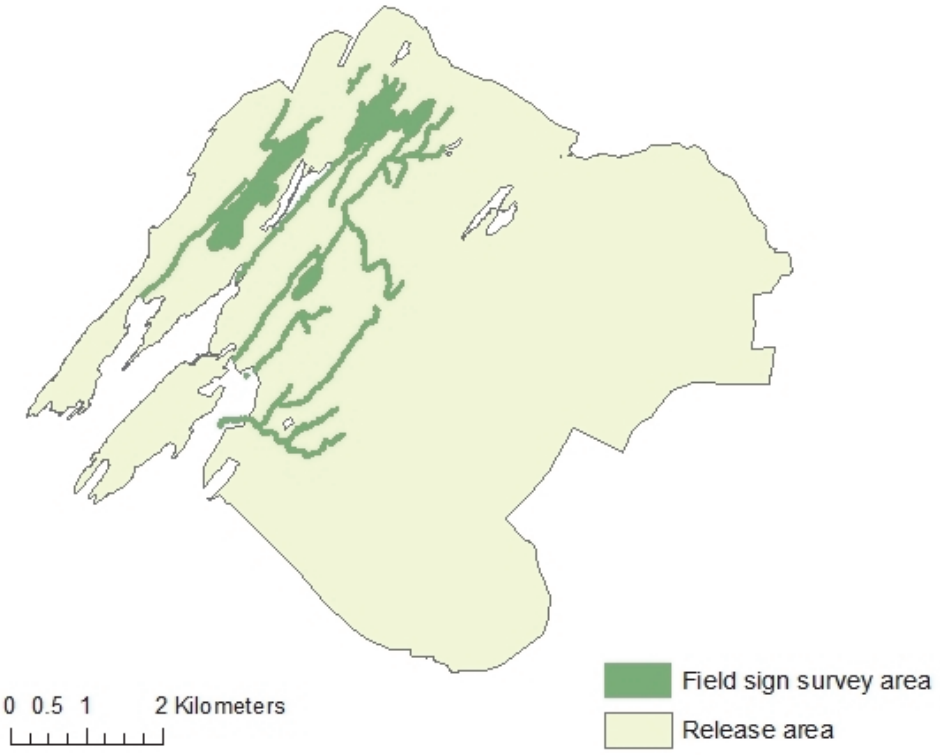

Figure A1.1. Areas surveyed for field signs within the release area (based on a 40 m buffer around each loch occupied by beavers), Knapdale, Argyll. Since January 2011, these areas have been surveyed seasonally (in Year 1, a smaller area – based on a 5 m buffer – was surveyed monthly – see text). © Crown copyright and database rights 2013 Ordnance Survey 100017908.

GPS telemetry

Overview

GPS telemetry is potentially able to provide a very detailed series of locations for beavers remotely and thus without the difficulties associated with observing beavers directly or with triangulation in VHF telemetry, and without significantly increasing the workload of the field team. Such data allow detailed analysis of (short-term) home range (and independent verification of home range boundaries as inferred from field signs) and, potentially (subject to limitations due to the precision of the data) habitat use, and could significantly help the ecological monitoring (both the quality of the data and the efficiency with which it can be gathered). Most importantly, GPS telemetry would provide data on nightly movements that we are otherwise currently unable to report on. Trials of inexpensive i-Got-U GPS loggers suggest that these tags would provide an affordable solution to the otherwise expensive GPS transmitters designed specifically for animal tracking. Preliminary trials show that locations are not

recorded when the animal is inside the lodge but this is beneficial insofar as it, in effect, provides data on the times of emergence from, and return to, the lodge and thus, indirectly activity periods and schedules. Simultaneous deployment of GPS transmitters on animals from neighbouring lochs would also provide data on home range overlap (if there is any) that is impossible with the use of field signs alone. One disadvantage of the method is that animals have to be trapped twice, once to fit the tag and once to remove it to retrieve the tag (although one of these trap sessions can be part of the annual health monitoring trapping).

Workplan — Considering the animal welfare implications of repeated capture and handling of animals, the risk of loss of the tag, as well as the limited number of years remaining until the end of the trial, the decision was made to capture and tag only adults with the aim of tracking all adults over the following two years, with half the animals tagged in early summer and half in late autumn[37] (ensuring that there is even coverage of males and females in both seasons), each tracked for approximately two weeks. Ideally, all adults would be tracked in both seasons and the feasibility of this will be reviewed as the project progresses. Other sub-adults or non-breeding adults should be tracked opportunistically if the opportunity arises.

Data — Data should be provided in its raw format in a csv file as downloaded from the tag.

Key information provided

Independent verification of home range boundaries as defined by field sign locations (and potentially, spatial overlap with neighbours)
Distance and pattern of nightly movements
Activity patterns[38]
Habitat use[39]

Temperature-depth recorders (TDRs)

Overview — One unanswered question that still remains even if GPS tags are used, is to what extent beavers use the aquatic habitat. The resolution of GPS locations mean that it will not be possible to distinguish between a beaver on the land at the edge of the bank and a beaver in the water at the edge of the loch. Detecting aquatic habitat use from GPS data is also complicated by the fact that a fix will only be obtained if a beaver in the water is at the surface, but not all 'surfacing events' will be recorded due to the 15 minute fix interval. Since animals will now be trapped for GPS tag attachment, the opportunity exists to attach DTRs at the same time. DTRs are very small, light weight devices (31 mm length, 8 mm diameter, weighs 2.7 g in air and 1 g in water) that are capable of recording depth and temperature at 1 second intervals (for approximately 6 days), providing very detailed dive profiles. Whilst it may not be possible to distinguish between foraging dives and travelling dives, or dives approaching the entrance to the lodge, dive data will provide information on the amount of time spent in the water, which, coupled with known activity periods from the GPS data, will allow us to infer the proportion of 'active time' that beavers spend in the water.

[37] although the ideal situation would have been to track animals over winter, the animal welfare implications of trapping animals in winter, and the difficulties posed to fieldworkers, meant that a more feasible solution would be to limit 'cold season' tracking to late autumn. Alternative methods of inferring activity times and/or movements in winter should be considered in future.
[38] as revealed by time of emergence from, and return to, the lodge
[39] subject to limitations due to imprecision inherent in these type of data

Workplan DTRs should be attached to animals alongside GPS transmitters, following the same schedule as for GPS tracking, with the same general aim of obtaining data from all adults over the following two years (half in each season – early summer and late autumn) or ideally, all adults in both seasons over the following two years.

Data Data should be provided as raw download files (both the csv and BIN[40] files).

Key information provided

Time spent using the aquatic habitat
Dive depth, duration and frequency[41]

Surveys of otters and other riparian mammals

Overview One of the qualifying features of the Taynish-Knapdale Special Area of Conservation (SAC) is the Eurasian otter (*Lutra lutra*) (which is also a UK BAP priority species). To demonstrate that the trial reintroduction of beavers into the SAC will not negatively impact on the site's qualifying features or on UK BAP priority species, otter presence in the area will be monitored over the duration of the project. Surveys for the presence of otter field signs will be undertaken by SNH following standard otter-survey methodology (see Appendix B). Supplementary data on the presence of mink field signs will also be recorded, since mink field signs are easily recorded alongside otter field signs, using the same methods. Further additional data on the presence of mink will be provided by SBT from their mink control activities.

Workplan 20 surveys sites (10 in the release area and 10 in the control area) will be surveyed annually in autumn by SNH (ideally, but should be delayed if weather conditions are unsuitable). The survey should not be undertaken immediately after a period of high-water levels and should be completed in a single four-day period of fieldwork, rather than split into two. Survey site locations are given in Appendix B; the same sites will be surveyed each year. Samples needing their identification verified should be stored in a freezer.

Data Data will be input into the riparian mammal survey data spreadsheet using unique section IDs that link to the survey sites in the GIS database. A record should be kept of all stored samples with IDs to allow links to survey data.

Key information provided

Presence, distribution and relative abundance of otters[42]

[40] These files can only be viewed using the datalogger HOST software provided by CEFAS, but are important for diagnostics should any problems occur
[41] Not necessarily part of the essential monitoring, but valuable biological data on beavers in loch systems
[42] It is not possible to assess habitat usage of otters from otter spraints

WORK-PLAN SUMMARY

Trapping **Annual trapping - once per year targeting all individual animals, time of year to be decided by SBT, but should be reported, and (ideally) within the same season each year**

Kit trapping – September or as soon as possible after emergence from the lodge

Observations

Data to be provided from SBT's monthly visual checks – one record per month for each individual.

Lodge/den counts

Fortnightly evening (8-12 pm) observations of active lodges or dens, counting animals present when kits emerge (from approximately mid-July, through September).

Field sign Surveys **Surveys of known occupied areas and riparian corridors within the release area every season (Spring = March, Apr, May, Summer = June, July, Aug, Autumn = Sept, Oct, Nov, Winter = Dec, Jan, Feb) recording (and marking) all new field signs seen (within 40 m of the waters' edge of occupied areas).**

GPS Telemetry **i-Got-U tags to be fitted to animals for 2 week periods with the aim of tracking, as a minimum, all adult animals over the following two years (half in early summer, half in late autumn).**

Depth-Temperature Loggers

To be fitted to animals alongside GPS tags.

In ensuring that the relevant key information is collected, the aim throughout is to achieve a balance between data collection, animal welfare and maintaining natural behaviours within the population.

ANNEX 2: MONITORING OF THE OTTER *LUTRA LUTRA* AND OTHER RIPARIAN MAMMALS – REPORT ON THE 2011 SURVEY

Monitoring of the otter and other riparian mammals was carried out by Rob Raynor from SNH. The full report on this aspect of the monitoring project (authored by Rob Raynor) is provided here; a short summary is given in section 7 of the main report.

Introduction

The rationale for undertaking monitoring of otters and other riparian mammals at the release site is detailed in Campbell *et al.* (2010). One of the qualifying features of the Taynish-Knapdale Special Area of Conservation (SAC) is the Eurasian otter (*Lutra lutra*). In order to ensure that the trial reintroduction of beavers into the SAC will not negatively impact on the site's qualifying features, a programme of monitoring, coordinated by SNH, is being undertaken and this includes for otter. In addition to the SAC issue, the monitoring will also provide a broad level indication of beaver effect on otter. Other riparian mammals, notably American mink (*Neovison vison*) and water vole (*Arvicola terrestris*) were included, as the former, at least, can be readily surveyed using the same methodology as for the otter. Both otter and water vole are UK BAP priority species and, if information on the occurrence of latter can be collected at the same time, this can only be beneficial, as the current distribution of water voles in Scotland is still incompletely known. Notwithstanding this, given the important ecological role that beavers play in the influencing the hydrology of their habitat and the experience from elsewhere in their European range, negative impacts from beavers on any of these other species are considered unlikely.

The fieldwork

The protocol for site selection and the fieldwork methodology are described in the first (2009) riparian mammals monitoring report (Harrington *et al.* 2011). Most sites are associated with bridges or obvious physical features such as loch outflows. Digital photographs of nine of the survey sections are available in this report with the remaining 11 shown in the corresponding report for 2010. A GPS 10 figure grid reference recorded for the position at which the photograph was taken. The direction in which the camera was pointing was recorded as "upstream" or "downstream", with the exception of coastal site 7.

At most sites, it was possible to conduct the survey by walking within the watercourse channel and recording any field signs observed from there. In very narrow watercourses, both banks could be inspected simultaneously, whereas at others it was necessary to survey each bank separately and/or complete part of the survey from the bank. In 2009, 2010 and 2011 two of the larger watercourses (sites 3 and 16) were surveyed along one bank only.

The length of each survey section was estimated by counting paces as the survey progressed. The following field signs were recorded: holts/dens/places of shelter, spraints/scats, footprints/tracks and otter paths. Any evidence of prey was also recorded. The distance from the start to the first evidence of otter was recorded.

In 2011 the fieldwork was undertaken in a single 4 day block from 1-4 November. Each 100m section was walked, noting any signs of otter, mink or water vole.

Practical constraints

All of the sites were surveyed in the first period of predominantly dry weather after an extended period of several weeks of heavy rain and high water levels. The intention had been to undertake the survey during October but the weather conditions had precluded this.

Water levels were therefore very high at several sites, notably at sites 4 and 5. In the case of the latter (the outflow of Loch Linne) – this may (again) have accounted for the negative result at the site.

Photographs

Photographs of 5 sites in the trial area and 4 sites in the control area included below. Photographs of the remaining sites are included in the 2010 report. In addition, some photographs of otter field signs are included below. The abundant field evidence at Site 16, plus the sighting of an adult female otter and a well-grown cub indicate that this site was used for breeding in 2011.

Photographs: Field signs

Figure 1: Feeding remains on otter run at Site 4

Figure 3: Otter run at Site 16

Figure 2: Couch / lie-up at Site 16

Figure 4: Feeding remains at Site 16

Photographs: Trial area

Figure 5: Site 11 Barnluasgan

Figure 7: Site 12 near the Faery Isles

Figure 8: Site 20 Barnagad Burn

Figure 6: Site 19 by Lochan Buic

Figure 9: Site 16 Loch Craiglin

Photographs: Control area

Figure 10: Site 8 Glashan Dam

Figure 12: Site 2 A83 at Ardcastle

Figure 11: Site 6 A83 at Lochgair

Figure 13: Site 7 looking north up Loch Fyne

Results

The results of the survey are summarised in Table 2. Most field evidence was in the form of spraints and otter paths/runs.

Evidence of otter activity was confirmed at seven sites (70%) in the trial area and six sites (60%) in the control area. In the trial area, this is the same as for 2010 but is a slight reduction for the control area. At the 5% significance level[43], there was no difference in the percentage of sites occupied in the control and trial areas. There was also no change over time. Also, the interaction between area and year was not significant. It is the interaction that is of most interest as this is the term that informs whether the beavers are having an effect on the distribution of otters.

Conversely, when the spraint data are compared, it is evident that the quantity of spraint recorded at sites in the trial area is again higher than that recorded in the control area (Table 3), even when the data from Site 16, which had abundant otter evidence indicative of a breeding site, are excluded. However, this has not been statistically tested.

Perhaps more significantly, the quantity of spraint found at five of these positive sites was substantially greater than any of the positive sites in the control area, suggesting a higher overall level of otter activity in these areas (Table 3). Many of the control area sites are at higher altitude than those in the trial area and are located within dense commercial conifer forest. It is possible therefore that this whole forested area around Loch Glashan represents a sub-optimal habitat for otters when compared with the beaver trial area to the south-west. The results of future monitoring may help to shed more light on this. However, it is how occupancy in the control area changes over time compared to how occupancy in the trial area changes over time that is of most interest.

The mean number of spraints recorded for all positive sites where spraint was found in 2009, 2010 and 2011 is given in Table 3. In 2011, spraint evidence in the control area was markedly lower (30% of sites) than the trial area, but clear otter paths were visible in three other sites where spraint was not found, hence the comparable overall figure for otter presence.

Mink evidence was inconclusive with possible unconfirmed signs at three sites, but none of the scats were fresh, so the evidence remains questionable. No mink evidence was found on the mink rafts at the outflows of Lochs Creagmhor (Site 18), Loch Linne (Site 15) or Loch Coillie-Bharr (Site 13) in the trial area.

There was evidence of crustacean remains in spraints at several sites (5, 13, 16, 18), indicating movement of otters between the coast and inland waters. The presence of such remains at Site 16 is consistent with evidence of breeding, as crabs often feature significantly in the diet of cubs in coastal habitats. At two sites, salmonid eggs were present in association with other otter signs. A spraint at Site 6 contained a nematode worm.

[43] The model of best fit was explored using generalised linear models and generalised linear mixed models. Fixed terms tested were year, area (control or trial), location (coastal, inland freshwater and loch) and their interactions as it is the interaction between year and area that is of most interest. The random effects tested allowed for each site to have their own intercept and each site to have their own slope over years. Nested models were tested with AICc. It was found that the only fixed term that was an important predictor was location. However, it was never significant because the standard errors were always very large. This was because all coastal sites were always occupied. Ignoring location, no other terms, either random or fixed, helped to explain otter occupancy. Work is currently underway to determine what size of interaction between year and area may be detectable by the end of the trial.

As in previous years, no evidence of water voles was detected.

Rob Raynor
Policy & Advice Officer (Mammals)
Scottish Natural Heritage

References

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Harrington, L.A., Feber, R., and Macdonald, D.W. 2011. The Scottish Beaver Trial: Ecological monitoring of the European beaver *Castor fiber* and other riparian mammals – First Annual Report 2010*. Scottish Natural Heritage Commissioned Report No. 450*.

Table 1: Location of all survey sites inside the trial area (Y) and outside (N)

Site no.	x	Y	Inside_trial_area	Description	Location	National_site
1	188600	690900	N	100m downstream d/s of track	Inland	N
2	194500	692400	N	100m d/s of road bridge	Inland	Y
3	191200	694800	N	100m d/s of track	Inland	N
4	191200	690200	N	100m upstream of entrance to un-named pond/lochan	Inland	N
5	191700	689200	N	100m d/s of road bridge	Coast	Y
6	192600	691500	N	100m d/s of road bridge	Coast	Y
7	191700	686600	N	100m south of landward end of pier	Coast	N
8	192000	692700	N	100m d/s of dam	Freshwater loch	N
9	193300	695800	N	100m d/s of fish ladder	Freshwater loch	N
10	195300	697000	N	100m d/s of dam	Freshwater loch	N
11	178900	691000	Y	Burn near L. Barnluasgan - d/s from road	Inland	Y
12	176700	688700	Y	coastal burn u/s from shore	Coast	N
13	177800	689700	Y	outflow from L. Coille-Bharr	Freshwater loch	N
14	178100	689100	Y	d/s from bridge - By Gariob cottage	Inland	Y
15	179400	690500	Y	outflow from L. Linne	Freshwater loch	N
16	177300	687700	Y	100m d/s of road bridge by L. Craiglin	Coast	N
17	177900	687600	Y	up un-named coastal burn from shore	Coast	N
18	180200	690800	Y	outflow from L. Creagmhor	Freshwater loch	N
19	179000	689200	Y	d/s confluence of 2 un-named burns, by ford	Inland	N
20	178200	686900	Y	d/s confluence of Barnagad Burn and Alltan Ghabhar	Inland	N

Table 2: Riparian mammal evidence, November 2011

Date	ID	Surveyor	Osight	Ospraint	ORP	OTR	Distance to first otter sign (metres)	Msight	Mscat	MT	Mother	Wsight	Wlat	Wother	Notes
1.11.11	1	RR	0	0	0	0	-	0	0	0	0	0	0	0	Possible otter run, but inconclusive due to lack of other evidence.
1.11.11	2	RR	0	0	0	0	-	0	?	0	0	0	0	0	Possible old mink scat on road bridge
3.11.11	3	RR	0	0	?	1	<10	0	0	0	0	0	0	0	No spraint, checked both sides under bridge. Possible lie up, but unconfirmed
1.11.11	4	RR	0	1	?	1	12	0	0	0	0	0	0	0	High water level. Prey remains (including salmon eggs) on one of the otter runs. Runs at various points along transect. Old spraint with fish bones. Probable couch.
1.11.11	5	RR	0	1	0	1	0	0	0	0	0	0	0	0	Run and old spraint (containing crab remains) by bridge where otter run leads over the main road.
1.11.11	6	RR	0	2	1	1	9	0	0	0	0	0	0	0	Fresh spraint containing nematode. Old spraint by lie up (location NR92649 91455).
3.11.11	7	RR	0	0	0	1	<10	0	0	0	0	0	0	0	2 x spraint found just outside transect – north of start point.
1.11.11	8	RR	0	0	0	0	-	0	0	0	0	0	0	0	
3.11.11	9	RR	0	0	?	1	Not specified	0	?	0	0	0	0	0	Numerous potential lie up sites. Unidentified scat containing rabbit fur on bridge – possible mink.
3.11.11	10	RR	0	0	0	0	-	0	0	0	0	0	0	0	
2.11.11	11	RR/ DC	0	8	1	0	4	0	0	0	0	0	0	0	4 x fresh spraint. 4 x old spraint. Lie up with feeding remains (trout eggs) nearby
2.11.11	12	RR/ DC	0	7	0	1	22	0	?	0	0	0	0	0	Old spraints. Possible (old) mink scat at 30m. Also potential den sites.
2.11.11	13	RR	0	3	0	0	70	0	0	0	0	0	0	0	3 x old spraints, 2 containing crab remains. No signs on mink raft.
3.11.11	14	RR	0	9	0	1	31	0	0	0	0	0	0	0	Some fresh spraint and anal jelly (at 31m). (Also badger evidence - snuffle holes).
2.11.11	15	RR/ DC	0	0	0	?	-	0	0	0	0	0	0	0	High water level. Difficult site due to dense/rank vegetation and few obvious places for otters to spraint. No mink or otter sign on mink raft.
4.11.11	16	RR	2	47 +	1	1	1	0	?	0	0	0	0	0	Female otter and grown cub seen. Breeding site. Numerous runs, abundant fresh spraint and feeding remains (including crab remains), couch. Unidentified scat (mink?)
2.11.11	17	RR/ DC	0	5	0	1	59	0	0	0	0	0	0	0	1 x fresh spraint, 4 x old spraint. (Also numerous badger latrines – territory boundary).
2.11.11	18	RR/ DC	0	1	0	0	43	0	0	0	0	0	0	0	Fresh spraint containing crab remains. No signs on mink raft
4.11.11	19	RR	0	0	0	?	-	0	0	0	0	0	0	0	Possible otter run, but inconclusive due to lack of other evidence.
4.11.11	20	RR	0	0	?	0	-	0	0	0	0	0	0	0	Difficult site with access restricted in places due to high water

	flow which had probably removed all field signs from the channel and under bridge. Several potential lie ups but no conclusive evidence.

ID = Transect identification number, Osight = otter sighting, Ospraint = otter spraint, ORP = otter resting place, OTR = otter track, Msight = mink sighting, Mscat = mink scat, MTR = mink track, Mother = mink other field sign, W = water vole sighting, Wlat = water vole latrine, Wother = water vole other field sign. Surveyor RR = Rob Raynor, DC = Donna Causer

Table 3: The mean number of otter spraints recorded for all sites where spraint was found

	Trial area		Control area	
	Proportion of sites with evidence of otter spraint	**Mean no. spraints per site (where spraint was found)**	**Proportion of sites with evidence of otter spraint**	**Mean no. spraints per site (where spraint was found)**
2009	7/10	3.9	6/10	1.3
2010	7/10	6.3	4/10	1.5
2011	7/10	11.4*	3/10	1.3

* If Site 16 with >47 spraints is excluded, the mean of the remaining 6 positive sites is 5.5

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