North West Wildlife Trusts

A study to compare and contrast human observation (traditional) survey methods with two technology based methods (using a drone and a web cam) to survey the grey seal (*Halichoerus grypus*) population at South Walney Nature Reserve

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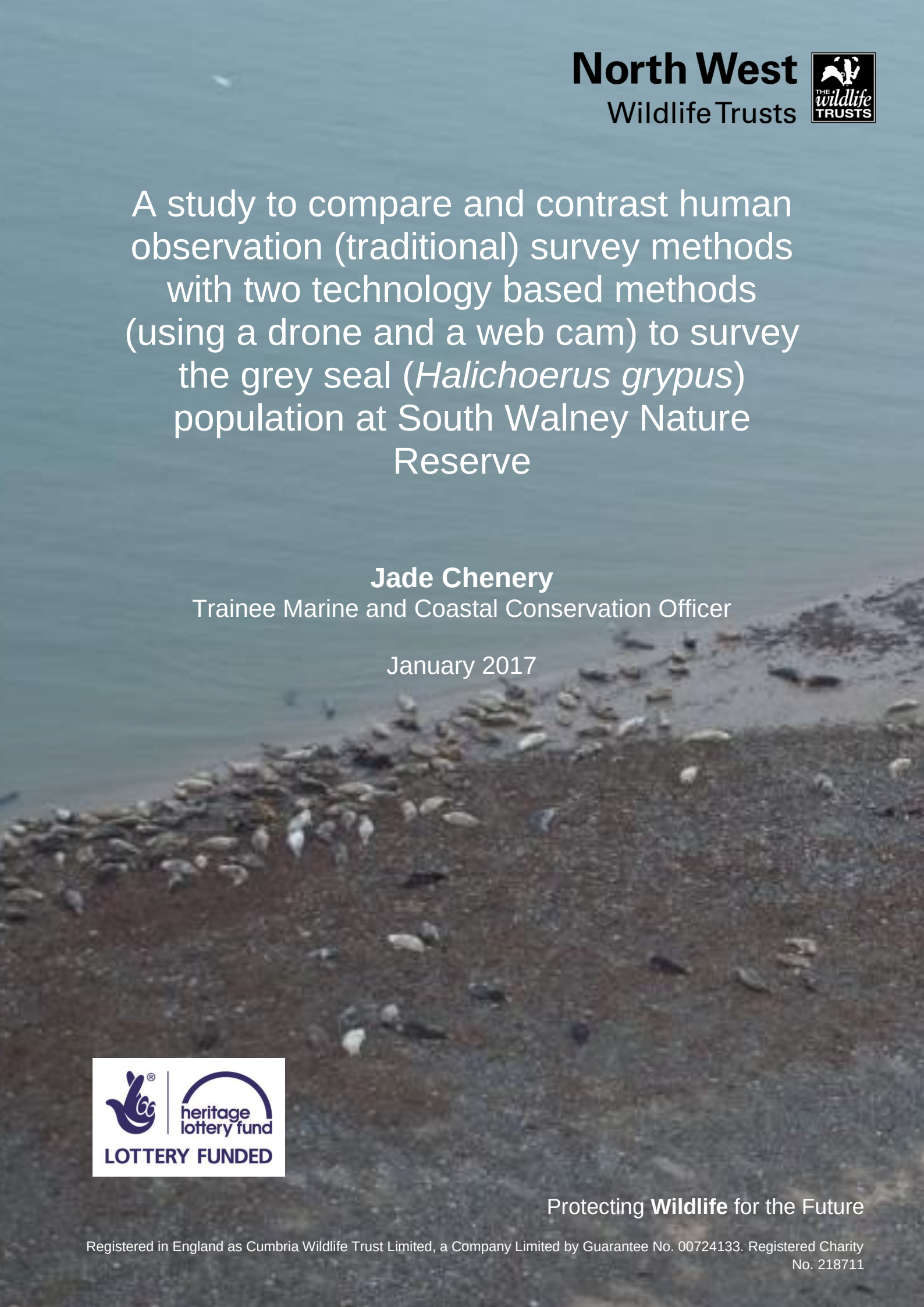

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1 Introduction

There are two species of seal resident in the UK; the Atlantic grey seals (referred to as grey seals from this point forward) and the common or harbour seals (Thompson, 2008). Of the world's population of grey seals (*Halichoerus grypus)*, 40% of these are found in the UK which represents 95% of the European population (Hammond *et al.,* 2008). Approximately 38% of the world population of grey seals breed in the UK and usually occur along uninhabited coastlines, on islands and a small number within caves (Bonner & Thompson, 1991). Major breeding colonies include those at the Isle of May, Scotland, Donna Nook and the Farne Islands both in north east England (Hammond *et al.,* 2008). Males reach sexual maturity between four and six years old and females within five years and few can go on to live for over 20 and 35 years respectively (Hammond *et al.,* 2008). Of the two UK species the grey seals are the largest with females weighing between 150 – 200 kg and males weighing up to 300 kg making them the largest carnivore in the UK as males can reach to three meters in length.

Cumbria Wildlife Trust started to manage South Walney Nature Reserve in 1963 and historic records show that grey seals were first observed around the reserve in the early 1980's either alone or in pairs most commonly during June, August and September. Grey seals have been recorded as a resident population (which means they permanently live on the spit at South Walney Nature Reserve) since the mid 1990's. Over time numbers have increased and they can now be observed all year round. The spit is an extended expansion of beach material that is connected to the mainland on one side and made up of material that is carried by tidal currents and deposited off a headland. South Walney Nature Reserve is located on Walney Island which sits west of Barrow-in-Furness in Cumbria and is the only recorded haul-out site for grey seal in the North West of England.

Grey seals can spend up to two thirds of their time at sea foraging or travelling however they haul-out in large numbers on land to rest, breed, moult their fur (for several weeks each year) and digest food (Hammond *et al.,* 2008). Due to their high sensitivity they prefer to haul-out in locations with minimal human disturbance and close to the sea (Hammond *et al.,* 2008). The spit at South Walney Nature Reserve has the Irish Sea on three sides and due to restricted public access imposed by CWT to the beaches and spit they experience very little human disturbance.

Grey seals mate in the autumn and pupping occurs around a year later with the earliest seal pups being born in the south west of England between September and October. The next area to pup is the north and west of Scotland from October to late November and between early November and mid-December in eastern England (Hammond *et al.,* 2008). The

number of pups born to a colony can range from a small number each year (such as that at South Walney) to over 6,000 pups born annually at Ceann Iar, Monarch Island, Outer Hebrides (Hammond *et al.,* 2008). In 2015 two seal pups were recorded born within the colony based at South Walney Nature Reserve. In 2016 a further five pups have been recorded to the seal population with Table 1 showing the discovery dates. Previous surveys conducted until 2015 have not shown the population to be breeding and the exposed environment of the haul-out was proposed generally by those at the Trust to be the reason why this resident population were non-breeders for many years.

Table 1: Dates and method of discovery for the five grey seal pups born on South Walney Nature Reserve in 2016.

Seal pup number	Date of discovery	Method of discovery
1	12/10/2016	Seal Cam
2	3/10/2016	Seal Cam
3	9/11/2016	Seal Cam
4	19/11/2016	Seal Survey
5	24/11/2016	Drone survey

The Natural Environment Research Council (NERC) provides detailed and up-to-date scientific advice on the management and status of the protected British seal populations annually as a requirement of the Conservation of Seals Act 1970 and the Marine (Scotland) Act 2010 (SCOS, 2014). The Special Committee on Seals (SCOS) perform these duties whilst the Sea Mammal Research Unit (SMRU) based at St Andrews University provides advice to the Government. Hence the studies carried out at South Walney Nature Reserve are important to add to this database of information for this protected species. Whilst the seal population on South Walney Nature Reserve have had intermittent surveys carried out, many other populations around the UK have been well studied including those at Donna Nook, England (Harrison *et al*., 2006), Isle of May, Scotland (Pomeroy, *et al*., 2000), North Rona, Scotland (Pomeroy, *et al*., 1994) and Skomer Island, Wales (Büche & Stubbings, 2014).

The survey methodology at South Walney Nature Reserve has not been carried out in a structured manner since the mid 1990's. These casual population counts, visitor and incidental records indicated that the grey seal population was made up of a large percentage of males (both old and young) and the surveyors hypothesised that they have been outcompeted elsewhere in during breeding seasons for female mates. These surveys have gained more structure over recent years to conduct more consistent population counts and behaviour surveys on the seal population hauled out on the spit. Since 2011 the seals have

been monitored due to the introduction of the Marine Graduate Training Programme (2011-2014) which was followed by the Marine and Coastal Heritage Programme (2014-2017). Both of these schemes, established by Cumbria Wildlife Trust, were funded by the Heritage Lottery Fund to provide graduates and non-graduates with work-based marine conservation and community engagement experience. The methodology to which the data has been regularly collected by these trainees was standardised in 2013 so regular and consistent monitoring could continue to gain a better understanding of the grey seal population at South Walney Nature Reserve. Since 2005 the average total number of grey seals observed has increased from 20 to 79.

1.1 Seal Cam

Cumbria Wildlife Trust has a number of live streaming cameras for example 'Osprey Cam' based at Foulshaw Moss Nature Reserve provides a real time view of a nest and the subsequent chicks onto the CWT website. After the success of the public engagement with increased visitor numbers to the website this provided reasoning for a similar camera to be installed at South Walney Nature Reserve to record the seals when the seals are hauled out. An Axis Q6044 E network camera was installed on 6 meter camera pole on the spit during June 2016 and 'Seal Cam' went live over CWTs website in September. This set up is connected back to the office via a 1.2KM of 25mm 3 core SWA PVC power cable with the addition of four NET-EL-ENH500 wireless links to maintain the internet connection and streaming between the camera and office set ups. The camera produces a HDTV 720p image and provides a 30x optical zoom and pan/tilt to cover a wide area that can be controlled from a laptop. The web cam image can be viewed and controlled via a laptop to ensure the best view of the seals and viewed from the office based at South Walney Nature Reserve and is duplicated on a screen in the small museum for visitors to view on arrival to the nature reserve. There is also the capability to take screen shots from the stream and save video clips from the last 24 hours of footage all using the AXIS Companion computer software. The camera does not however have night vision or the option to record audio.

1.2 Drone use

In February 2016 a drone flight was trialled to count the seals by Dave Morris and Callum Booth from the RSPB. From the images taken, 235 seals were counted, which was significantly larger than the average number recorded from previous traditional seal surveys which was 89 individuals in the 2014/2015 survey period (Bradshaw, 2015). This large difference in numbers influenced the idea to introduce a drone to this years seal survey methodology to count the population along with the addition of Seal Cam surveys.

Drones are a form of unmanned aerial vehicles (UAVs) which have been intensely developed over the years (Jones *et al*., 2009). There are abundant designs for UAV platforms and their physical size and power (which limits the range, operating altitude and carry capacity) are the key for their distinction (Anderson & Gaston, 2013). Small UAVs, with a wing span of less than 3 metre, can be autonomously controlled to provide a safe, inexpensive and user friendly way to survey wildlife providing statically robust results (Jones *et al*., 2009). Drones are also referred to as Unmanned Aerial Systems (UAS) and have been recognised and used by biologists and ecologists to gather data quickly and effectively (Pomeroy *et al.,* 2015). The use of this type of technology is relatively new here in the UK with only a few similar seal orientated studies having been carried out in Canada and Scotland (Pomeroy *et al.,* 2015). One of the main advantages of such technology is the option to record information with photographs and videos what would be either impossible or too expensive to gather using traditional human orientated methods (Pomeroy *et al.,* 2015). Counts of animals provide population scale estimates of abundance and productivity and when using higher resolution equipment can be used to distinguish age, sex and size classes and even down to an individual level (Pomeroy *et al.,* 2015). Risk to personnel, financial cost and limitations of the information gained are all considerations for such research but these will be to a minimum due to the scope of this project.

A summary of wildlife research with unmanned aircraft found that aquatic mammals had received the most focus overall amongst mammals and wading birds amongst bird studies as both these groups being located hard-to-access and hence hazardous habitats to survey with manned aircraft (Chabot & Bird, 2015). During a dugong surveys in Western Australia, dolphins, turtles, shark, rays, sea snake, schools of fish and birds sat on the surface of the water were also incidentally recorded with the first of the two animals listed often identifiable to species level (Hodgeson, 2013).Other studies of estimating the number of animal in large aggregations have included studies on krill dependent predators including chinstrap penguins in Antarctica (Goebel *et al.,* 2015). This research also recorded footage of four leopard seals which was used to identify and measure the individuals. Antarctic fur seal were also detected on the surveys in which small identification tags were visible (Goebel *et al.,* 2015). Small UAVs have also been used to study wading birds, alligators and manatees in Florida (Jones *et al.,* 2006). Sea turtles have also been detected during aerial surveys by Hodgson et al. (2013) and Brooke et al. (2015).

1.3 Aims and objectives

This project aims to:

- Compare and contrast traditional survey methods and modern technology (drones and Seal Cam) by surveying the seals at South Walney Nature.
- Collect the annual survey data using three methods; traditional seal surveys, Seal Cam surveys and drone surveys.

2 Materials and methods

2.1 Site information

South Walney Nature Reserve was established as a warderned nature reserve in 1963 by the Lakes District Naturalists' Trust and Lancashire Naturalists' Trust after there was a change in ownership to the Cavendish family from the Buccleughs (Dean 1990). South Walney Nature Reserve sits on the southern tip of Walney Island which is located close to the Lake District on the tip of the Furness Peninsula just off the west coast of Barrow-in-Furness shown in Figure 1. From the beach at North End to South End the island is approximately 10 miles long and at its widest point it is around 1 mile wide. The main haul-out site of the grey seals is located on Haws Point spit (Figure 2) at the end of the Island and is the only known colony of grey seals in Cumbria.

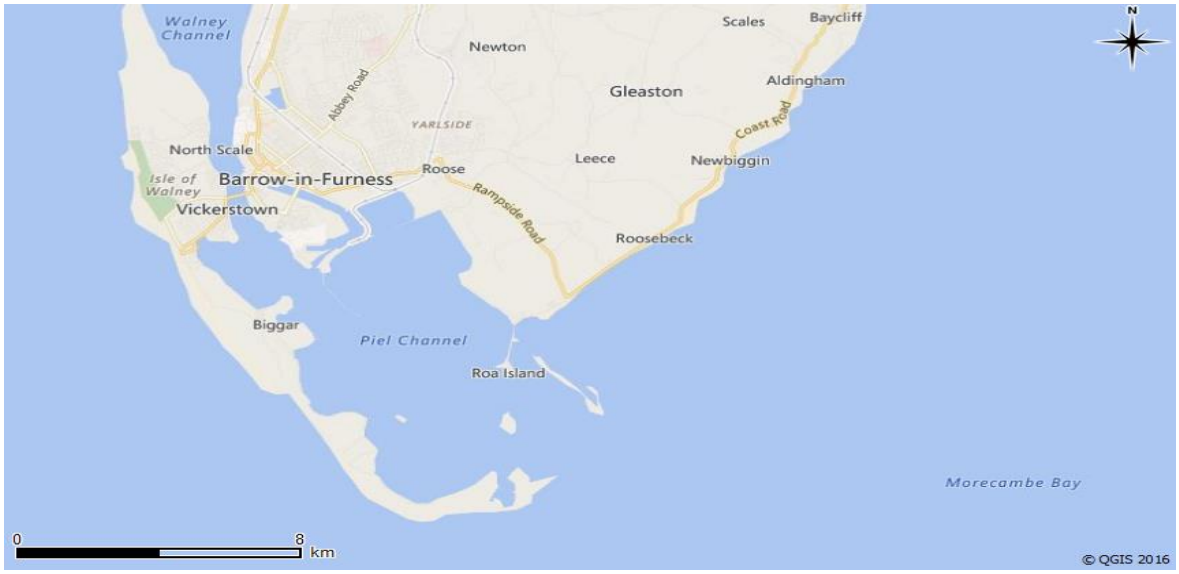

Figure 1: Location of Walney Island in relation to Barrow-in-Furness

Figure 2: Overview of South Walney Nature Reserve with Haws Point spit shown by the circled extension of land on the right.

The bedrock of the island is thought to be approximately 150 million years old having formed during the recession of the last Ice Age. When the ice began to melt a 'finger like' body of water pushed southward allowing 'three' small bodies of land to break from the mainland each forming a small islet. The three islets became eventually merged to become one as each glacier movement deposited large amounts of rock, clay and sand in its wake. The island itself consists of red sandstone with an overlay of boulder drift, sand, gravel, alluvium, blown sand and shingle (Steers, 1981).

Walney hosts a large range of environments including mudflats, sandy beaches, pebble ridges, saltmarshes, sand dunes, rough pastures and freshwater and brackish pools. These offer habitats for fauna and flora specialised to these environments and provide areas of ecological interest. The coastal elements of these habitats provide important sites for many bird species including wildfowls, waders and migrating birds around the reserve. It also hosts the largest colony of mixed gulls in Europe (1,156 herring gull and 2,312 lesser black backed gulls from the 2016 warden counts) and most southerly breeding colony of eider ducks in Britain. The Nature Conservancy classified South Walney and the Piel Channel Flats as a Site of Scientific Interest (SSSI) in 1951 due to the reserve significance for many bird species and geology. The reserve is also included within the Morecambe Bay RAMSAR site and areas at the South End Haws have Special Area of Conservation (SAC) and Special Protected Area (SPA) status shown in Figure 3.

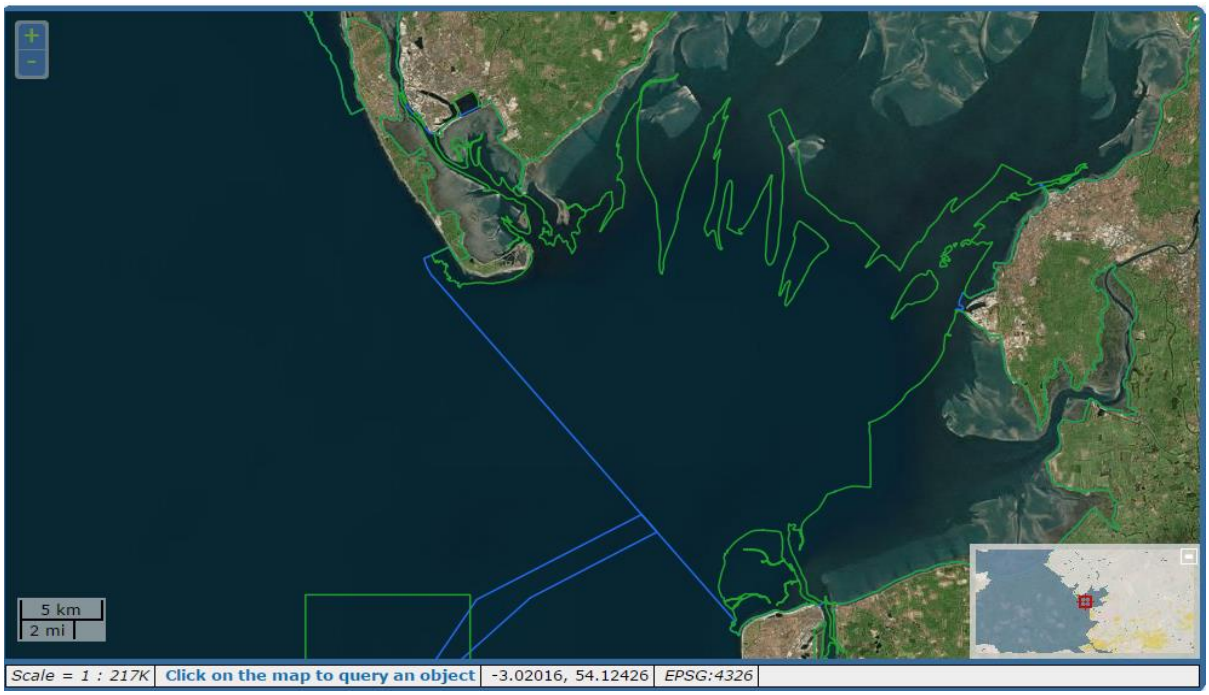

Figure 3: Boundaries of SACs (blue) and SPAs (green) around South Walney Nature Reserve (JNNC, 2016)

Morecambe Bay, the Duddon Estuary and the Irish Sea surround the Island and multiple wind turbine projects are stationed offshore. Of the three projects the Barrow turbines have 30 units, Walney has 102 and West of Duddon provides a further 108. The Walney extension (Figure 4) due for completion in 2018 will install a maximum of 207 more turbines into the area making the combined turbines the largest wind farm in the world. A study involving the attachment of GPS devices on common and grey seals in the North Sea showed that some individuals from both species focused their foraging effort at it he bases of the wind turbines (Russell *et al*., 2014).The data also showed movement along subsea pipelines within both species across multiple trips of up to 10 days at a time (Russell *et al*., 2014).. Furthermore, directed movements showed that animals could effectively navigate to and between structures (Russell *et al*., 2014).

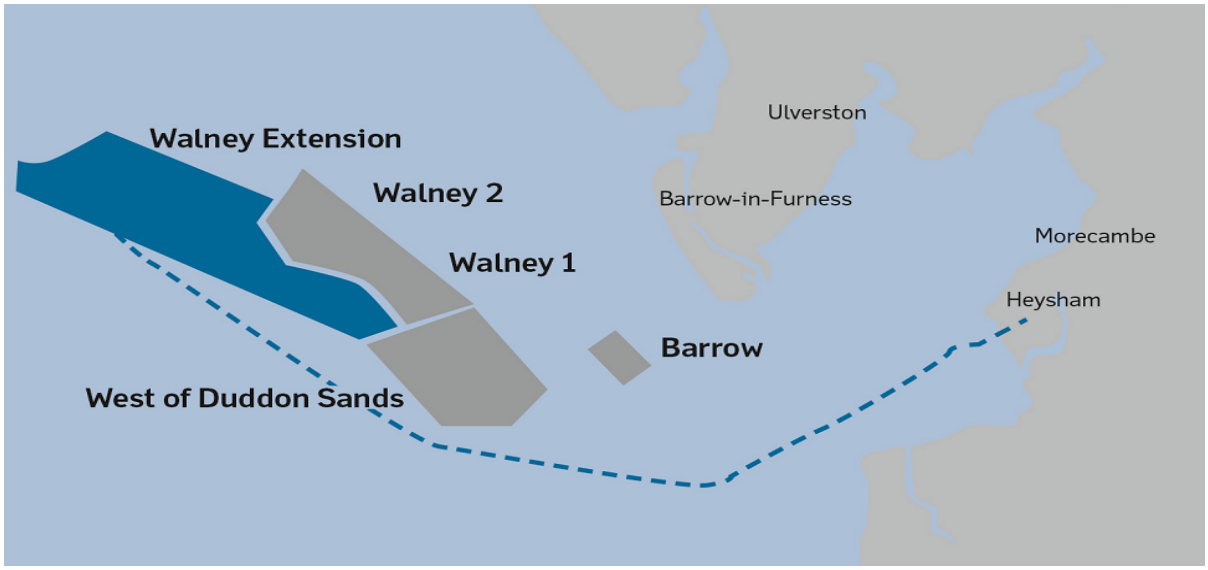

Figure 4: Walney wind farm extension proposal alongside the existing turbines off of Walney Island with the dashed line showing the cable landfall.

2.2 Data collection

The time taken to prepare, conduct and enter the data from the traditional, 'Seal Cam' and drone survey methods will be logged along with any observed advantages and disadvantages of using the methods to survey the seals. The number of planned surveys was agreed in advanced with the time constraints of the project considered. The criteria in which the methods will be compared against include; reliability, number of surveys effected by the weather, effort, identifiable individuals and amount of disturbance. Whilst this project is comparing and contrasting the established traditional seal survey method and the introduced Seal Cam and drone surveys it will continue to add to the long-term monitoring of the seal population at South Walney Nature Reserve to monitor counts and behaviour patterns. Any suggestions that become apparent from this project will be recommended towards the management plan of South Walney Nature Reserve to continually monitor the grey seal population in future years.

2.2.1 Traditional seal surveys

The traditional surveys will be conducted in the same data collection technique used during the previous fieldwork conducted from September 2015 to January 2016 (Tapp, 2016), September 2014 to March 2015 (Bradshaw, 2015) and September 2013 to February 2014 (Bunney, 2014).

The traditional surveys were carried out every fortnight from the 22nd of September to 6th of December 2016. To minimise the disturbance to the birds and maximise the number of seals hauled out, the surveys are carried out half an hour either side of low water in daylight hours

(Bradshaw, 2015; Tapp, 2016). A minimum of two observers conducted each survey with one of the two observers being a more experienced member of staff who are knowledgeable in seal identification. In order to get in position for the survey with minimal disturbance to the seals the observers used the Seal Cam monitor in the office to locate the approximate location of the seal haul-out position. They then drove down to the spit and walked to the nearby location of the seals and crawled up the shingle and over the ridge to gain a suitable vantage point to carry out the surveys. This position varied between the surveys as the seals hauled out in different areas of the spit. For safety and comfort shin pads and roll mats were provided.

The one hour survey is then split into six 10 minute periods in which the seal population is scanned using binoculars to record data. During each period a count is conducted to record the total number of seals visible, hauled out and in the water and divided into male, females, juveniles and unknowns (individuals that cannot be identified). The presence and absence of common behaviours were also recorded using the one-zero method used by Bradshaw (2015) and Tapp (2016) during the 10 minute periods if displayed by a male, female, juvenile or unknown. To gain an estimate of which behaviours are displayed most frequently this data gives the proportion of sample intervals in which the behaviour has occurred amongst the seals.

In the same 10 minute periods the group formations and density (seals tightly grouped or spread out), positions of the groups on the shore and sex ratios of the seals were also recorded. Any potential anthropogenic land or water based disturbances within 200m of the seals which may have affected the seals were also recorded. This included: type of disturbance (e.g. motor boat, kayakers); duration of disturbance; and the seals response using the corresponding response code (NR – no response; A – alert, heads up, no change in position; L – alert, seals moved short distance on land; G – seals formed a tighter group; W – seals moved into water; O – other). This survey methodology was consistent with that of 2013-14 (Bunney, 2014), 2014-15 (Bradshaw, 2015) and finally 2015-2016 (Tapp, 2016).

Notes on vocalisation and the number of photographs taken during each 10 minute slot is also recorded. Any relevant additional information was noted in the comments section of the survey sheets so that any anomalous results could be explained by something that was not obviously affecting the survey at the time. The forms used to record the above observations are displayed in Figures A1 a-d and A2 a-c in Appendix A.

2.2.2 Seal Cam survey

The Seal Cam survey was carried out using the same recording sheets (Appendix A) and methodology as the traditional surveys however this survey was done using the laptop to manipulate the camera from the office at South Walney Nature Reserve. The Seal Cam surveys were carried out by one observer sat undisturbed at a desk in the office preferably in the same week as the traditional surveys. The surveys were also carried out for an hour and ideally started half an hour before low water during day light hours. The camera was controlled via a laptop in the office to scan across the seals from left to right and up and down to check the water (←,↑,→ and ↓ keys) and zoom in and out (+ and – keys) on the haul-out location. This was used to count and identify the seals both hauled out and in the water along with collecting data on behaviour, group structures and disturbances across the six 10 minute periods. Screen shots were also taken from the Seal Cam stream of both individuals and wider colony images to keep a record of the survey.

2.2.3 Drone survey

As the drone surveys were carried out on a Site of Specific Scientific Interest (SSSI), permission was applied for and approved by Natural England (Appendix B). In August 2016 a DJI Inspire 1 Pro was purchased by the Trust to best suit the needs of this project and other requirements for the future. The drone featured a Zenmuse X5 camera with a 1.5mm lens mounted on a 3-axis gimbal to provide a steady 360° view which can be fed to a mobile device via the DJI GO downloadable app software or monitor through FPV glasses with a HDMI input. Two radio controllers were included to operate the drone as a pilot (master controller) and another to control the camera (slave controller) if required.

The drone surveys were carried out as close to low tide as the weather permitted as a maximum wind speed of 15mph was set for use of the drone. In the days before the proposed surveys the batteries and controllers were recharged to enable maximum survey time. The drone was also assembled to check for any faults and the camera was tested. The DJI GO app was also opened in order to check for firmware upgrades and any such prompts were installed.

On the survey days Seal Cam was used to locate the position of the seal haul-out site in order to gain an idea of where to launch the drone. The drone was transported down to the spit with the use of the 4x4 truck and the reserve warden supervised the flights. An area of flat and short vegetation was sought for the landing and take-off. The drone was then set up and launched as per the recommended start up procedure. The drone was then manually taken up to a height of 120m altitude and flown towards the seals using the live link from the camera to orientate this flight path. A series of photographs were taken as the drone was

directed towards the seals and the drones altitude was decreased in 10m intervals to no less than 50m. Using the live camera stream the seals behaviour was constantly monitored for signs of disturbance (heads up and movement towards the water). The drone was moved away both vertical and horizontally if such behaviour was observed by more than 10% of the individuals present. This survey was carried out with the use of one battery to acquire the photographs suitable for analysis giving flight times of less than 10mins. The very maximum flight times the TB47 batteries can provide is 18minutes. The pictures and flight data were extracted from the SD card and DJI GO app to analyse.

In order to count the number of individuals from the photographs taken the best three were selected from the survey in terms of quality and closeness. They were then opened in Microsoft Paint software and using the zoom function each seal identified was given a colour dot on top. These coloured dots were added in groups of ten before adding another ten dots of another colour until all individuals have been counted. Using the colours in blocks of ten reduced the amount of error and allowed the overall total to be easily counted. This total was then averaged across the three images to account for individuals in the water that may not have appeared across all images. If the colony was spread out multiple images were used to cover all of the individuals e.g. two images used for one total count meaning six photographs were used to produce an average total of individuals. A similar method was used to identify the number of males and females (by size) in which blue and red dots were used to count the sexes respectively.

For all surveys a log book (Appendix C) has been kept in order to record the time taken to prepare, carry out and input the data from the three survey methods in order to keep track of the effort required which will displayed in the results section. The external weather conditions and any additional comments about the surveys have also been recorded in case of further analysis or anomalous results.

3 Results

Table 2 shows the dates in which the surveys were conducted along with the assigned survey name in which they will be referred to from this point forward. Due to the time period of the proposed project, restricted low water times and day light hours a compromise of six surveys were proposed for each method and timetabled in around surveyors availability.

Table 2: Dates and number of the three survey methods along with the survey names used in the results of this report.

Survey method	Survey Number	Date	Survey Name
Seal Cam	1	20/09/2016	Seal Cam 1
Traditional survey	1	22/09/2016	Traditional survey 1
Drone survey	1	30/09/2016	Drone Survey 1
Seal Cam	2	05/10/2016	Seal Cam 2
Traditional survey	2	08/10/2016	Traditional survey 2
Drone survey	2	14/10/2016	Drone Survey 2
Seal Cam	3	20/10/2016	Seal Cam 3
Traditional survey	3	21/10/2016	Traditional survey 3
Seal Cam	4	4/11/2016	Seal Cam 4
Drone survey	3	5/11/2016	Drone Survey 3
Traditional survey	4	06/11/2016	Traditional survey 4
Drone survey	4	24/11/2016	Drone Survey 4
Seal Cam	5	5/12/2016	Seal Cam 5
Traditional survey	5	6/12/2016	Traditional survey 5
Drone survey	5	10/12/2016	Drone Survey 5

3.1 Population, behaviour and disturbance data (2016)

3.1.1 Population size and structure (2016 data)

Figure 5 shows the average number of seals recorded from the traditional surveys carried out though human observation. Over the survey dates between September and December there was no clear increase in the average number of seals seen both hauled out and in the water. The fourth traditional survey provided the highest average count of 102 from this method before decreasing again for the final traditional survey. The average numbers of females counted were higher than the number of males for all surveys apart from traditional survey 2 in which there was on average 11 females compared to 16 males. The average number of males, females and unknown individuals roughly matched that of the trend shown by the average total numbers whereas the number of juveniles fluctuated between four and zero individuals seen.

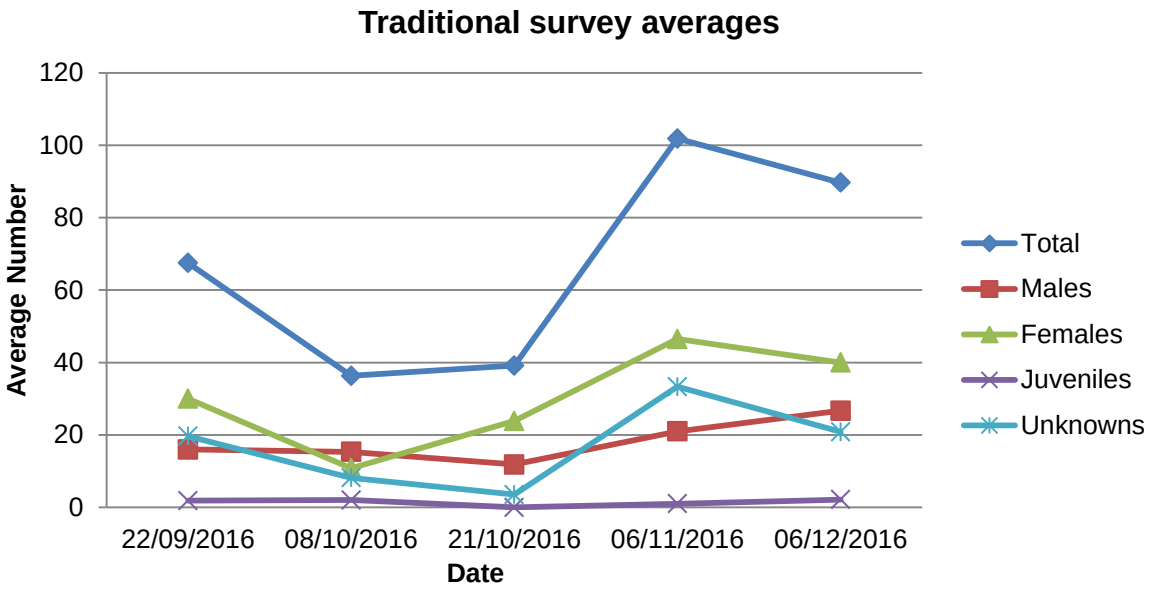

Figure 5: Average numbers of seals in total and number of females, males, unknowns and juvenile recorded on the five traditional surveys between the 22/09/2016 and the 06/12/2016.

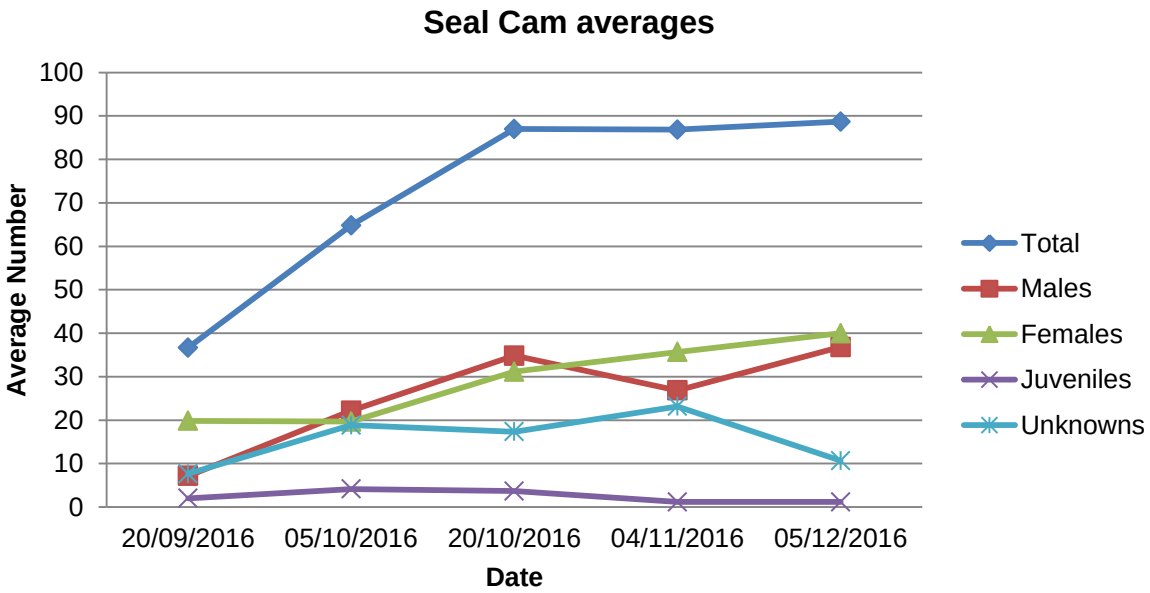

Figure 6: Average numbers of seals in total and number of females, males, unknowns and juvenile recorded on the five Seal Cam surveys between the 20/09/2016 and the 05/12/2016

The average total number of seals recorded from the Seal Cam surveys steadily increased on the first three surveys from 37 to 87 as shown in Figure 6. The following two surveys produced an average total number of individuals of 87 and 89. The average number of females observed steadily increased across the five Seal Cam surveys from 20 to 40 whereas the males showed a less obvious increase from eight to 37 between the first and last survey. The number of unknowns fluctuated across the surveys with a minimum and maximum recording being 8 and 23 respectively. The number of juveniles identified from the Seal Cam surveys ranged from four to one with fluctuations across the surveying period.

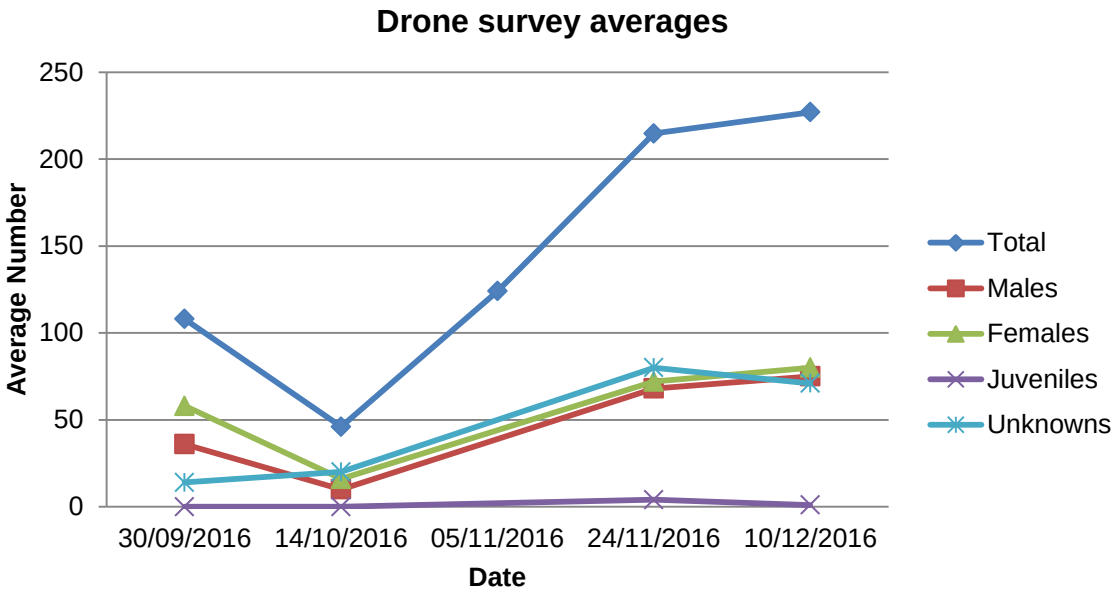

Figure 7: Average numbers of seals in total and number of females, males, unknowns and juvenile recorded on the five drone surveys between the 30/09/2016 and the 10/12/2016.

Figure 7 shows that the total number of individuals counted from the drone surveys started at 108 then decreased to 46 in the second survey. This average number of total individuals seen then increased to a final count of 227 individuals during the last survey. Examples of the flight paths (Figure D1-2) used during the surveys along with the example images (Figures D3-6) captured and showing the method used to count the individuals is shown in Appendix D.

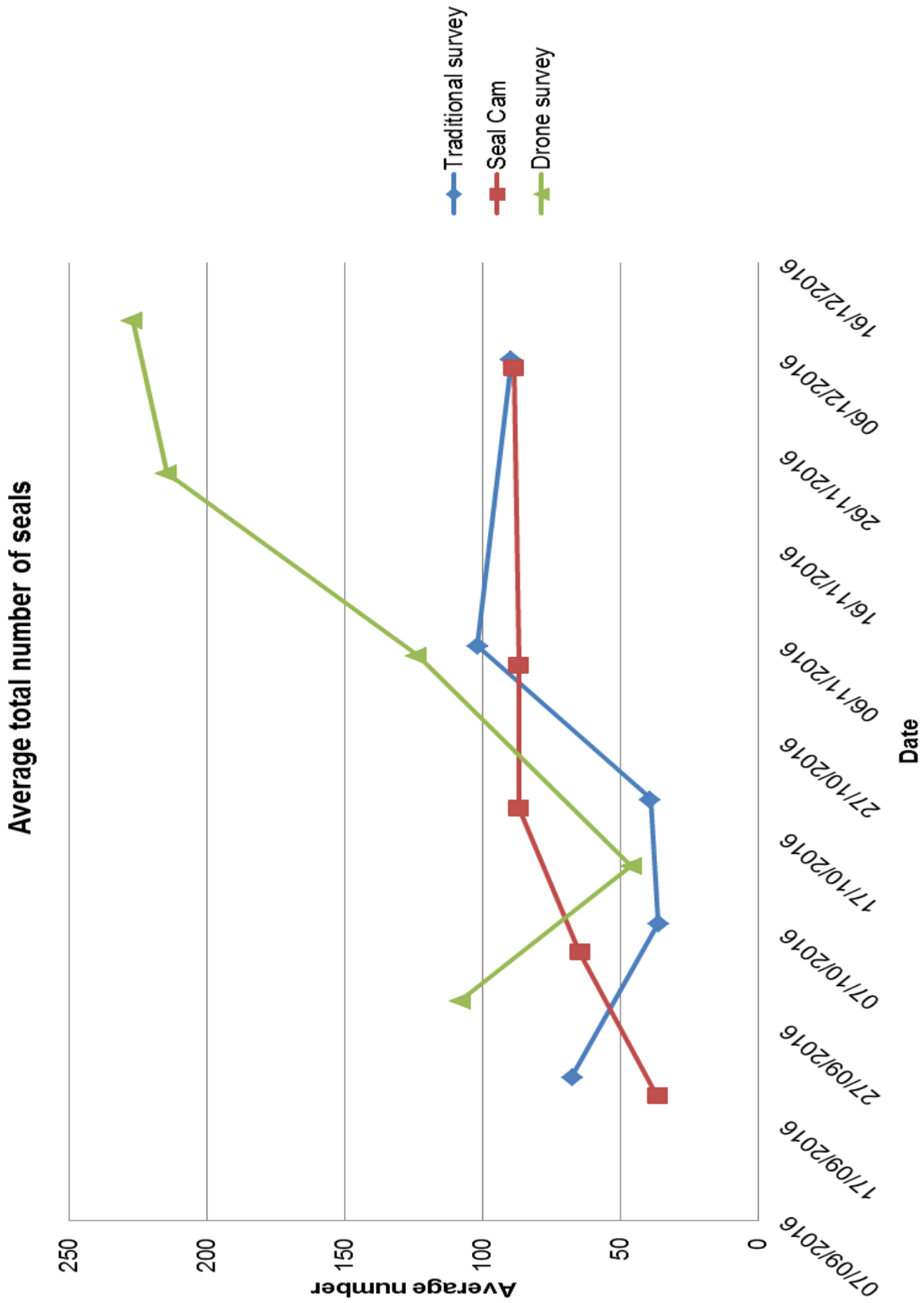

Figure 8: Average number of seals in total recorded on the five drone surveys between the 30/09/2016 and the 10/12/2016.

Figure 8 shows that during the first four traditional and Seal Cam survey and the first three drone surveys the average number of seals counted in total were a in a similar range but no clear trend can be seen. However the final traditional and Seal Cam surveys recorded the average total number of individuals to be over 100 less compared to the drone survey 4 and 5.

3.1.2 Male and female ratios

Figure 9 shows there was no clear increase or decrease in the male to female ratios as the surveys progressed through the season however those ratios produced by the traditional and Seal Cam surveys followed a similar pattern to one another. Between the September and early October surveys for both of these methods this male:female ratio increased from around 0.5 (1:2) to over 1.0 (+1:1). In late October these ratios decreased again over the next two surveys before increasing again for the December surveys with ratios of 0.7 (7:10) and 0.9 (9:10) respectively for traditional and Seal Cam surveys.

The male to female ratios produced from the drone surveys showed the least amount of range (0.6 to 0.9) and overall showed a weak increase in females to males as the surveys progressed over time. Those surveys conducted last across the three methods were beginning to fall within a similar value.

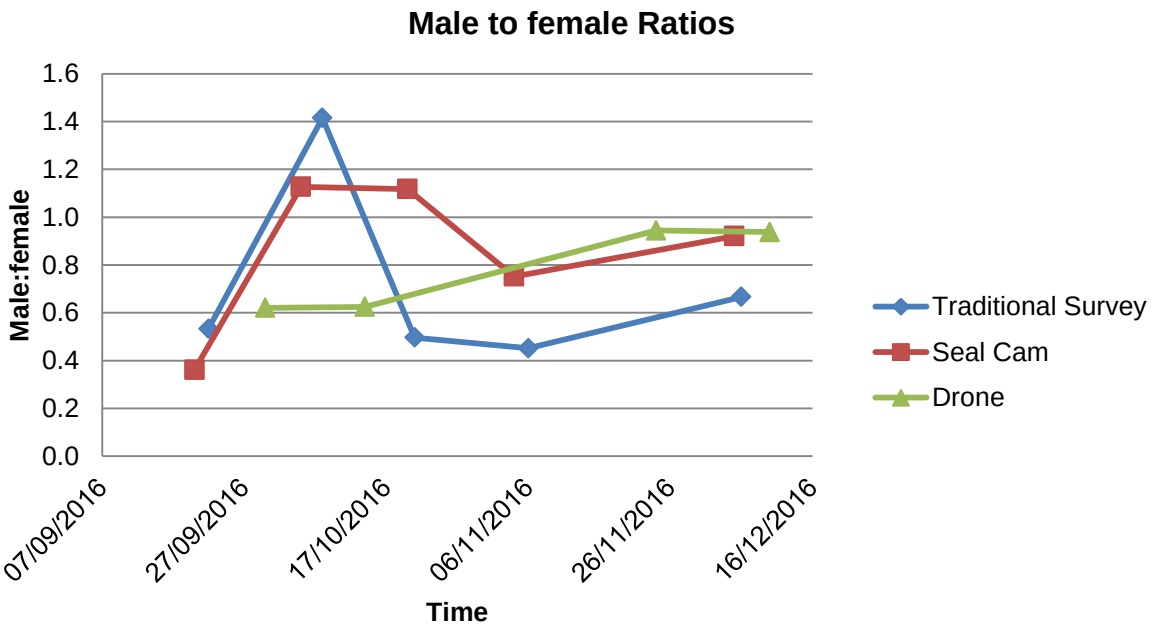

Figure 9: Male to female ratios across the 14 surveys.

The percentage of identifiable (males, females and juveniles) individuals from the total count was high for the traditional surveys ranging between 67 and 91% and for the Seal Cam surveys ranging from 71 to 88% across the ten surveys shown in Figure 10. The drone

surveys produced a percentage of identifiable individuals ranging from 56% to 87% across the four surveys where this was possible. In terms of the average percentage of identifiable across the three surveys the traditional survey identified 76.7%, Seal Cam surveys was 78.2% and the drone surveys was 56% including the unusable survey and 70% across the four surveys in which individuals were identified. The images obtained from the third drone survey were too grainy as they were taken from too far away to be able to confidently identify male and female individuals which is indicated by the 0.00 proportion on Figure 10.

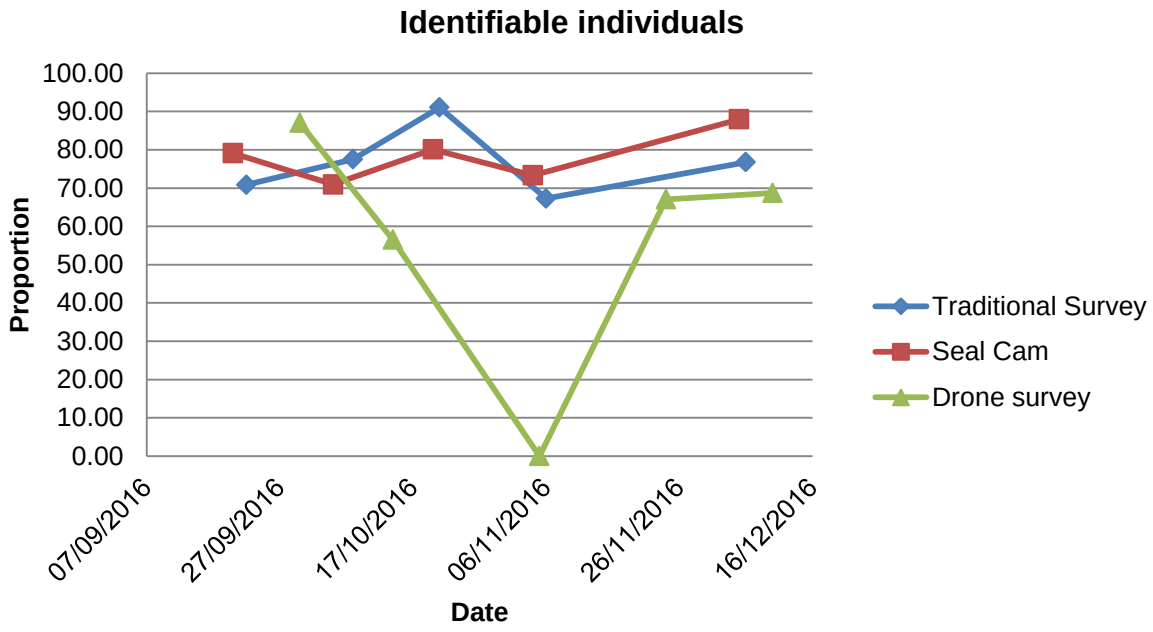

Figure 10: Percentage of the average number of identifiable individuals (males, females and juveniles) compared to the average total number of individuals for each survey method.

3.1.3 Behaviours

Due to the nature of the surveys behaviours were only recorded during the traditional surveys and using Seal Cam.

Figure 11 shows that the highest proportional behaviour observed on the land was asleep and relaxed with the second most observed behaviour being alertness. Of the behaviours observed, in the water; travelling, milling and bottling, milling was observed the highest. During the traditional surveys aggression/playing was highest on the final survey and aggression/playing was the highest proportional behaviour during the Seal Cam survey 4 (Figure 12). For both survey methods the seals were observed to be their most alert during the final of the two types of surveys. Table 3 shows that on average a higher proportion of the behaviours witnessed during the Seal Cam surveys included asleep/relaxed, alert,

aggression/playing and travelling on the land whilst the other five behaviours were more proportional during the traditional surveys.

Behaviour responses to the drone occurred in two of the six surveys carried out (including the trail survey) of which details can be found in Table C1.

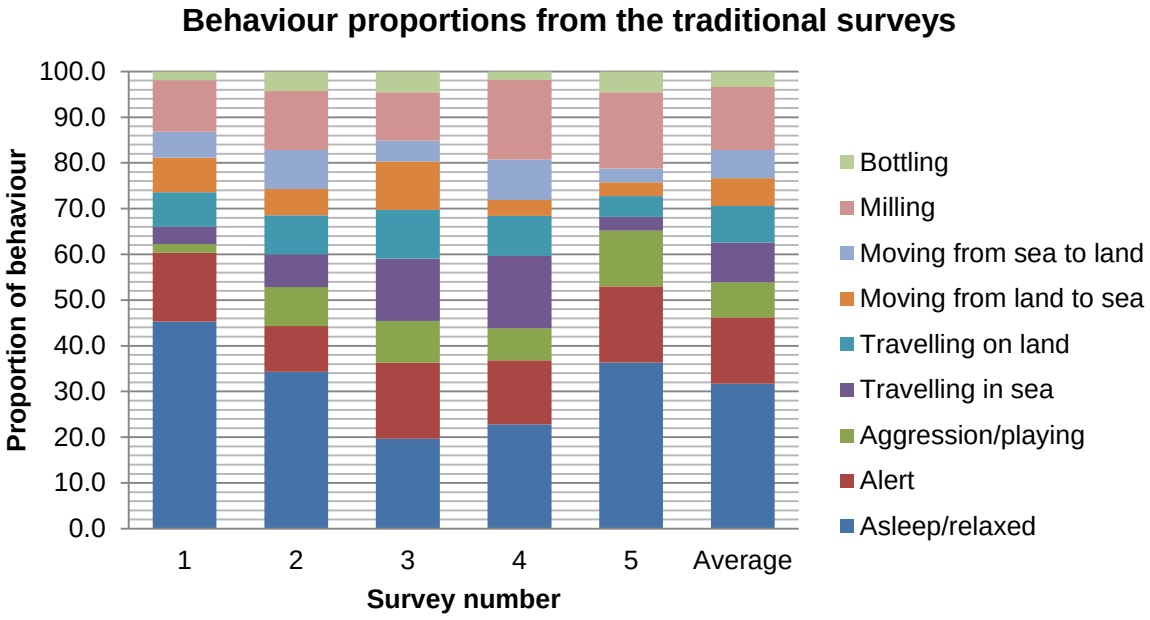

Figure 11: Proportion behaviours observed from the traditional surveys

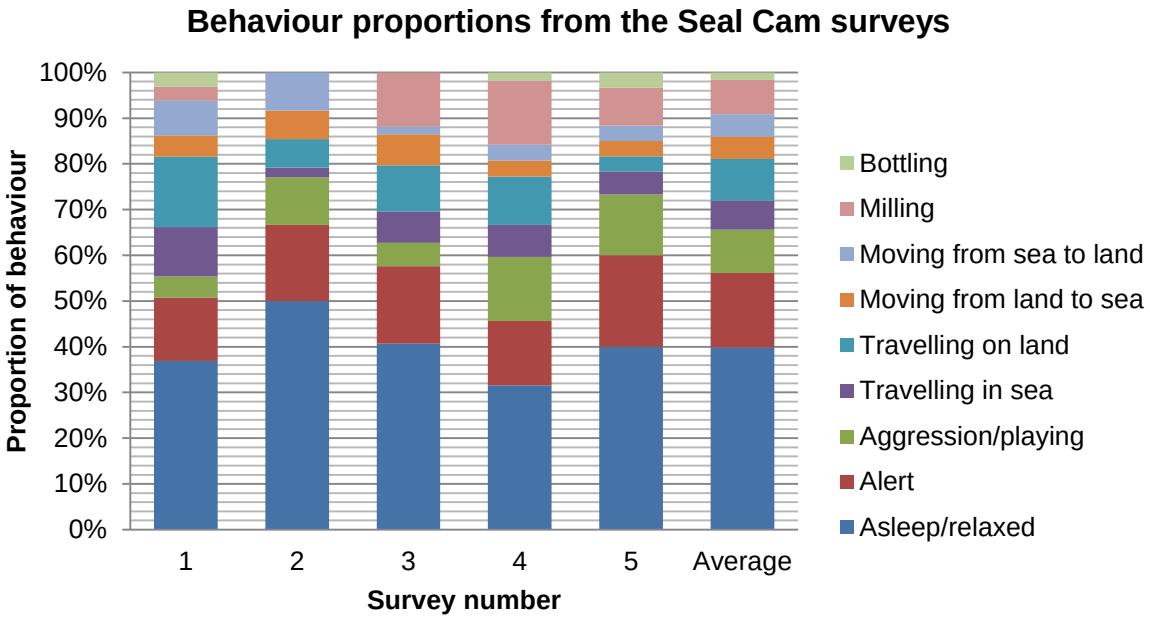

Figure12: Proportional behaviours observed from the Seal Cam surveys

Table 3: Average percentage of proportional behaviour recorded during all of the traditional and Seal Cam surveys. Those boxes shaded in grey so the highest percentage between the two survey methods.

	Asleep/ relaxed	Alert	Aggression/playing	Travelling in sea	Travelling on land	Moving from land to sea	Moving from sea to land	Milling	Bottling
Seal survey	31.7	14.5	7.7	8.7	8.0	6.1	6.1	13.8	3.4
Seal Cam	39.8	16.3	9.5	6.3	9.1	4.9	4.9	7.5	1.6

3.1.4 Disturbances and responses

Across the traditional and Seal Cam surveys a total of nine disturbance incidents were recorded which are shown in Table 4. Seven of the nine incidents were boat related and one being aerial and one from an unknown source. In terms of responses the majority of the grey seal showed no response and those that did respond only occurred in a small number of individuals. During the last traditional survey the movement on land was a response to the wash created by a boat hitting the seals low down on the water line as opposed to the boat itself. The only record of seals moving into a tighter group on land was during a Seal Cam survey 2 however the source was unidentified. During the first traditional survey six seals became alert after a low flying plane went overhead. None of the disturbance lasted more than 60 seconds.

During the drone surveys no external disturbance incidents were recorded however during three of the surveys the drone itself acted as a disturbance. Several seals moved towards the water in response to its presence. These movements were detected on the cameras live feed so the drone was pulled back and such movements ceased. Further details of these surveys can be seen in Table C1 in Appendix C.

Table 4: Disturbance incidents recorded on the traditional and Seal Cam surveys with details on time, source, responses, duration of disturbance and any additional comments noted.

Date	Type of survey	Time	Source	Response (number of individuals)	Duration (secs)	Additional comments
22/09/2016	Seal survey 1	09:22	Aerial (low flying plane)	A (6)	30	None
08/10/2016	Seal survey 2	10:20	Boat (NSL Adventurer)	NR	45	Wash created
08/10/2016	Seal survey 2	10:35	Boat (small motor boat <6m)	NR	45	None
20/10/2016	Seal Cam 3	09:53	Unknown	G & L(10)	60	None
21/10/2016	Seal survey 3	10:26	Small power boat (Wild Rose)	NR, A (4)	60	Stopped vocalising
21/10/2016	Seal survey 3	10:36	Small power boat (sea angler)	NR	60	Continued vocalising
04/11/2016	Seal Cam 4	07:33	Boat	L (1)	45	Within 100 to 150m of the animals.
06/12/2016	Seal survey 5	09:35	Boat (Wind farm - 'Bayard 7)	L (6)	45	Movement as a response to the wash not the boat
06/12/2016	Seal survey 5	10:10	Boat (Wind farm - 'Wildcat 27')	L (3)	45	Movement as a response to the wash not the boat

3.2 Method comparison

Table C1 in Appendix C shows the comments noted whilst performing the surveys. Of the six proposed surveys planned for all three of the methods 15 surveys were completed successfully, five for each of the survey methods.

Tables showing the logged time taken to carry out and prepare each survey along with the number of observers are shown in Table 4-6 below.

3.2.1 Traditional seal surveys

The traditional surveys experienced little problems occurring during the surveys themselves. The tradition al survey planned of the 19 November 2016 was cancelled as on arrival and investigation of the survey location two seal pups were present in the spot the two surveyors needed to be positioned in order to have the best vantage point to carry out the survey. There was also a hail storm which distorted the view of the seals that were visible so a decision was made to end the survey. On return to the office it was obvious using the Seal Cam that there was a significant amount of individuals which were not visible from the trialled positions so the right decision had been made.

These surveys took the longest amount of time (between 1 hour 45 minutes and 2 hours) to carry out due to the travel time down to the haul-out location and preparation of equipment. Also as two surveyors were required as a minimum to complete the traditional surveys this increased effort time. The data entry of the data collected only required one individual and on average took 30 minutes to complete including the sorting of photographs.

Table 5: Logged effort for traditional survey preparation, data collection and entry.

Date	Persons	Hours	Total effort	Comments
21/09/2016	1	01:30	01:30	Survey prep - printing sheets, etc
22/09/2019	2	01:45	03:30	Seal survey 1
22/09/2016	1	01:10	01:10	Setting up master Excel spreadsheet & inputting data
08/10/2016	1	00:30	00:30	Survey preparation
08/10/2020	2	01:45	03:30	Seal survey 2
08/10/2016	1	00:30	00:30	Inputting Data
20/10/2016	1	00:10	00:10	Preparing the equipment
21/10/2016	3	01:45	03:30	Seal survey 3
24/10/2016	1	00:30	00:30	Inputting Data
04/10/2016	1	00:15	00:15	Preparing equipment including printing
06/10/2016	3	01:45	03:30	Seal survey 4
07/10/2016	1	01:00	01:00	Inputting Data
19/11/2016	2	01:45	03:30	Failed Seal survey
06/12/2016	2	02:00	04:00	Preparation and Seal survey 5
07/12/2016	1	00:30	00:30	Inputting Data
	Total	16hrs 50mins	27hr 35mins	

3.2.2 Seal Cam surveys

Although this survey used the same method of data collection as the traditional seal survey the total time of the survey was less as there was no travel time to the Spit and no equipment needed to be prepared prior to the survey excluding the data sheets which is reflected in the total effort of the method. This method also only required one person to conduct the survey which reduced the amount of effort required for this method which was reflected in the total time logged for the Seal Cam survey ranging between 1 hour and 10 minutes and 1 hour showed in Table 5. As with the traditional survey, data entry of the data collected only required one individual and average took between 40 and 45 minutes to complete including the sorting through any screen shots taken whilst doing the survey.

Table 6: Logged effort for Seal Cam survey preparation, data collection and entry.

Date	Persons	Hours	Total effort	Comments
20/09/2016	1	01:05	01:05	Print sheets/survey 1
05/09/2016	1	01:00	01:00	Survey 2
08/10/2016	1	00:45	00:45	Excel master created & inputting two data sets
10/10/2016	1	00:15	00:15	Sorting Photos
20/10/2016	1	01:00	01:00	Survey 3
01/10/2016	1	00:40	00:40	Inputting data + sorting photos
04/11/2016	1	01:10	01:10	Survey 4
04/11/2016	1	00:40	00:40	Inputting data + sorting photos
05/12/2016	1	01:10	01:10	Survey 5
07/12/2016	1	00:45	00:45	Inputting data + sorting photos
	Total	8hrs 30mins	8hrs 30mins	

3.2.3 Drone surveys

Three of the planned drone surveys were unsuccessful due to a pup discovery on the Seal Cam (12th October) and weather constraints (>15 mph winds) on the 19th of October and 10th of November. However the dates for these surveys were flexible due to sensitivity of this method to weather conditions so five surveys did go ahead as two of the three unsuccessful surveys were successfully rearranged.

In regards to effort the drone surveys took the least amount of time to complete including travel time down to the haul-out location due to the battery life restricting the flight time. However this survey method did also require some preparation due to the nature of the technology being used. Pre-flight checks were required to look over the equipment and check for updates. Whilst only one person was required to pilot the drone a secondary person supervised the survey for health and safety reasons and to monitor disturbance to other wildlife in the area. This means that the effort required for this survey increased. The time required to count the individuals required longer than expected to complete.

Table 7: Logged effort for drone survey preparation, data collection and entry.

Date	Persons	Hours	Effort	Comments
20/09/2016	1	00:45	00:45	Drone research
30/09/2016	1	03:00	03:00	Drone training
30/09/2016	3	01:15	03:45	1st Drone survey with external pilot
08/10/2016	2	00:45	01:30	Drone survey with external pilot trial
08/10/2016	1	00:30	00:30	Counting 1st Survey photo
10/10/2016	1	00:30	00:30	Counting Trials Survey photo
13/10/2016	1	02:00	02:00	Drone practice and update
14/10/2016	2	00:45	01:30	Drone survey 2
15/10/2016	1	00:30	00:30	Counted 2nd survey photos
04/10/2016	1	00:10	00:10	Booted up drone to check for updates
05/11/2016	2	00:45	01:30	Drone survey 3
24/11/2016	1	00:10	00:10	Booted up drone to check for updates
24/11/2016	2	00:45	01:30	Drone survey 4
10/12/2016	2	00:45	01:30	Drone survey 5
11/12/2016	1	00:30	00:30	Counted3rd survey photos
11/12/2016	1	00:40	00:40	Counted 4th survey Photos
11/12/2016	1	00:45	00:45	Counted 5th survey photos
11/12/2016	1	00:45	00:45	Male:female ratio check
	Total	15hrs 15 mins	21hrs 30mins	

Across the three methods Tables 5-7 show that the most effort was required for the traditional surveys (27hrs and 35 minutes) followed by the drone surveys (21hrs and 30 minutes) with the Seal Cam surveys requiring 8hrs and 30minutes to complete the method.

3.3 Results summary

Table 8 below gives a general over view of the advantages and disadvantages discovered through the use of the three survey methods which will be discussed in the next section.

Table 8: Summary of the traditional, Seal Cam and Drone surveys.

Survey method	Traditional	Seal Cam	Drone
Number of planned surveys	6	6	6
Number of surveys completed +/– two days of scheduled date.	5	5	4
No of planned surveys effected by weather	1	2	2
Total survey effort time (hr:min)	27:35	08:30	21:30 (17:45 excluding training)
Number of disturbances recorded	7	2	3
Average percentage of identifiable individuals	76.7	78.3	69.8 (55.9 including drone survey 4)
Maximum average number of total seals observed	102	89	227

4 Discussion.

4.1 Population, behaviour and distribution data (2016)

4.1.1 Population size and structure (2016 data)

In terms of counting the number of individuals across the three survey methods the use of the drone provided the most accurate way of achieving this. The drone gave a birds eye view of the colony meaning that all of the individuals were captured on an image providing a true count of the population at that point in time. It could be suggested that the traditional surveys is the least the accurate of the methods due to the vantage point of which the counts are carried out from. The shingle beach where the seals haul-out has a steep gradient meaning some seals may have gone uncounted. Also later on in the season when the colony was producing pups the mothers often moved the pups away from the main colony as they got older so were not counted during the traditional surveys. For example after traditional survey 5 three seal pups and one male and female were located further down the spit on the edge of where the sandy beach begins to the north of the usual haul-out location.

The drone surveys 5 and 6 produced the average numbers of individuals counted across three images were 215 and 227 respectively. However between these two drone surveys where higher than ever previous recorded number have been noted, traditional survey 5 and Seal Cam 5 was also carried out. These surveys produced an average number of 90 ad 89 individuals recorded respectively. Again without concurrent drone surveys being carried out during these surveys it could be presumed that the colony was growing between these two

dates with total numbers being in the region of 200 which were not observed from the traditional or Seal Cam surveys. Looking at the images captured from the drone of the colony on drone survey 5 (Figure D4) from the general location of where the traditional surveys were carried out the seals were tightly packed with rows of 6-7 individuals between the start of the colony back to the waters edge. Without concurrent methodology there is no proof that human observation would not have counted all of these individuals but from experience the observers could only see up to three individuals running back into what could be a densely packed group down to the water. During traditional survey 2 a drone survey was also conducted as a trial. This survey was not included in the main results as a further drone flight was conducted the following week after practising with the drone. When assessing the images taken from this flight the number of individuals counted matched those observed from the shingle bank with the human observations. However on this particular survey there were only 39 individuals hauled out which were well spread out.

It is also felt that even if the animals were well spread and viewable that a single observer would be unable to accurately count this number of seals and identify them to a life stage and sex within the 10 minute periods in which the survey is broken down into. It could be suggested that these two methods have a threshold of accuracy up to point in which the seal population become too heavily populated and densely packed to count accurately.

4.1.2 Male to female ratio

All three methods produced a varying degree of the male to female ratios recorded. During the traditional surveys the males, females and juveniles were easier to identify as the survey progressed as the sizes of the individuals were easier to gauge. Across the surveying hour as individuals displayed behaviours the males and females became more obvious and a identification of the sex of the individuals being counted was built up between the two observers. This was however not as strong during the Seal Cam surveys as only one observer was collecting the data. Also as the camera was zoomed in on a few individuals as it was moved across the colony present there was a lack of peripheral vision to take in any behaviours and subsequent sex identification elsewhere in the colony. It was also harder to judge the size of the individuals in relation to others to identify the sexes and juveniles on size alone. This helps to explain why on average the percentage number of identifiable individuals was higher during the traditional surveys. Towards the end of the surveying period the ratio was similar across the last three surveys indicating that the male to female ratio was beginning to stabilise or the methods used to detect the sexes was improving giving a more accurate ratio.

The ability to identify the sexes of the individuals and number of individuals from the drone surveys depended on the quality of the images acquired. As the confidence of the pilot increased across the surveys the drone was flown closer to colony and hence clearer images were obtained. The seals also became less receptive to the drone as the surveys progressed showing a form of habituation however more surveys over a long period and more frequently would be needed to prove this. The highest percentage individuals identified was acquired from the clearest images taken by the external pilot due to his experience drone survey 1. However across drone surveys 2, 3 and 5 the percentage of identifiable individuals increased slightly. Due to the quality of the images taken on drone survey 4 no individuals were identified. With increased competence and habituation to the drone within the seal colony this percentage has the potential to increase higher as the quality of the pictures increases. This would mean that whilst this study showed the traditional survey to provide the most accurate percentage of identifiable individuals the drone could become the most accurate method for this factor.

4.1.3 Behaviours

Due to the nature and battery restrictions of the drone surveys behaviours within the seal colony were not recorded as only a snapshot was taken. Behaviours observed amongst the colony were however recorded during both the traditional and Seal Cam surveys. However as above the latter of the two provided a restricted view of the seals no behaviours outside of those within the cameras view were noted. Also during the human observations from the shingle bank there was a secondary observer available to take in any behaviours occurring amongst the colony whilst a count was being conducted by one observer. Also vocalisations and other noises triggered the attention of the observers of behaviours such as aggression/playing and individuals moving on the land or between the land and water as the Seal Cam provided no audio.

Certain behaviours such as moving from land to sea on average made up a higher proportion of those behaviours observed during the traditional surveys. It could be suggested that this was due to the presence of the human observers and that surveys through the Seal Cam were recording more natural behaviours such as aggression/playing. This however is not reflected always as based on this theory it could be suggested that behaviours such as alertness would be more prevalent in the traditional surveys which was not the case.

A small number of individuals are shown to move towards the water during the drone surveys however when observed on the mobile device streaming the live camera feed the drone was pulled away from the colony and such movements ceased before any animals entered the water. Those individuals that did exhibit a response behaviour to the drone were

those towards the back of the haul-out group and hence closer to the drone itself and perhaps the subsequent noise.

4.1.4 Disturbances and responses

More disturbance incidents were recorded during the traditional surveys potentially due to the methodology. Again the presence of two surveyors compared to use of one using the Seal Cam allows for a more peripheral view of the colony along with the audio detection of both boat and airborne disturbances. The source of a disturbance was recorded as unknown during the Seal Cam 3 as the source occurred off the screen and due to lag of the camera controls the camera could not be moved around quick enough to locate the source. The drone limitations in regards to battery life restrict this method to pick up disturbances within the colony and record subsequent responses due to the likelihood of a disturbance occurring within the short survey time. Of all the methods, the drone had the most potential to be a disturbance (two out of five surveys resulted in a small number of individual showing an alert response towards the drone) within itself which Seal Cam providing zero human disturbance. With the above all taken into consideration the traditional surveys appear to provide a more accurate method for recording the responses of the seals to disturbance incidences.

4.2 Method comparisons

Of all the three methods on average the Seal Cam surveys required the least amount of effort with the traditional surveys taking the most amount of time. This was due to ability to carry out the Seal Cam surveys from the office so no addition time was required to travel to and from the seal haul-out location. These surveys also required the minimal amount of equipment compared to the traditional surveys as the use of shin pads, roll mats and health and safety requirements such as a first aid kit and sharps box were not needed. The amount of effort was also minimal due to number of observers participating in the surveys. Only one surveyor carried out the Seal Cam survey compared to two used during the other surveys. This caused an increase in the amount of effort required for the traditional and drone surveys as the survey times were multiplied by the number of people present. These surveys did however give untrained surveyors the opportunity to shadow the surveys so they can be continued next year.

In terms of the raw surveys the drone surveys took the least amount of time to record the data as the flight time was restricted by the battery life. The device had two batteries however only one was ever used to complete the surveys. Whilst the secondary person supervising the pilot and observing other wildlife during the surveys had no direct input into the data collecting their effort was still required (and hence multiplied into the time) to complete the surveys.

4.3 Results summary

As the progression of the surveys advanced the pros and cons of the methods themselves became apparent. However some of the issues that were noted did not occur across all of the surveys. Technical problems occurred during both the Seal Cam and drone surveys due to the equipment used. These problems were often unpredictable and influenced by things out of the control of the surveyor. Due to restricted daylight hours during the months of surveying and inconvenient low water tide linked with a lack of resources a sixth Seal Cam survey was not completed. The success of the Seal Cam surveys highly depended on the quality of the camera steam. On some occasions there was a large lag of around 10 seconds between the camera responding to a keyboard instruction. The quality of the image also affected the ability to count the seals and identify the sexes of individuals caused by the weather as wind often buffered the camera causing the images to move. There was also a level of external office based distractions. The above problems were apparent in the third and fourth surveys and additional comments can be seen in Table C1.

Originally videos were not intended to be taken during the drone survey however after some difficulty with the app (Table C1) on drone survey 2 a video was recorded and stills were taken to analyse. To ensure multiple image errors didn't occur again videos were taken as a back-up in the next two surveys until a update for the app appeared to fix the problem.

The three surveys also had different constraints however all of them were restricted by the weather in one way or another but perhaps the drone surveys were the most sensitive of the three methodologies. With this in mind five of the six surveys were complete across the three methods which is a success when bearing in mind the tidal constraints and exposure of the area is taken in to consideration.

All of the survey methods highlighted key strengths within them dependent on the factor being considered. In terms of the range of data collected the traditional surveys provides the best scope of this for monitoring the grey seal population. Whilst this method is similar to that of the Seal Cam surveys, data such as that of vocalisation presence and the a wider view of the colony to detect behaviours and disturbance along with noise stimulus is better collected via the human observational surveys at the expense of an increased amount of equipment needed and effort due to the number of people required and the travel time. The drone survey appeared to provide the most accurate count of the number of individuals but as this only provided a snapshot no dynamic data such as behaviour and disturbances could be monitored. It should also be noted that all of the survey methods required an experienced human to be able to distinguish between males and females. Whist not discussed, the drone

survey also provided the best vantage point to look at group structures within the population. Table 9 summaries the above discussion.

Table 9: Advantages and disadvantages of the three survey methods summarised.

Survey	Advantages	Disadvantages
Traditional survey	+ Ability to observe the behaviour of the seals. + Able to hear the seals vocalising. + Two people surveying – able to confirm thoughts on numbers, behaviours etc. + Photographs can be taken for photo-identification.	-Survey is the longest of the three due to the drive down to the spit. - Survey requires the most amount of effort. - Survey requires the most amount of preparation time. - Due to the steepness of the bank some seals may go uncounted resulting in the counts being less accurate.
Seal Cam	+ Quicker survey as no need to drive down to the spit. + Can be carried out in bad weather within reason. + Slightly higher vantage point compared to the traditional survey so more providing a more accurate count compared to the traditional survey. + Only one surveyor required so reduces the amount of effort. + Minimal equipment needed.	- No sound so unable to-hear vocalisation or any signs of disturbance e.g. planes. - Lack of peripheral vision as the camera is zoomed in on individuals to help with the counting so there's no recording of behaviours/disturbance outside of this view. - Effected by camera quality and lagged movement. - Due to the steepness of the bank some seals may go uncounted. - Easily disturbed in the office.
Drone survey	+ Quickest of the surveys. + Provides most accurate count. + Birds eye few of group formation + Easier to see male and females on better quality photographs	- As it provides a snapshot – there is no recording of behaviour and disturbance. - Batteries have a 10-12 minute flight time which restricts this survey. - Initially expensive for the purchase of the drone. - Limited by bad weather e.g. winds >15mph. - Increase in effort required due to flight supervisors presence and the pre-flight checks of the equipment.

5 Conclusion and recommendations

To go forward with this research a decision would need to be made about what data was required from the monitoring program going forward. In terms of accurately gaining a number of total individuals and identifying the number of males, females and juveniles within the colony the drone has the potential to provide the best method for this. However important behaviour and disturbance responses are not feasible to record with this method. Whilst the Seal Cam provides minimal disturbance and effort to collect the data it does however fall short of the advantage of two observers, size comparison, peripheral views of the colony and noise ques to detect and record behaviours, identify sexes and disturbance incidents in which the human observation surveys allow.

Further to this study the follow recommendations are suggested:

- More concurrent surveys of the three methods to confirm theories suggested in the above about which method provides the most accurate number of individuals within the colonies.
- More drone surveys to habituate the seals to its presence so they are less alert and better images can be obtain to sex the individuals and identify juveniles.
- A more advanced method of measuring individuals to identify life stages and sexes could also be used with these better quality photographs obtained from the above recommendation.
- If Seal Cam surveys are continued a dedicated location needs to be established in which the surveyor encounters zero distractions during the survey period.
- Continually research into the use of research to survey wild life including seals to keep up with regulations and the capabilities of such methods.
- The Trust needs to work with other organisations that have experience of monitoring pupping colonies.
- These three methods (along with the roughly fortnightly surveys) should be used again during the next surveying period to increase the sample size to help add to the findings of this report.
- A tablet to be purchased with a larger screen to be used for the drone surveys to allow for a better view of the seals and detect any alert behaviour quicker.

Regardless of the method or combination of methods that go forward as a result of this report the grey seals at South Walney Nature Reserve need to be continually monitored. This is as important as ever now as a second year of seal pups being born in the colony is an indication that this population is becoming an established breeding population. If the

numbers of seal pups born annually continue to increase in future years the reasons for this can also be investigated in more detail.

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7 Appendix

A: Traditional and Seal Cam survey forms

a)

Grey Seal Behavioural Survey Recording Form

Date:		**Observers:**	
Location:		**Time of low tide:**	
Survey start time:		**Survey end time:**	
Co-ordinates: (where you are surveying from)			
Weather conditions:	**Cloud cover:** None☐ Light☐ Moderate☐ Heavy☐ **Precipitation:** None☐ Light☐ Moderate☐ Heavy☐ **Wind:** None☐ Light☐ Moderate☐ Heavy☐ **Wind Direction:**_____ **Sea state:** (0-9)_____ 0 = mirror calm; 1 = slight ripples, no foam crests; 2 = small wavelets, glassy crests, but no whitecaps; 3 = large wavelets, crests begin to break, few whitecaps; 4 = longer waves, many whitecaps; 5 = moderate waves of longer form, some spray; 6 = large waves, whitecaps everywhere, frequent spray; 7 = sea heaps up, white foam blows in streaks; 8 = long, high waves edges breaking, foam blows in streaks; 9 = high waves, sea begins to roll, dense foam streaks.		

- Fill in details above
- Record the time at the start of each interval period (intervals every 10 minutes)
- Count how many seals are visible and in each position (hauled-out or in water) within each interval period of 10 minutes, and write the number in relevant section

- Mark the appropriate box in the 'behaviour exhibited' table when a behaviour is demonstrated. Only mark each box once, even if the same behaviour is exhibited several times during the same interval period.

b)

Interval:	0-10mins					10-20mins					20-30mins					30-40mins					40-50mins					50-60mins				
Start Time:																													
Sex:	**T**	**M**	**F**	**J**	**U**	**T**	**M**	**F**	**J**	**U**	**T**	**M**	**F**	**J**	**U**	**T**	**M**	**F**	**J**	**U**	**T**	**M**	**F**	**J**	**U**	**T**	**M**	**F**	**J**	**U**
Total number of grey seals: **VISIBLE**																														
Total number of grey seals: **HAULED-OUT**																														
Total number of grey seals: **IN WATER**																														

T – Total seals; **M** – Male seals; **F** – Female seals; **J** – Juvenile seals; **U** - Unknown

c)

Behaviour Exhibited

Time Interval: / Start Time: / Sex:	0-10mins				10-20mins				20-30mins				30-40mins				40-50mins				50-60mins			
	M	F	J	U	M	F	J	U	M	F	J	U	M	F	J	U	M	F	J	U	M	F	J	U
Asleep/relaxed																								
Alert																								
Aggression/playing																								
Travelling in sea																								
Travelling on land																								
Moving from land to sea																								
Moving from sea to land																								

d)

Time Interval: / Start Time: / Sex:	0-10mins				10-20mins				20-30mins				30-40mins				40-50mins				50-60mins			
	M	F	J	U	M	F	J	U	M	F	J	U	M	F	J	U	M	F	J	U	M	F	J	U
Milling in Sea																								
Spy Hopping																								

M – Male seals; **F** – Female seals; **J** – Juvenile seals; **U** - Unknown

Any seals vocalising? (Y/N)						
No. of photos taken						

Comments/Notes

Figure A1a-d: Screenshots of the four pages of the 'Grey Seal Behaviour Recording Form' used during the traditional and Seal Cam surveys to record the data.

Grey Seal Population and Disturbance Recording Form

Date:		**Observers:**	
Location:		**Time of low tide:**	
Survey start time:		**Survey end time:**	
Co-ordinates: (where you are surveying from)			
Weather conditions:	**Cloud cover:** None☐ Light ☐ Moderate☐ Heavy☐ **Precipitation:** None☐ Light ☐ Moderate☐ Heavy☐ **Wind:** None☐ Light ☐ Moderate☐ Heavy☐ **Wind Direction:**_____ **Sea state:** (0-9)_____ 0 = mirror calm; 1 = slight ripples, no foam crests; 2 = small wavelets, glassy crests, but no whitecaps; 3 = large wavelets, crests begin to break, few whitecaps; 4 = longer waves, many whitecaps; 5 = moderate waves of longer form, some spray; 6 = large waves, whitecaps everywhere, frequent spray; 7 = sea heaps up, white foam blows in streaks; 8 = long, high waves edges breaking, foam blows in streaks; 9 = high waves, sea begins to roll, dense foam streaks.		

- Fill in the details above
- Record the time at the start of each interval period
- At every 10 minute interval, note how many seals are visible, the no. of seal groups, the position of the groups on the shore, the group density (whether the seals are close together or spread out within the group) and whether the groups consist of mixed or same sex seals.
- If it is possible draw a map of the seal grouping structure and their position on the shore on the back of this sheet
- Note any disturbance factors during the survey, e.g. boat and foot traffic.

DISTURBANCE Comments:

GROUPING Comments:

GROUPING

Time Time Interval Period	No. of seals visible on the shore	Group Structure			
		No. of groups	Position of groups on shore	Group density (seals close together or far apart)	Sexes (mixed or same sexed groups)
0-10mins					
10-20mins					
20-30mins					
30-40mins					
40-50mins					
50-60mins					

DISTURBANCE

- Note down the time and duration of any disturbance that comes within 200m of the seals
- Specify what the disturbance is (e.g. motor boat, kayakers, dog walkers)
- Note the response of the seals using the key below. If 'Other' please note down the alternative response of seals. Use multiple codes if necessary.

Time of disturbance **Time Interval Period**	**Disturbance to seals (within 200m)**			
	Water based	**Shore based**	**Response (code & any other information)**	**Notes (approx. duration of disturbance)**
0-10mins				
10-20mins				
20-30mins				
30-40mins				
40-50mins				
50-60mins				

Response:
No response – **NR**; Alert, heads up, no change in position – **A**; Alert, seals moved short distance on land – **L**; Seals formed a tighter group – **G**; Seals moved into water (note how many) – **W**. Other; **O**

Figure A2a-c: Three pages of the 'Grey Seal Population and Disturbance Recording Form' used during the traditional and Seal Cam surveys to record the data.

B: SSSI permission

a)

South Walney and Piel Channel Flats Site of Special Scientific Interest, Cumbria ("the SSSI")

CONSENT OF NATURAL ENGLAND

Section 28E(3)(a) Wildlife and Countryside Act 1981 (as amended and inserted by section 75 and Schedule 9 of the Countryside and Rights of Way Act 2000)

To: Sarah Dalrymple, Cumbria Wildlife Trust, South Walney Reserve, South Walney, Barrow in Furness

Natural England gives you consent to carry out, cause or permit to be carried out the operations as specified in the notice dated 19 September 2016, on the land as specified in the notice:-

Specified operations:

A minimum of two people carry out each survey; the pilot and one to monitor the live stream for signs of alertness. The drone will be flown from the surveyor's position away from the colony and flown in at an altitude of around 120m. Whilst monitoring the seal reactions, several pictures will be taken to capture the whole colony in the area. These photographs will be used to count the number of individuals. Depending on the area in which the colony are spread and the amount of disturbance with the seals the drone will then be moved down to around 80-50m (no lower than 30m) to take closer photographs at a closer range in a tiled fashion over the colony. These photographs will be used to sex the seals to produce a male and female ratio within the colony and provide a number of juvenile or pups. The maximum flight altitude required to successfully carry out this level of identification will be established after the first survey and followed through.

The drone will be taken higher or away from the seals if more than 10% of the individuals are showing an alert behaviour of heads up and looking around. The survey will be abandoned if this is threshold is breeched more than twice or if a more severe alert behaviour such as individuals entering the water.

A log book will be kept to record the date, time, duration, weather conditions, surveyors names, battery changes, number of photographs taken, any external disturbance (land/water based), signs of alertness and percentage of colony displaying behaviour, general comments. This will be used to compare any differences in the drone flights and used to help compare the methodology (such cost of time, disturbance levels etc) against the human observation seal surveys.

- Flight time: maximum time of 45 minutes on the spit (30 minutes in flight) including battery changes if needed. Ideally all pictures will be acquired during one 10-15min flight.
- Altitude: 120m down to a minimum of 30m
- Maximum wind speed: 15 mph

b)

Timing of proposed operations:

Surveys to commence from the week beginning 26/09/2016 fortnightly until the 11/12/2016. They will be carried out as close to low water in order to capture the maximum amount of seals hauled out. Ideally the survey will start around 30 minutes before low water. In total six surveys are proposed.

Land on which operations are to be carried out:

On the spit of South Walney Nature Reserve. Approximate location of surveyors standing position: SD 233 625.

Signed for Natural England: Nicola Evans

Date: **26 September 2016**

If you wish to change the proposed operations or their location or to carry out additional operations for which consent has not yet been given, or if a time period set out above, has expired, you are required to give further written notice to Natural England.

Unauthorised operations may destroy, damage or disturb features of special scientific interest.

It is the responsibility of the grantee of this consent to ensure that no other consents, whether of a public or a private nature, are needed and, if needed, to secure them him/herself. The grantee is also responsible for carrying out the consented operation(s) safely and in all ways according to the law.

NATURAL ENGLAND

Cumbria Team, Juniper House, Murley Moss, Oxenholme Road, Kendal, Cumbria LA9 7RL

If you have any queries or concerns over this consent, please *contact Nicola Evans, at the above address*.

Reference number of operations from SSSI notification documents, for Natural England's use only: 10, 26, 27,

Figure B1a-b SSSI permission granted from Natural England to carry out the drone surveys.

C Surveys log book

Table C1: Survey comments for all three of the survey methods including the unsuccessful surveys.

Survey method	Survey Number	Date	Comments
Seal Cam	1	20/09/2016	Good first survey. Camera was of poor quality. I had started this survey later than I intended as I lost track of time.
Traditional survey	1	22/09/2016	The first survey – we went down early to spend around 10mins getting our eye in to count the seals and compared counts to ensure we were close in numbers.
Drone survey	1	30/09/2016	1st drone survey with external pilot. Flight time of: 6mins and 27 secs at maximum altitude of 120m. Around 5-10 seals in the back right corner of the haul-out location began to move forward when drone got closer but the pilot pulled back the drone before those in front moved in to the sea.
Seal Cam	2	05/10/2016	I felt more confident with this survey. The camera was responsive and had a clear picture. Group was also close together which helped the counting process.
Traditional survey	2	08/10/2016	This was one of the surveyors' first survey so we went down 15 mins before the start time to practice our counts and ensure they was confident identifying between males and females.
Drone survey	Trial	08/10/2016	The second drone survey done earlier than planned as the external pilot was due to go on holiday and I still wanted to observe another flight. He came down with the warden to do a survey whilst the surveyors were surveying. This provided a good comparison of numbers. Option to use this survey if later surveys do not go ahead.
Drone survey	Unsuccessful	12/10/2016	I was due to go out and complete my first drone survey however when we scanned the colony with the Seal Cam to get an idea of their location and spread we found the first pup of the season so we decided not to go out.
Drone survey	2	14/10/2016	This was the first of my drone flights to carry out a survey. Flight altitude of 120m down to 50m in intervals close to the seals. Camera was taking multiple pictures (+600 in total) – DJI GO app appeared to have a bug.
Drone	Unsucce	19/10/2016	A planned survey did not go ahead as the wind speed was

survey	ssful		recorded at 20mph.
Seal Cam	3	20/10/2016	This was a difficult survey there were more seals present than I had been used to so I struggled to count them all in the 10min slots. They were also spread out and the camera was lagging slightly. The office was also busy due to the time of the survey with people leaning over to get keys etc as I was unable to move the laptop away from the area.
Traditional survey	3	21/10/2016	An inexperience surveyor joined the two surveyors to shadow the survey and practise her counting and identifying between the sexes.
Seal Cam	4	4/11/2016	This was a difficult survey as the seals were very spread out and the camera movement was very delayed. There was also a large number of seals which made the counting difficult so I overlapped the 10minute counts and had to take screen shots to fill in any gaps. Camera had to be restarted but the camera quality and light levels increased as the survey progressed.
Drone survey	3	5/11/2016	Drone survey carried out by myself. Flight time of 5mins 35secs and maximum altitude of 120m. Mother and pup seen on camera screen. Drone was edged towards the colony and descended in 10m intervals. Two individuals seen in the video began to move forward at altitude of 50m so the drone was pulled back and the movement ceased. Video taken on this survey.
Traditional survey	4	06/11/2016	Another experienced survey was accompanied by two apprentices observe the survey and practise their counting and identifying sexes.
Drone survey	Unsucce ssful	10/11/2016	Drone survey cancelled due to bad weather. Wind recorded above 15mph.
Seal Cam Survey	Unsucce ssful		Due to lack of resources paired with unsuitable low water times a Seal Cam survey was not completed around this time.
Traditional survey	Unsucce ssful	19/11/2016	Seal pup discovery and hail storm – survey abandoned.
Drone survey	4	24/11/2016	Third drone carried out as the pilot. Flight time of 8mins 25secs to a maximum altitude of 120m. A series of photographs and video was taken as the drone was piloted closer to the seals and altitude was dropped in 10m increments. The birth of seal pup number 5 was caught on this survey.
Seal Cam	5	5/12/2016	Successful survey carried out undisturbed in the office. The

			camera was of high quality and very responsive.
Traditional survey	5	6/12/2016	One experienced surveyor present. Survey went well however the colony was tightly packed. Struggled to see the seals over the bank to the right. We located seal pup number 5 and it's mother after the survey along with two of the older pups and another individual.
Drone survey	5	10/12/2016	Successfully final drone slight, pilot beginning to feel more confident. Flight time of 4mins 37secs with a maximum flight altitude of 120m. The DJI GO App crashed on the route back so actually flight time was longer. I was able to land the aircraft and the drone.

D: Drone logs and images

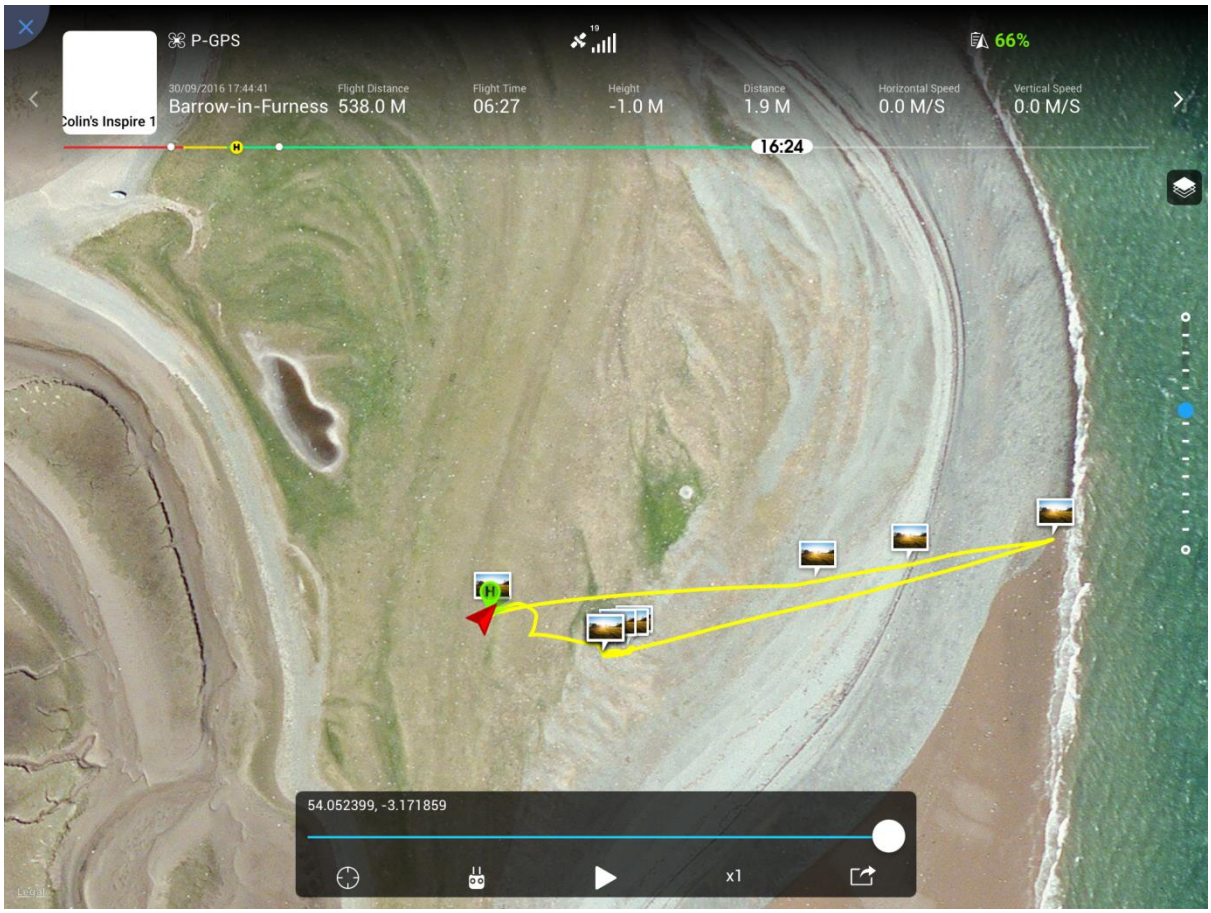

Figure D1: Screen shot of the flight log showing the flight path, distance, duration and location of photographs taken from drone survey 1.

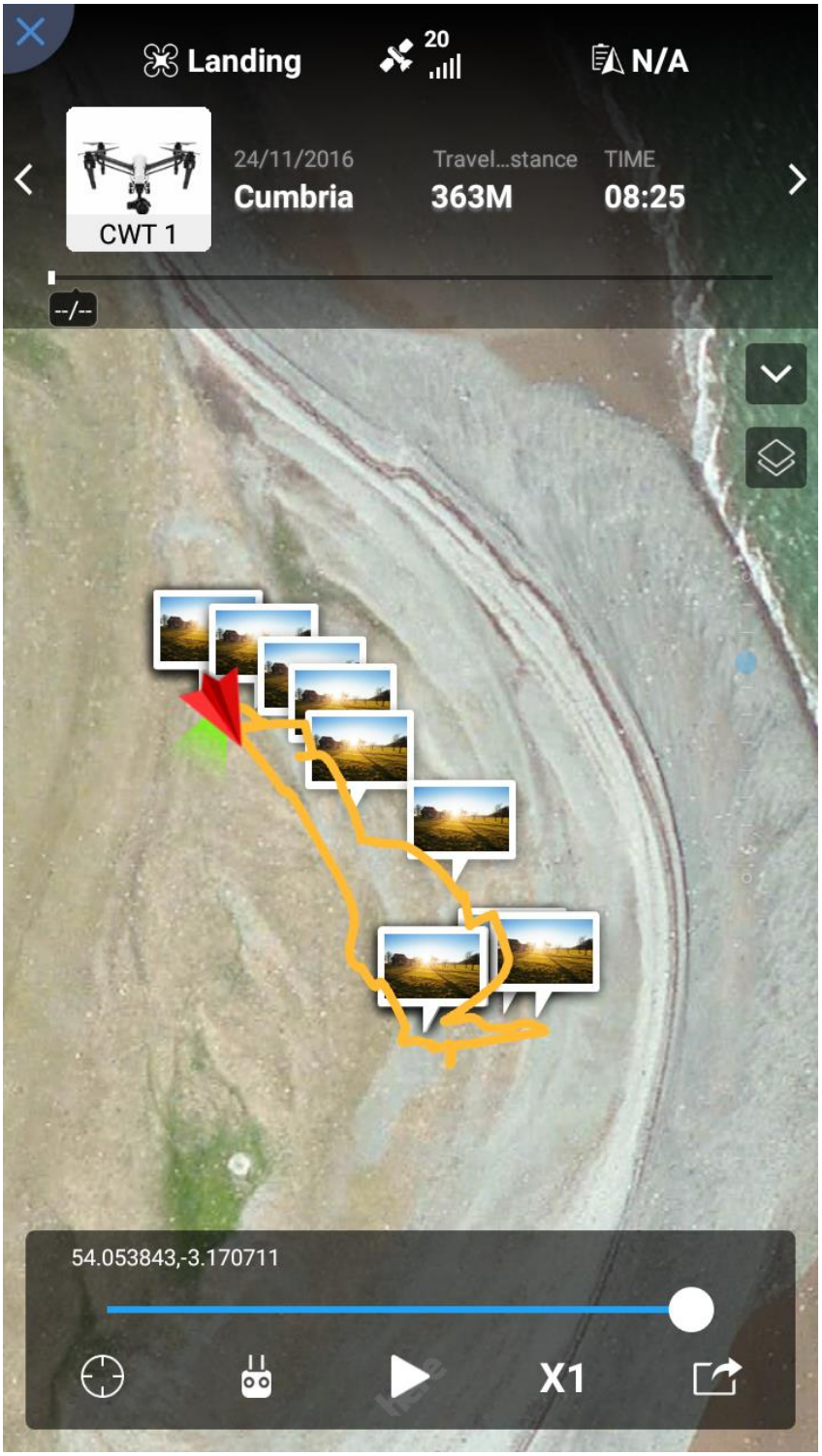

Figure D2: Screen shot of the flight log showing the flight path, distance, duration and location of photographs taken from the survey on the drone survey 4.

Figure D3: Photograph taken from drone survey 2.

Figure D4: Photograph taken from drone survey 4.

Figure D5: Image showing the method used to count the individual seals from the survey on drone survey 2.

Figure D6: Image showing the method used to count the individual seals from the survey on drone survey 5.