St. Kilda Soay Sheep Project
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Request for permission to

(1) Retain automatic weather recording stations on Hirta 2016-2021.
(2) Continue to erect temporary netting to catch Soay sheep on Hirta 2016-2021.

Overview
The unmanaged Soay sheep population of St Kilda offers unparalleled opportunities for ecological and evolutionary research. The ecological system is relatively simple, with no predators and no competing herbivores. In Village Bay, through tagging, Soay sheep can be monitored at the level of the individual so that entire individual life histories, the factors affecting them and the way they contribute to the overall population dynamics, can be assessed. Similarly, in evolutionary studies it is extremely unusual to be able to monitor the characteristics of individuals (for example body weight, parasite load) in such detail and then observe what happens to each individual, thereby studying natural selection directly. The research project is acollaboration between several universities and research institutes, currently led by Edinburgh University, and has been continuously funded by grants obtained in open competition, principally from the Natural Environment Research Council, since 1985. Since that date, the study has generated more than 170 published research papers and in 2004 the work was brought together in a monograph (Clutton-Brock and Pemberton 2004).

This application is to cover two activities of the research project which have already taken place for a number of years under previous SMCs. They both involve SAM number 2276, St Kilda Village and related structures.

1) Retain automatic weather recording stations on Hirta

The Requirement
The weather plays an important role in the dynamics of the Soay sheep population, both through its effect on plant growth and hence forage for the sheep, and the direct effects of winter conditions on body heat loss and sheltering (i.e. not eating) behaviour. We have previously documented associations between sheep population dynamics and weather records from airport met. stations in the Outer Hebrides, and also between sheep population dynamics and a large scale index, the North Atlantic Oscillation (NAO; which is indicative of the type of winter, crudely an axis of cold and dry to stormy and wet) (Grenfell et al. 1998, Coulson et al. 2001, Hallett et al. 2004). Although these analyses have been successful in demonstrating associations, the explanatory power of the airport data is not that great, and we would like to know if this is genuine or a consequence the different weather experienced by Hirta when compared with Benbecula and Stornoway.

By following the lives of many individual sheep, we have also shown that the Village Bay population is not homogenous. Specifically, the ranging behaviour of individual sheep reveals that there are three hefts, occupying the Western, central and Eastern parts of the bay, and furthermore the sheep living in these different hefts have different vital rates (i.e. fecundity, lamb survival etc) so that their population dynamics are subtly different (Coulson et al. 1999). These differences partly arise from variation in the quality of forage (Regan et al. 2016) but may also arise from variation in the weather conditions experienced in these different areas.

From these considerations it is clear it would be good to have (a) continuous weather recording on Hirta and (b) continuous weather recording at the different locations occupied by the Village Bay sheep hefts. In addition, it will be necessary to maintain weather recording for many years in order

to establish correlations with sheep performance.

Previously existing weather data

Weather recording on St Kilda has been sporadic. Detailed records were kept in the late 1950s, prior to Operation Hardrock, but the quality rapidly declined after the Range was established. Collection of data at the met. site in Gun Meadow was abandoned in the early 1990s. Wind speed data have also been recorded at the Mullach Mor radar installation, but these are neither digitised nor archived, and in any case are unrepresentative of the conditions experienced in less exposed areas of the island. Of the Outer Hebrides met stations, Benbecula closed in 1996 and Stornoway is now the nearest.

Existing Sheep Project automatic weather stations

In 1999-2000, with National Trust for Scotland and Historic Scotland permission, we erected three automatic weather recording stations on Hirta. Their locations are shown in Figure 1 below, which also shows what they look like.

Impact of the Automatic Weather Stations

Natural Heritage: The stations require no fencing, since the instruments are mounted on a post or tripod clear of the ground. There is therefore little influence on grazing of the vegetation.

Archaeology: The tripods require secure anchorage, but we believe our installations have minimised soil disturbance. Station (a) is attached to an MoD lighting pole and so requires no additional support. Station (b), sited on the hardstanding at the quarry, is entirely surface-mounted, using a low-lying rock-filled 'hopper' on the end of each leg (the rocks were taken from the hardcore in the quarry). Station (c), at the Abhainn Ruaival, is secured at each leg by a steel pin (approximately 40 cm long). Each station is earthed for lightning protection, and this requires two copper rods to be inserted in the ground. In addition, the soil-water probe requires two rods (30 cm x 3.2 mm) to be inserted into the soil; and the soil temperature thermocouple is placed at a depth of 10cm. These operations required no excavation or disturbance beyond insertion of the rods.

Visual: The tripods are approximately 2 m tall. The sites are removed from the main Scheduled structures, and, where possible, are in areas already disturbed by the MoD. By the very nature of the measurements, however, the stations must be sited away from undue shelter and so have some visual impact. However, we have received no adverse comment on this point since they were put up.

Data & its Stewardship

The automatic weather stations currently record, at appropriate intervals, air temperature, ground surface temperature, soil temperature, relative humidity, soil moisture, rainfall, solar radiation and wind speed and direction. The data are downloaded three times a year from each station and uploaded to an Access database. We are happy to make the data available to any *bona fide* users on request and regularly send a summary to NTS for its annual report.

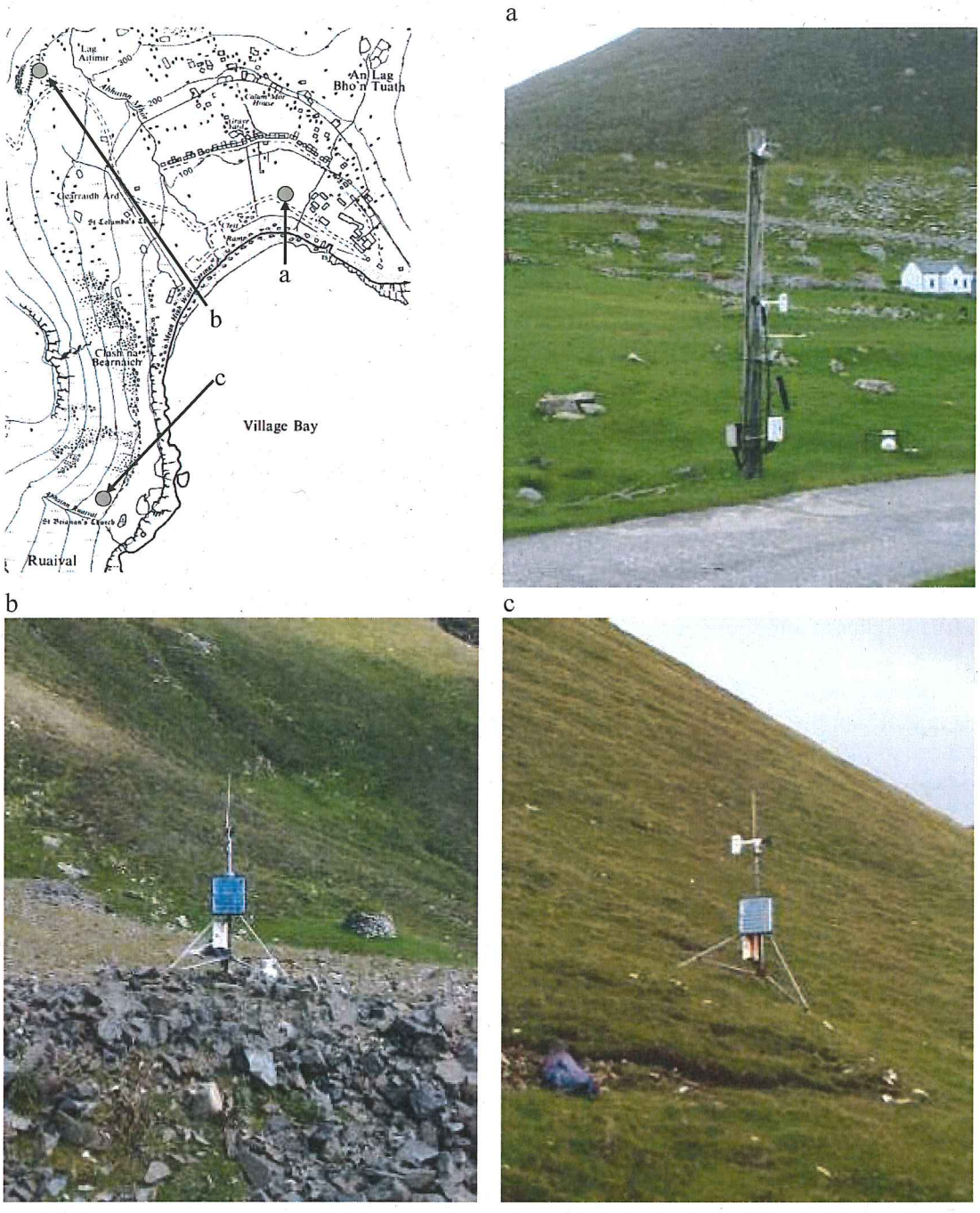

Figure 1. Location (top left) and photos of the existing three Soay Sheep Project automatic weather stations in Village Bay, Hirta. (a) is attached to an MOD lighting pole by the road at the bottom of Signals Meadow (b) is at the lip of the quarry and (c) is at Abhainn Ruaival, well above the structures at St Brianan's and outwith the SAM.

2) Continue to erect temporary netting to catch Soay sheep on Hirta

The Requirement

Information and samples collected from live-caught sheep each summer provide one of the most important data sets for our ecological and evolutionary studies on the Soay sheep. It is from this data that we have been able to show how natural selection acts on the characteristics of individuals

and whether this results in evolutionary change (i.e. genetic change). Some highlights from the last few years: (1) pinpointing of the gene controlling the horn polymorphism in Soays (Johnston et al. 2010, Johnston et al. 2011) and an analysis demonstrating that it is maintained by heterozygote advantage in male Soays (Johnston et al. 2013) (2) The first study in a wild animal of 'tolerance' of parasites, measured as the weight of an individual relative to its parasite burden (Hayward et al. 2014), (3) Evidence that a specific anti-worm antibody measured in sheep captured in August is associated with survival through the subsequent winter (Nussey et al. 2014).

In order to continue these studies we would like to continue to run a two-week summer catch on Hirta, of the kind that we have run every year since 1987 and using the methodology outlined below. This will allow us to continue measurements of horn length, body size, body weight and to sample for parasitological and immunological studies.

Procedure

Broadly, our strategy is to reinforce the head dyke and to split the area within the head dyke into two halves. Sheep enter the area using existing paths and gaps in the head dyke, which are then sealed. The sheep are then herded into small enclosures where they are caught. To do this, 1.7-2.0 m high nets (mesh size ~ 100 mm knot to knot) are set around Village Bay in various locations as indicated in Figure 2. Not all netlines and only a small number of the possible catch enclosures illustrated are used in any one year. Netting is up for a maximum of 12 days, and often less. Two different net-setting techniques are employed:

1. Free standing nets – these are set through fields, along cliff edges and to form traps where there is no available support.

(i) Poles are placed at ~10 m intervals. Poles are ~2 m high and ~80 mm in diameter.

(ii) The pole tips are either on the surface of the ground or knocked in to a maximum distance of 50 mm.

(iii) Each pole is guyed on either side for support. Pegs are wooden and up to 250 mm in length. Pegs are knocked into the ground to a minimum depth required to provide stability. Pegs are only knocked into soft ground; since rocks damage the pegs, they are withdrawn if rock is hit.

(iv) Netting, which has been threaded onto poles, is tightened between the poles and pegged down at the bottom with wooden pegs of the same size.

2. Against walls – here nets are used to raise the height of the walls to deter sheep from escaping from the area, and to protect the walls.

(i) Poles are laid loosely against the walls and guyed with one guy backwards over the wall.

(ii) Where needed, the base of the net is secured to the wall with pieces of string threaded into the cracks between the stones.

(iii) Against cleits, pegs are never used on turf roofs; instead long guys are taken to the ground on the other side of the cleit.

(iv) Against [roofless] cottages, nets and poles are sometimes tied to cottages by threading though doors and windows

Impact

Each year we consult the NTS archaeologist on the island before setting up our nets, in order to be aware of any changes we should adopt from previous years. The catch-up team is always briefed on the archaeological importance of the site, and we take tremendous care not to dislodge any stones from walls. We regularly net off structures of known delicacy. After the catch-up, all equipment is removed and extensive searches are made to make sure of this. The small holes created in the soil by posts and pegs soon close over after removal.

Data & its Stewardship

The data for individual sheep is recorded on paper process sheets and later transferred to an Access database. The data is then available to all within our existing collaboration for analysis. We also receive quite a few requests for data from other researchers wishing to conduct other analyses. We assess each request on a case-by-case basis and often hand over data where there is no conflict with existing project plans.

Figure 2 (overleaf). Map of Village Bay showing (in yellow) location of nets used in the August Soay sheep catch up. Net lines are shown as lines, while traps are shown as solid areas. Note that we do not use all traps or net lines every year.

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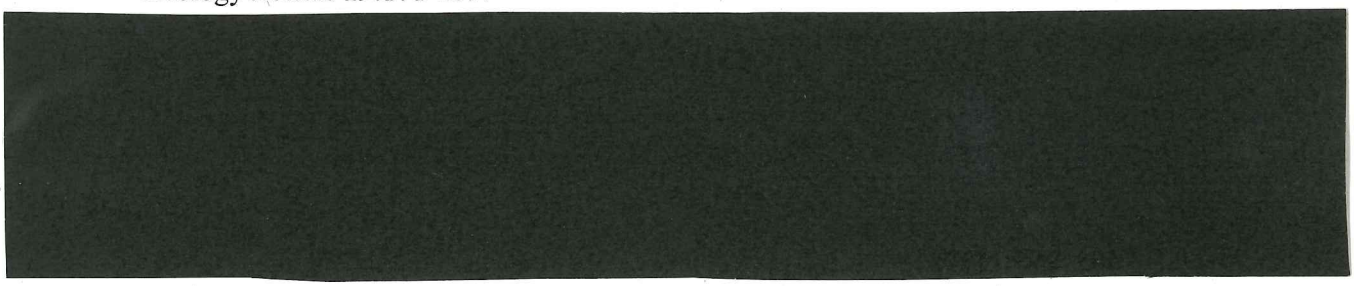
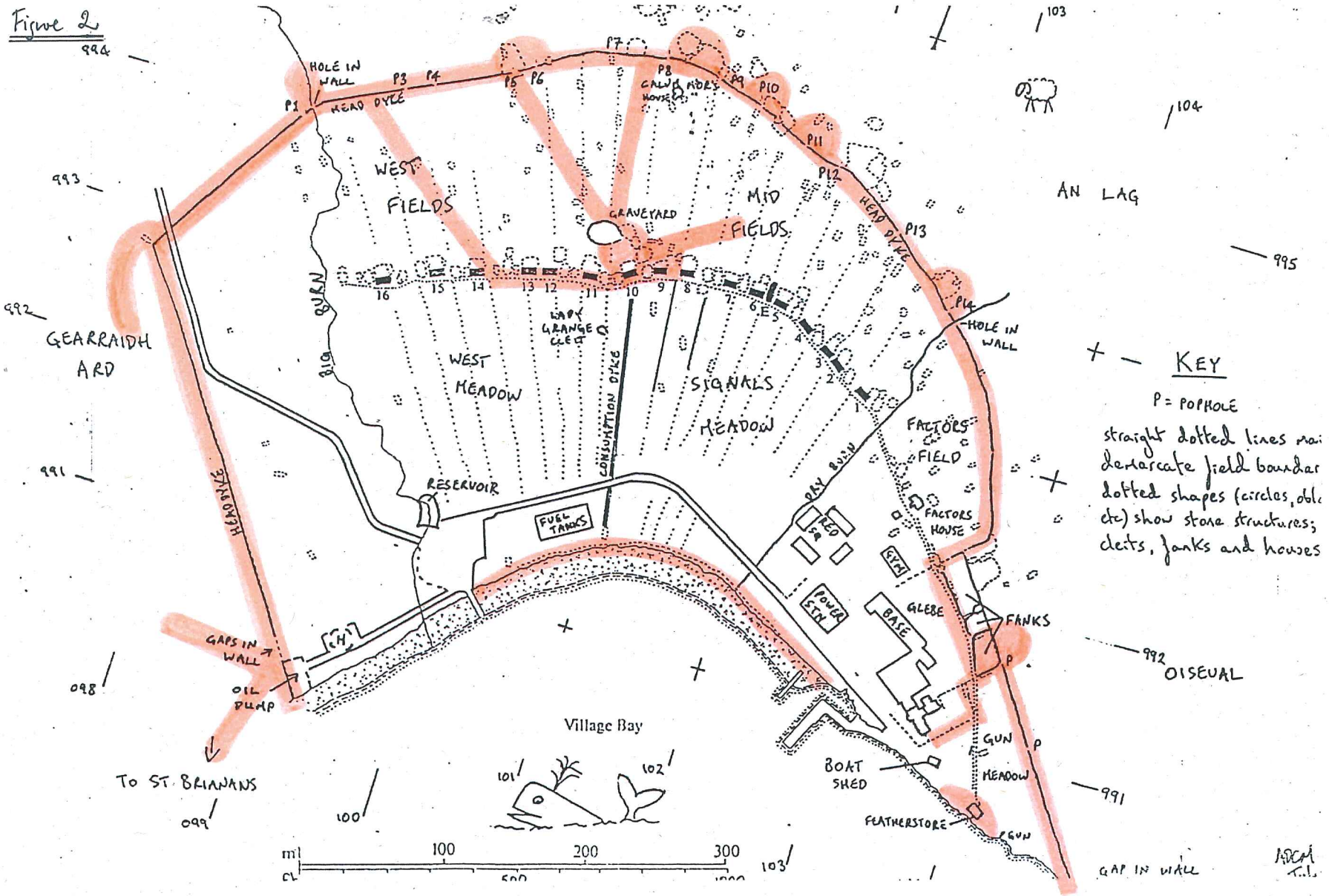


Figure 2



KEY

P = POPHOLE

straight dotted lines mai demarcate field bounda dotted shapes (circles, obl etc) show stone structures; cleits, fanks and houses