Manx Wildlife Trust
Treisht Bea-Feie Vannin

Calf of Man Seal Survey

Autumn 2024

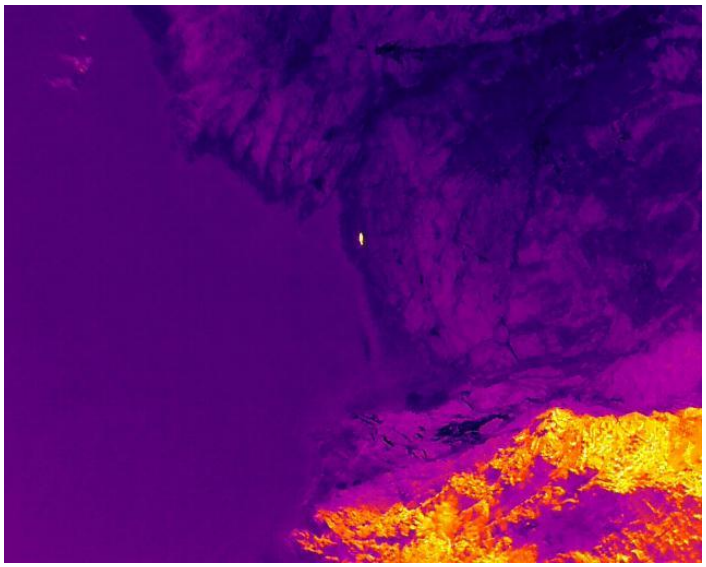

Image: Thermal image of grey seal at West of Cow, Calf of Man. MWT. 2024

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Contents

With thanks to the Department of Environment, Food and Agriculture for their support this season.

Summary

Pup Census:

- A total of 98 seal pups were recorded and monitored on the Calf of Man during the survey period.
- Pup numbers increased steadily over the years, reaching a new peak in 2024.
- The survey revealed the timing and distribution of pup births across the island, with certain sites being more productive than others.
- An All- Island Census count of 456 Grey seal individuals within the 2024 season is the highest recorded count on the Calf of Man.

Pup Development and Mortality:

- Out of the 98 pups observed, 84 were born on the Calf of Man, with 14 being wanderers.
- The mortality rate of pups during the survey period was 16.67%, the highest recorded mortality rate since records began.
- Factors contributing to pup mortality included stillbirth, infection, trauma, and adverse weather conditions.

Site Fidelity:

- Over half of the identifiable breeding cows (65%) were returning mothers, indicating a degree of site fidelity.
- Site fidelity analysis showed that 51.85% of returning mothers pupped at the same site as their last recorded pup, with only an additional 5.56% pupping within the same sector.
- A third of returning cows were recorded as pupping within a new sector.

Birthdate Analysis:

- 51% of mothers within the 2024 season pupped earlier than the 2023 season.
- While storm aversion may impact pupping dates, returning mothers have been recorded mating while their pup is still dependent, suggesting that early mating events result in earlier birth dates.

Use of Thermal Drone Technology (UAS):

- Thermal drone technology proved to be a valuable tool in monitoring seal populations, especially in inaccessible areas.
- Drones facilitated the identification of pups, monitoring of growth stages, and collection of high-definition images for individual identification.
- Elevation protocols were established to minimise disturbance to seals during drone operations.

Additional Observations:

- Disturbances caused by human activities, such as supply boat docking, were recorded, highlighting the need for minimising human impacts on seal habitats.
- Brown rat activity was identified during pupping season and investigated.
- A live web camera was utilised on Cow Harbour, increasing outreach to the general public on the importance of the Calf during grey seal pupping season.
- One tagged seal was identified, providing insights into seal movements and research collaborations.

The research conducted on the Calf of Man Island has provided valuable insights into grey seal pup mortality, site fidelity of returning mothers, and the effectiveness of using drone technology for wildlife monitoring. The findings contribute to our understanding of seal population dynamics and habitat conservation efforts in the region. Efforts to minimise disturbances and mitigate human impacts on seal habitats are crucial for the continued conservation of grey seal populations on the Calf of Man Island. Suggestions for future research are highlighted throughout the study and within the discussion.

Introduction

Background

The British Isles is home to two species of "true seal", grey seals (*Halichoerus grypus)* and harbour seals (*Phoca vitulina)*. These species were previously overexploited, being hunted for meat and gaining a bad reputation within fisheries. This led to noticeable declines in number (Mowat, 1984), with grey seal populations falling to only 500 in the early 20th century. Both are now protected under the 1976 Wildlife Act and the 1990 Manx Wildlife Act, with recovery in both populations being seen because of enforcements of these protections. The IUCN now recognises both species as 'Least Concern' in their assessment, with population numbers beginning to stabilise.

Grey seals are the predominant species of seal spotted around our coastlines with an estimated population of over 150,000 grey seals around the UK making up 95% of the European population. The British Isles are extremely important for grey seals with an estimated 37% of the global population breeding in the UK and Ireland. Whereas harbour seals, though widespread globally, are more of a rarity in British waters (Manx Wildlife Trust., 2020). Thus, grey seals are the focus of many marine mammal surveys and marine research within the UK. The highly mobile and pelagic nature of marine mammal species often makes them difficult to monitor (Gordon et al., 2003) however seals spend set periods of time on land for moulting, breeding and resting (Sayer et al., 2019). During these times, individuals 'haul out' in large numbers providing a perfect opportunity to gather data on population, size and fecundity acting which can act as a good indicator of the local marine ecosystem health as a whole (Kaschner et al., 2001).

Here, breeding season is used as an opportune period to monitor population health, site fidelity and pup success due to the large aggregation of seals during this time. Female grey seals aggregate at specific locations during breeding season, giving birth to a single pup. Seal pups will suckle intensively for 16-21 days, during which the mums will stay with the pup and do not leave to feed (Fedak and Anderson, 1982; Pomeroy et al*.,* 1999). Females will leave their pups once they are weaned, with pups staying on land until they complete their moult. Pups will begin to lose their white lanugo coat post weaning revealing their adult pelage (Russell et al*.,* 2019), which can be used to identify individuals. This post-weaning period can last around 9-40 days (Baylis et al*.,* 2019), during which pups fast and can lose up to 25% of their body mass (Noren et al*.,* 2008) before fully

moulting and entering the sea to learn to forage and feed (Russell et al., 2019). First-year mortality for grey seal pups is high, ranging from 38% for females to 80% for males (Hall et al., 2001). Thus, studying them at this stage is important to better understand population dynamics (Hall et al., 2001).

In addition to monitoring pup success, breeding season provides a good opportunity to monitor site fidelity in not only breeding females but also in male seals. Grey seal cows are known to show significant site fidelity in pupping location (Pomeroy et al., 1999) influenced by previous pupping success, familiarity with local conditions, predictability of habitat quality and experience level of the female (Weitzman et al., 2017). On completion of weaning, the female seals mate with the male who has maintained dominance of that specific pupping location through repeated physical contests with rival males (Bubac et al., 2018). Due to the crossover between pupping and mating season, this period allows for study of population size of mature adults and their site fidelity. As early as post-weaning moult, grey seals are left with an individual pelage which can be used to identify them, much like human fingerprints. These unique patterns remain visible and stable throughout their lives (Sayer et al., 2019) but do darken with age (Vincent et al., 2001). Matching identification photographs from previous breeding seasons allows us to study the level of site-fidelity and number of returning individuals within the population.

Manx waters are particularly important for grey seal populations, with around 100-400 of the British population being observed around the Isle of Man at any given time (Howe and Parsons, 2017). The Isle of Man's abundant waters and rocky coastline provide the perfect habitat for grey seals with the Calf of Man, a small islet half a mile off the mainland, being recognised as a significant site for Manx seals (Duck, 1996). The isolation and low level of human disturbance makes the Calf the ideal location to study seals with minimal influence from external factors. The Calf is the main breeding site for grey seals around the Isle of Man and has been monitored annually since 2009 by Manx Wildlife Trust through their seal pupping survey. Through the months of September to November, two dedicated seal pup volunteers reside on the Calf partaking in daily surveys. With the main objectives of surveys as follows;

Objectives

1. Collect photographic identification images of seals, to compare and match individuals to the catalogue database.

2. To monitor site fidelity, reproductive output and life history, predominantly of female seals.

3. Produce a seal pup census, recording the number of grey seals born during the pupping season at all known pupping sites around the Calf of Man.

4. To monitor the development of pups and determine survival rates of pups born on the island.

5. Determine the proportion of returning and new mothers pupping on the island.

Methods

Study Area

The Calf of Man is a small largely uninhabited island located half a mile off the southwest coast of the Isle of Man. The Calf of Man has long been considered as an important site for grey seals within the Irish sea, due to its rocky inlets and beeches proving ideal habitat for seal birth site selection (Duck, 1996; Crow, 2013). Previous surveys of the seal pupping season have identified the 15 sites along the north and south coastlines utilised for pupping, which are now the pupping sites monitored throughout the survey season (Figure 1). These sites range in area from to 2,111m²-21,821m², with habitat consisting of gullies, rocky out crops and pebble beaches, providing haul out sites and possible shelter. The eastern and western coasts of the island lack suitable haul-out sites due to the sheer cliffs and therefore there has been a historical absence of pupping in these areas and so these areas are only surveyed during the island wide seal counts.

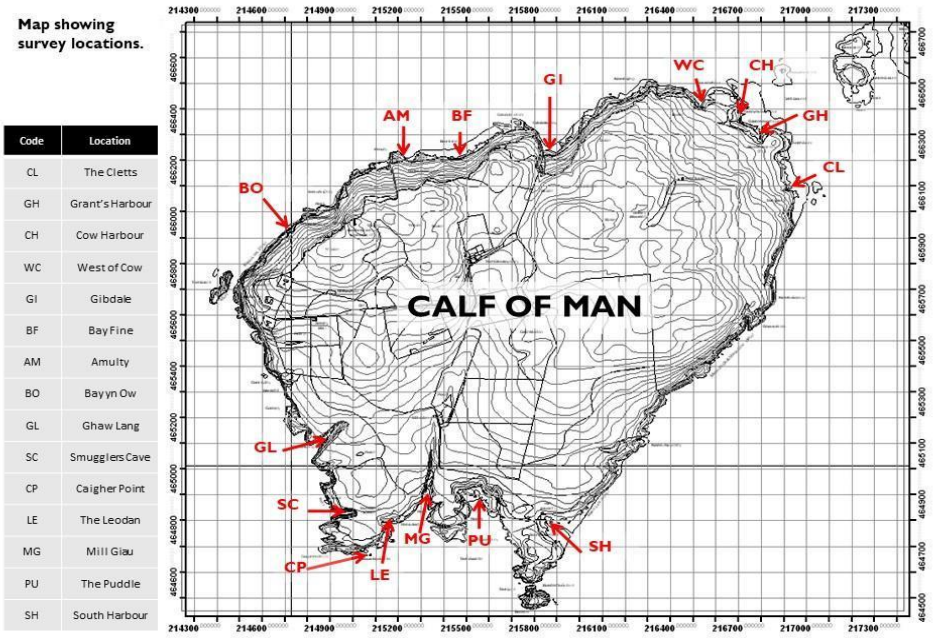

Figure 1. Map of Calf of Man showing the 15 different grey seal pupping locations used for surveys. Table provides full names of sites and corresponding codes.

Data Collection

The breeding season on the Calf of Man occurs between September and November (Stone et al., 2013), so data collection is carried out during this period, which this year was from 3rd September to 4th November by volunteers Duncan Kenny and Daisy McDonald, with guidance from Manx Wildlife Trust Marine Officer Dr Lara Howe. Of the 15 sites, two survey routes of seven sites were formed, consisting of North sites (BO-CL) and South sites (GL-SH) (Figure 1). To be able to accurately track pupping on the island, but with the aim to also reduce the impact of human disturbance, survey routes were carried out on alternate days. All seals and pups present at a site, both hauled-out and in the water, were counted at each visit.

The surveys consist of two parts, firstly to carry out a pup census of the island and secondly to count and photograph adult seals to carry out photo identification for population estimates. Upon reaching each site, the number of pups present were noted, including if there had been any births since the previous visit, as well as classifying the age of each pup. During pup observations, behaviours that confirmed filial relationships, such as suckling, were photographed and recorded. On occasions when insufficient data was collected during the initial site visit, a return visit was carried out later that day, sometimes requiring the surveyor to sit out-of-sight until the necessary photographs could be taken to match pups to mothers by witnessing suckling.

In addition to this, the number of adults were counted and photographed using a Nikon Coolpix P100 digital camera with a 24-3000mm lens and a Canon EOS 77D DSLR camera fitted with a 150-600mm lens. In order to carry out photo identification, images were taken of seals that showed clear natural pelage markings, with where possible of both left and right sides of the seal preferably of both the head and flank of each side. Using high-quality photographs of individuals increases chances of re-identify from previously identified individuals in the catalogue, and reduces the chance of false rejections, whereby one individual is duplicated (Hiby et al., 2013). Priority of photographs were given to mothers and pregnant females, to aid the tracking of pups and so we were able monitor mothers for analysis on site fidelity.

Poor visibility at some site observation posts makes it hard to identify the presence of seals and pups due to geographical restrictions such as cliffs, rocky outcrops, and sea level caves. Four sites in particular Smugglers Cave, Baie Fine, Amulty and Baie n'Ooig being notorious for this.

This year an additional photographic method was utilised to try and overcome the visibility limitations at these sites.

In 2023 the seal surveyors utilised a Pulsar Helion 2 XP50 Thermal Imaging Spotter Scope Camera and for the first time on the island drone surveys were introduced. The surveyors utilised a DJI Mavic 2 Zoom UAS (Unmanned Aircraft System [drone]) for this purpose. For the 2024 season Manx Wildlife Trust introduced a DJI Mavic 3 Thermal UAS, which combined both the thermal camera and long-range aerial capabilities. The use of aerial thermal and standard imagery transformed survey capabilities on the island by; minimising disturbance to wildlife, enhancing safety for researchers in remote and hazardous areas, improving time efficiency, and improving identification and data quality (Appendix A: The Role of Thermal Imaging Drones 2024).
The UAS thermal camera provides easy identification of seal locations whilst maintaining a high altitude (Figure 2).

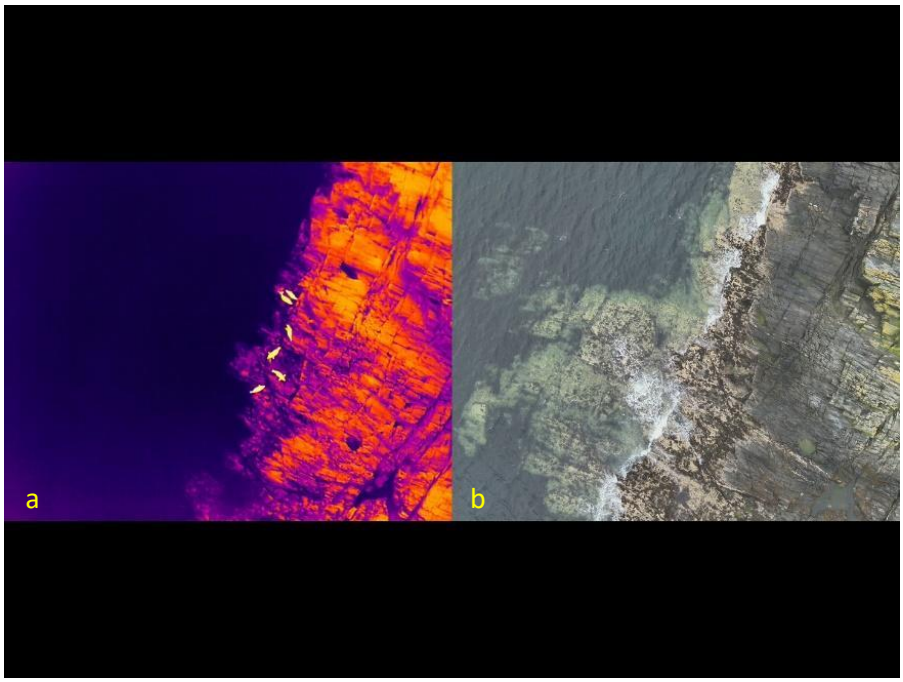

Figure 2. Simultaneous thermal (a) and standard (b) digital drone images taken at elevation exceeding 50m, comparing the effectiveness of grey seal location identification. MWT. Calf of Man 2024.

The UAS standard camera assists as the camera can be positioned at a safe distance utilising the powerful zoom feature minimising risk of disturbance and maximising appropriate angle for observation of seals in remote or hidden areas (Figure 3).

Due to this we were able to accurately count the number of seals and pups even when we were unable to see them ourselves from the observation posts.

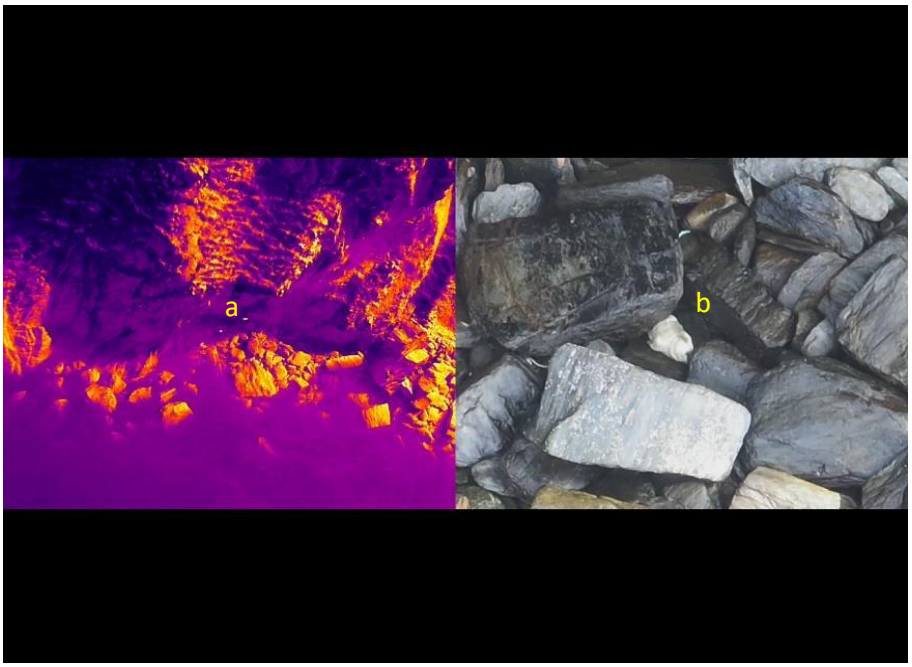

Figure 3. Simultaneous thermal and standard digital drone images taken at elevation exceeding 50m, showing thermal heat spot of partially hidden seal pup (a), and full zoom standard imaging of partially hidden seal pup (b). MWT. Calf of Man 2024.

Pup Development Stages

The photographs of the pups through their developmental stages were assessed using a system of classification into five stages (see Appendix B), whereby their physical appearance and behaviour can be related to pup age (Kovacs and Lavigne, 1986; Radford et al., 1978; Russell et al., 2019). The stages are separated by characteristics including percentage of lanugo coat vs moulted and body shape. The appearance of fresh afterbirth, umbilical cord and lanugo coat stained yellow along with blood around the mother also was used to indicate a pup was recently born. Tracking the developmental stages allowed the team to monitor the growth of seal pups (Figure 4), and the success rate of pups born, all of whom were named beginning with a single letter of the alphabet (the letter 'B') as per the ongoing naming convention on the Calf of Man.

The second successive year, surveyors utilised an assessment of pup condition as used by researchers on Skomer Island undertaking a similar project (Büche & Bond, 2023). An assessment of pup body condition was made at last sighting of pup, classified on a five-point scale:

1. Very small	Assumed not to have survived
2. Small but healthy	In good condition, would have a slim chance of survival
3. Good size	Most should survive
4. Very good size	All should survive
5. Super-moulter	An exceptional sized pup

Seal pups were considered successful if they survived past the third development stage, unless they were in poor condition (Hewer, 1974). If a pup disappeared before the final development stage, stage 3 or 4, an individual assessment was made on its likelihood to have survived based on body condition. Pups that had a size score of 3 or greater were assumed successful, whereas pups smaller than size 3 were assumed unsuccessful.

Figure 4. Photographs of a pup at SH, on the day she was born at stage 1 (a) (22/09/2023), and the same pup (b) at full wean stage 5 (13/10/2023), illustrating the significant development changes. Duncan Kenny. Calf of Man. 2023.

Wanderers

Fourteen pups were recorded as wanderers. Wanderers are pups which turn up unaccompanied by a cow, either stage 3, stage 4, or stage 5 development, and where their natal beach is unknown. Large wandering pups usually finish moult once they have established themselves on a beach, whereas the smaller ones (presumably abandoned or separated) usually disappear within days.
The appearance of wandering (unknown) pups is most commonly linked with storm and spring tide events. Pups that were classified as a wander at stage 5 development could possibly be pups born and recorded on the island but have left their birthing site prior to any stage 5 photos being recorded.

Photo Identification

Photographs of adult seals taken at the pupping sites were compared with a catalogue of individuals recorded previously on the Calf of Man, consisting of 651 females and 61 males before the 2024 season. There is a particular focus on identifying breeding females who were photographed with pups, allowing for continued analysis of the levels of site fidelity shown by returning females. Seals that were photographed and did not match any images in the catalogue were added as 'new seals' and assigned a number and a catalogue folder, establishing a record of their individualised pelage patterns and noting the dates and locations in which they were observed.

Camera Trapping

Camera traps are relatively inexpensive as well as non-invasive and a relatively inexpensive tool to monitor wildlife (Brassine & Parker, 2015), allowing to observe animal behaviour without human disturbance (Di Cerbo & Biancardi, 2012). Commonly used across terrestrial habitats, in recent years they have been introduced to study hauled-out pinnipeds (Gucu 2009; Koivuniemi et al., 2016). For the purpose of this study, camera traps were used to monitor disturbance recovery by mothers at key pupping sites subjected to occasional risk of disturbance. Additional monitoring of some sites was achieved by camera placement at a safe distance from the immediate pupping area (Figure 5). The camera trap allowed us to continually monitor seals and pups without disturbance. A total of five camera traps were deployed at four locations: one at South Harbour, one at Cow Harbour, one at the Puddle and two at Grant Harbour. All cameras were set on motion sensors, for two photographs followed by a 25 second video clip to be taken when triggered. Using these settings allowed reduced memory storage and battery drainage, which reduced the number of times cameras had to be checked, thus minimising potential human disturbance to seals.

Figure 5. Photo showing camera trap position at site GH to monitor grey seal behaviour and potential disturbance events at this location. MWT. Calf of Man. 2024.

All-Island Census

During the 2024 season, whole Island surveys were carried out using thermal drone technology, replacing the previously utilised boat survey method.

Data Analysis

The program Microsoft Excel 2017 was used to analyse results of pup and female grey seal data collected. This program was also used to produce graphs comparing this year's data compared to previous years as well as calculating levels of site fidelity and success rates of pups.

Results

Pup Census

A total of 98 pups were recorded and monitored on the Calf of Man over the survey period this year. This is the highest number of pups recorded on the Calf since surveys began in 2009, it should be noted that this year extra data was collected with help of the thermal imaging UAS facility. Figure 6 illustrates the number of pups born each year overall. Pup numbers increased steadily from 2009 (n=26), reaching a previous peak pup number of 84 in 2016. After 2016 the annual pup number plateaued, remaining at an average of 64.6 pups until 2023 where numbers peaked to 96 pups.

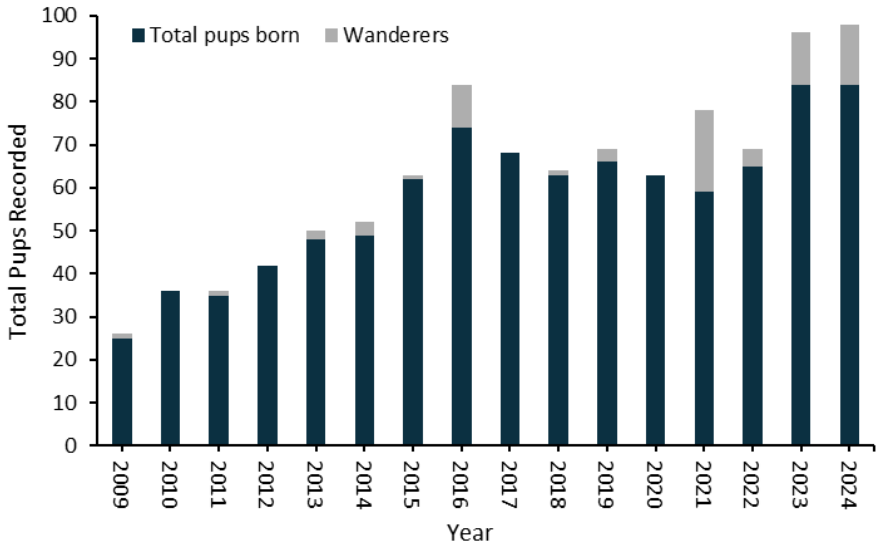

Figure 6. A graph showing the annual total pup number since 2009. Wanderers are highlighted separately for an overall comparison of total pups recorded.

The number of pups observed each week during the survey period is displayed in Figure 7, showing the spread of pupping dates across the season and a comparison of the previous year's pupping dates and the historical average. This year's survey started a week earlier than the 2023 survey and ended 3 days later. The peak pupping period started within the same week as the 2023 survey and the historical average, 22/09/2024 to 28/09/2024, however this year saw a prolonged peak pupping period over 3 weeks. This reflects the pattern of pupping periods of the historical average and not that of the trend of 2023 which observed a high peak followed by a secondary high peak (Figure 7). The 2023 survey also illustrated a greater influx of pups within a single week in comparison to this season and the historical average. While the 2024 period was seen to continually

increase in production within the 6th monitoring week, 6/10/2024 - 12/10/2024, the 2023 productivity decreased until the second peak seen within 20/10/2023 - 26/10/2023.

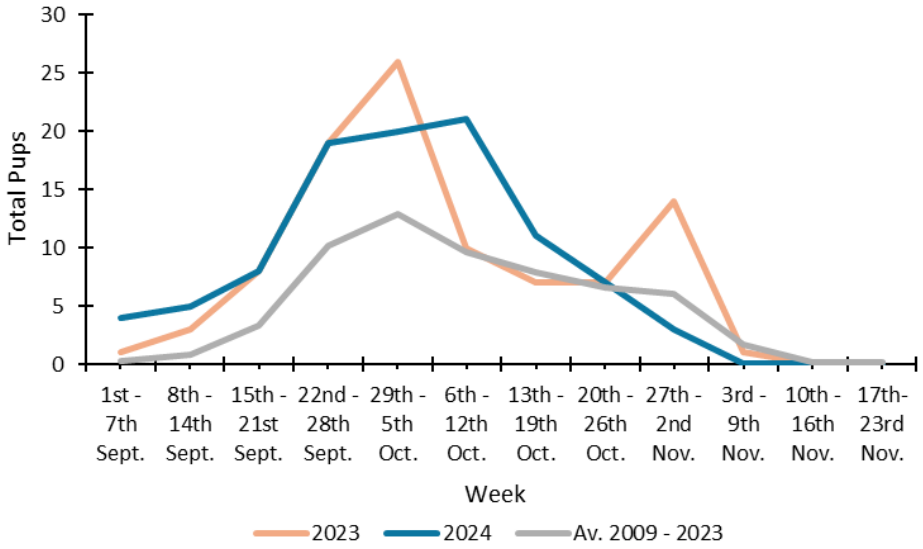

Figure 7. Graph showing the spread of pupping dates over the 2024 season compared with both the 2023 season alone and the survey average from 2009-2023.

On 24th October 2024, the volunteer seal surveying team recorded a total of 456 grey seals on a single survey. This is the highest seal count for a single day recorded in the history of the Bird Observatory. In November 2024 the team recorded a total of 15,564 (235 surveys) grey seals for the year. The surveys were carried out by the wardens (March to August) and the volunteer seal team (September to November). This is the highest total grey seal year count recorded on the Island since record began, surpassing the previous record of 15,044 (236 surveys) grey seals from 2019.

Of 98 pups observed on the calf, 84 were born on the Calf with 14 wanderers. Of all these pups 16 were confirmed deceased during the survey period, making up 16.67% of the pup population. This is the highest recorded mortality rate seen within the Calf, with the highest mortality rate previously recorded in 2014 at 13.73% (Figure 8). The average mortality rate over the 16-year data set is 5.99%. A total of 57 pups were observed all the way to stage 5 of development (59.38% of pups), 21.32% higher than the survey average. Due to the high mortality rate, further analysis of the pup fatalities was deemed necessary. The highest form of fatality was stillbirths with a total of 5 (31.25%) of pups recorded in 2024 (Table 1).

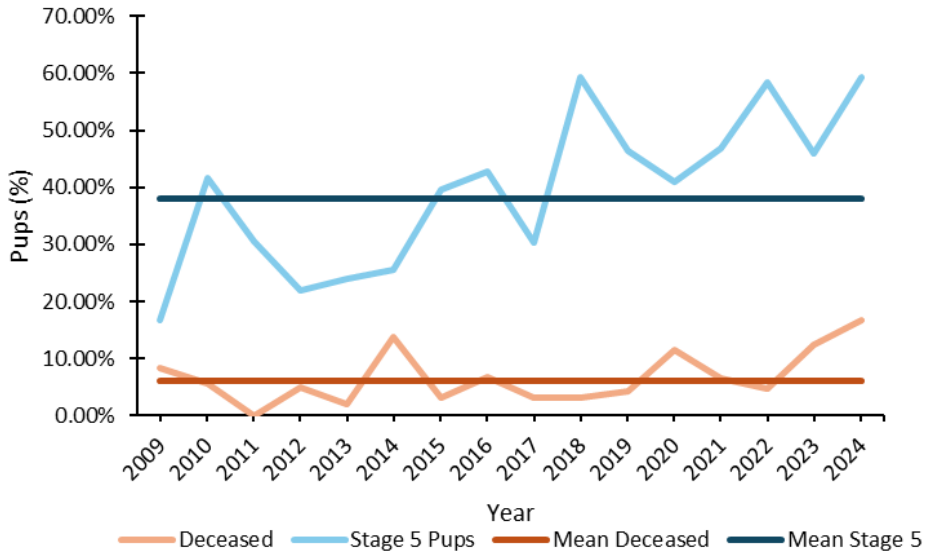

Figure 8. Percentage of pups confirmed as deceased each year, compared to the mean between 2009-2023, as well as the percentage of pups successfully tracked through to stage 5 of development each year and the mean of previous years.

Table 1. 2024 causation of the recorded pup deaths.

	< Stage 3	≥ Stage 3	Total	%
Stillborn	5	0	**5**	31.25
Washed up	2	0	**2**	12.50
Storm	0	3	**3**	18.75
Disappeared	3	0	**3**	18.75
Unknown	2	1[†]	**3**	18.75
			16	

[†] Suspected viral or pathogenic cause

Pup Distribution

98 pups were recorded in total this year across 17 pupping sites (Figure 9). During the 2024 season two new pupping sites were observed (KI and KR) taking the island's pupping sites total from 15 to 17.

Pup abundance was highest at PU (n=13) contributing to 15.48% of the total pup number. The second highest productivity site was GH with 10 pups (11.90%) and third highest being CH with 9 pups (10.71%). Historically PU, GH, and CH have produced the highest number of pups, with this season following the similar trends. Together these 3 highly productive sites account for 38.10% of all pups. The lowest pup numbers (n=1) were seen at CL, KI and LE.

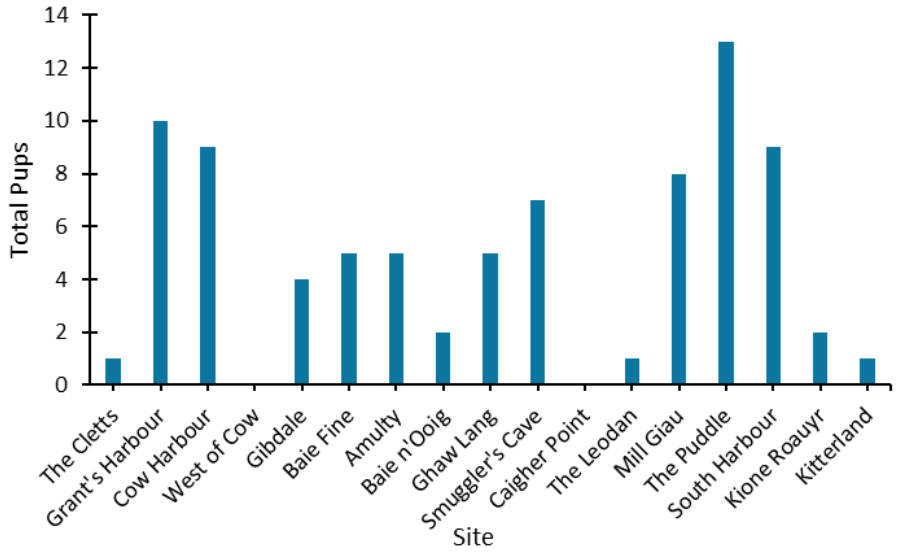

Figure 9. A bar graph showing the number of pups born at each site around the Calf of Man for the 2024 season.

Leodan observed a significant drop in productivity in 2024 (n=1) compared to 2023 (n=4). South Harbour observed a growth in productivity in 2024 (n=9) compared to 2023 (n=6) (Figure 10).

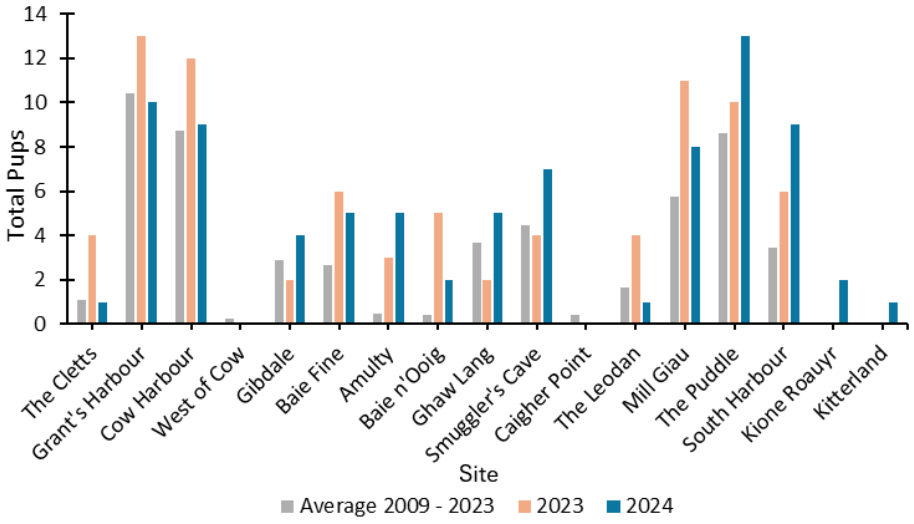

Figure 10. Graph showing the number of pups at each site in 2024, compared to the mean of previous surveys and 2023 standalone.

Site Fidelity

Returning cows

Of the 98 grey seal pups recorded on the Calf of Man in 2024, 65% (n=54) of identifiable breeding cows were returning cows (Figure 11). Subsequently, 11% (n=9) of pupped cows were unable to be

identified or recorded, either not observed or photographed, marked as unidentified. 24% (n=20) of pupped cows were new mothers and added to the Female Seal ID 2024 catalogue, reaching a total of 671 recorded females.

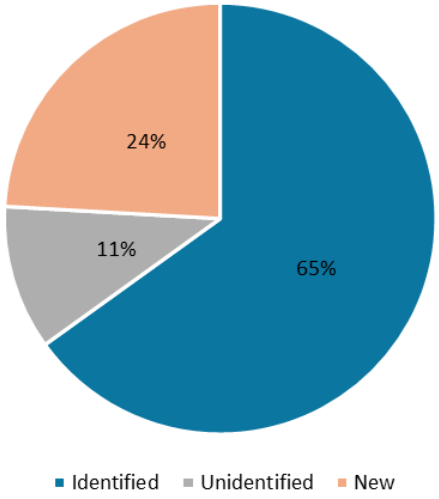

Figure 11. A pie chart representing the proportion of mothers which were identified, unidentified or new during the 2024 season.

The oldest breeding female was ID:004 who pupped for the fifteenth time on the Calf of Man in 2024. The first time she was recorded she pupped at CH in 2009. Since then, she has been recorded as successfully pupping every year except for 2012, where no data for her was recorded.

Site Fidelity

Site fidelity was worked out by looking at a females' pupping site this season (2024) compared to the site used when they had their last pup. Out of the 54 returning mothers 51.85% pupped in 2024 at the same site as their last recorded pup with 5.56% pupping at a site within the same sector (Figure 13). Sites in close proximity were grouped into 7 sectors (Figure 12), where there was little distinction or separation between or the seals could move freely between the pupping sites. A total of 18 returning mothers were recorded to have pupped within a new sector, equating to a third of all returning mothers.

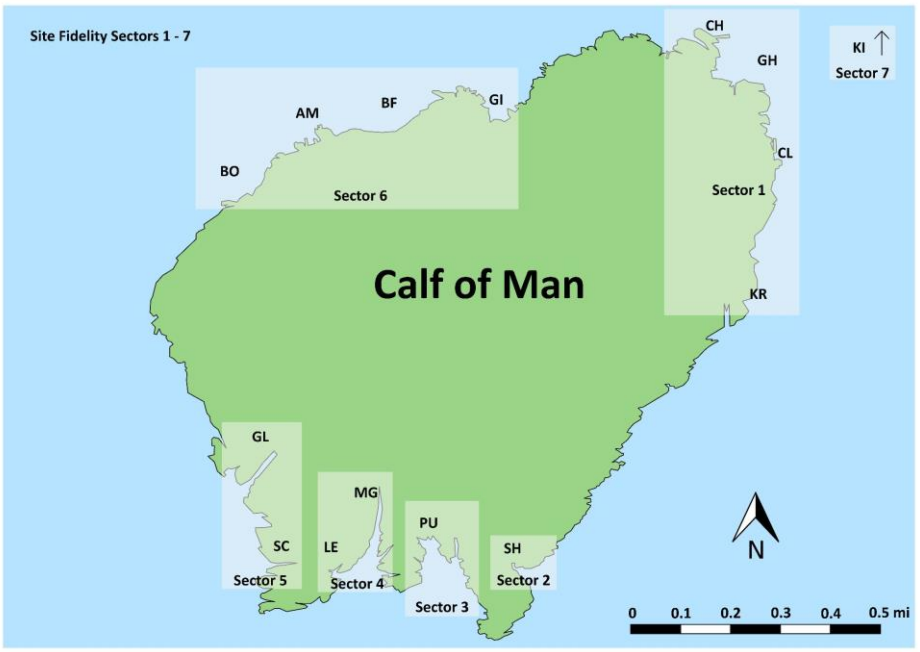

Figure 12. A map of the calf showing the grouped sites into 7 sectors

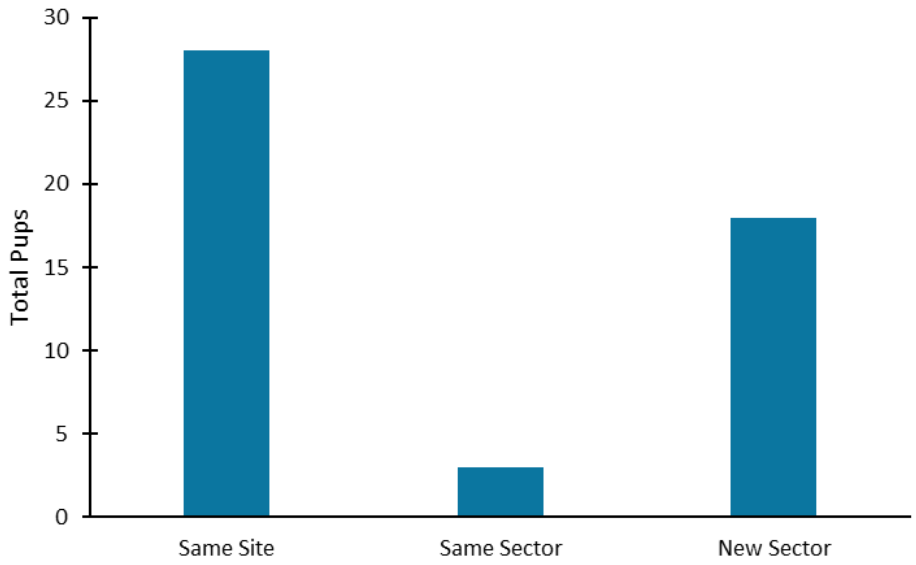

Figure 13. A bar graph showing site fidelity to pupping sites on the Calf. The graph shows the number of individuals that pupped at the same site, in the same sector or in a completely new area compared to the last time the female pupped.

All-Island Census

Between March and September 2024, the all island census was carried out on foot by the island Wardens. From September 2024 the volunteer seal surveying team conducted all island census utilising thermal drone technology. This resulted in the seal surveyors capturing additional species category data including breeding females, males, juveniles, and pups. Seal numbers dropped steadily pre-breeding season, from March to the beginning of September. There was a significant increase in the overall count up until the end of October, in which numbers then saw a significant reduction in early November (Figure 14). Breeding females remained the highest count within the seal population. There was a notable increase in male abundance after the peak pupping season had ended. Juveniles remained consistent in all survey counts within a slight reduction in early November.

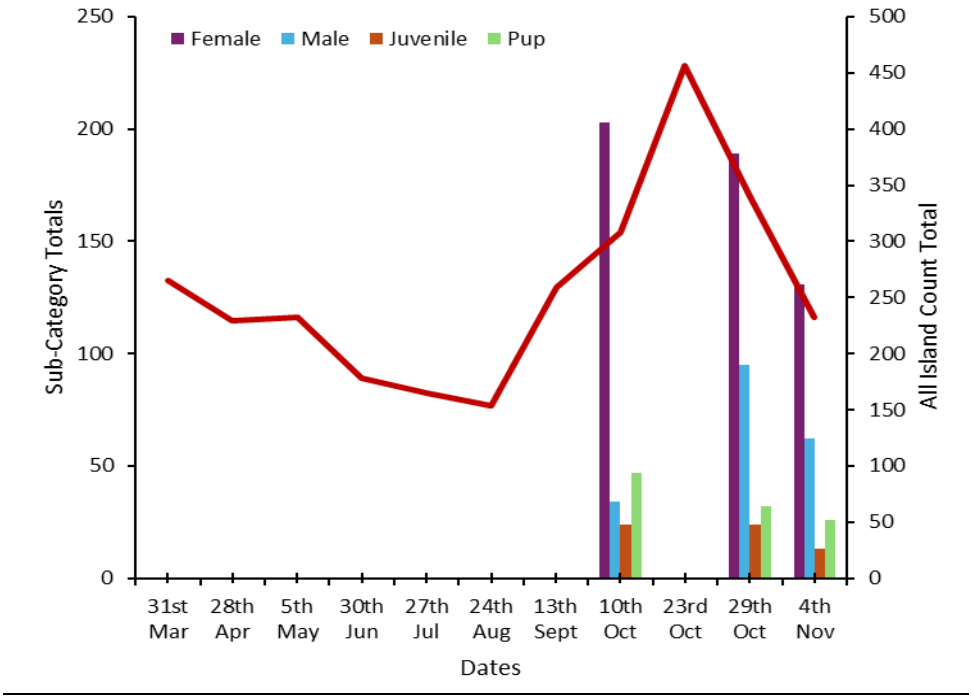

Figure 14. The total All Island Count totals over a 9 month period (March to November). Subcategories of breeding females, males, juveniles, and pups were recorded within 3 surveys.

Birthdate

Data collected over previous years can be used to analyse changes in pupping dates. Of the mothers which pupped on the Calf in 2023 and returned in 2024, 51% pupped at an earlier date than 2023 (Figure 15).

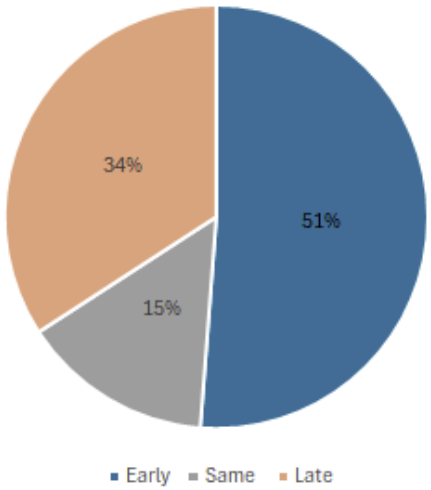

Figure 15. A Pie chart showing the percentage of known mothers who pupped earlier, later or the same date in 2024 as in 2023.

Discussion

Pup Numbers

The total number of pups recorded on the Calf of Man this season was 98, being the highest ever pupping season seen on the Calf. It was previously believed the Island had reached carrying capacity with pup numbers remaining within the 60s for previous seasons, and a peak of 96 in 2023. This followed previous research that showed growth of seal populations in areas besides the central and southern North Sea have dropped below 1% compared to 6% in the 1980s (Russell et al., 2019; Thomas et al., 2019). From the first survey year in 2009 up until 2015 pup numbers increased annually, most likely as a result of increased survey periods and improved methods. Pup numbers then reached a peak of 75 in 2016, before levelling out and staying in the 60s for the following survey years until 2023. Similar trends were seen in seal pupping populations in the Outer and Inner Hebrides, and on Orkney (Thomas et al., 2019) where pup production increased until overshooting carrying capacity and then levelling out. However, breeding populations in the North Sea are continuing to grow exponentially (Thomas et al., 2019).

The increase in pups seen in the 2023 season can be attributed to the use of a drone during surveys. The introduction of a thermal drone by Manx Wildlife Trust in 2024 improved surveying further. There were multiple occasions whereby the drone located seals which could not be seen by the volunteers looking from the observation points. This was especially true for sites on the north sites of the island where there are many caves and inlets which cannot be seen from the top of the steep cliff faces. This year saw pups recorded at Kione Roauyr and Kitterland for the first time due to aerial access and observation. This year seal volunteers left the island on the 6th of November, 3 days later than the 2023 season. No additional pups were recorded during the 3 additional days.

Pup trends

Weekly Trends

The pupping season this year started with the first pup born on the 31st of August, lasting 9 weeks with the last pup recorded as volunteers left the Calf on the 31st of October. The first pup of the season was born a week earlier than both 2022 and 2023. As the 2024 pupping season has a similar trend to that of the historical average, it suggests that the previous 2023 season is abnormal in its weekly pupping productivity. This may be due to the increase in storm events recorded in 2023 in

comparison to this year and previous years. As future surveys continue, a comparison to the historical average and an analysis of storm data could provide further insight into the weekly pupping trends recorded.

Mortality

Pup mortality was recorded only when the remains of a deceased pup was visible to surveyors. Sixteen pups were recorded as deceased this season, representing 16.67% of the pups born on the Calf of Man in 2024. This mortality rate is significantly higher than average. The highest mortality rate previously recorded was 13.73% in 2014 with an average over the 16-year period of 5.99%.

This year there was one named storm occurrence on the island during the survey period. Namely, Storm Ashley (20/10/2024). Bad weather conditions increase mortality rate (Baker and Baker, 1988), in 2017 on the Calf for example almost half the pups went missing, due to Hurricane Ophelia. Pups can potentially survive periods when violent seas are running on to the sites where they are being nursed (Westcott and Stringell, 2003). Of the 98 pups, 2 (1.96%) were classed as 'missing' during the survey, so it is possible that these missing pups were deceased.

The main causes of mortality in grey seal pups are starvation, infection, septicaemia, stillbirth, and trauma (Baily, 2014). Of the thirteen pups confirmed as deceased, five pups were recorded as stillborn in 2024. The stillbirths observed during the 2024 surveys may reflect a common occurrence among grey seals, first-time mothers often experience higher rates of pup mortality, particularly stillbirths (Pomeroy et al., 2000). This could be attributed to factors such as inexperience in birthing, or potential physiological constraints during a seal's first pregnancy (Baker et al., 1995), or the presence of Polychlorinated biphenyls (PCBs).

Polychlorinated biphenyls (PCBs) are persistent organic pollutants known to have harmful effects on marine mammals, including grey seals. These toxic compounds accumulate in fatty tissues and are passed from mothers to pups during gestation and lactation, potentially affecting reproductive success, especially in new mothers. PCBs act as endocrine disruptors, interfering with hormone regulation, which is essential for pregnancy and pup development (Sørmo et al., 2005; Hall & Barker, 2001). Reduced thyroid hormone levels caused by PCB exposure have been linked to impaired metabolism and development in grey seal pups, which can result in stillbirths, particularly for first-

time mothers who may be less physiologically prepared to cope with such disruptions (Robinson et al., 2018; Pomeroy et al., 2000).

Studies have shown that PCB transfer during lactation can lead to a reduction in pup survival rates. This is critical because stillbirths and early pup mortality are more common in inexperienced mothers. The metabolic and hormonal disruption caused by PCBs may exacerbate these challenges, making first-time mothers particularly vulnerable to reproductive failures (Debier et al., 2003).

Among the viral pathogens affecting grey seal pups, seal poxvirus has emerged as a noteworthy concern, although its exact role in pup mortality is still being studied. During the 2024 surveys on the island, surveyors recorded two individual grey seals with suspected seal pox (Figure 16). One at West of Cow on 04/09/2024 and one at Mill Giau on 07/09/2024.

Seal pox is a viral infection caused by a parapoxvirus, and it primarily affects young seals, leading to skin lesions and potential secondary infections. While the virus itself is rarely fatal, the stress and immune suppression caused by infection can increase a pup's vulnerability to other health issues, including malnutrition and opportunistic bacterial infections, which may indirectly contribute to mortality (Baker et al., 1995; Wilson et al., 2021).

Figure 16. Photo illustrating suspected seal pox on a juvenile grey seal at Mill Giau, Calf of Man on 07/09/2024. MWT. Calf of Man 2024.

Research on grey seal populations in the UK and other areas has indicated that seal pox infections are more prevalent in environments with high seal density, where close contact facilitates viral transmission. Pups, with their immature immune systems, are particularly susceptible. Seal pox is often associated with crowded rookeries where competition for resources is high, and environmental stressors such as pollution may weaken immune defences (Hammond et al., 2005; Thompson et al., 2010). However, the direct link between seal pox and pup mortality is less clear. Seal pox is not considered a primary cause of death in most cases, but when combined with other factors such as environmental contaminants (like PCBs), food scarcity, or poor maternal health, it can exacerbate the risk of death in vulnerable pups (Hall & Frame, 2010; Van Bressem et al., 2014). Continued research is needed to fully understand how seal pox interacts with other stressors to affect overall pup survival.

Within the season a total of three adult individual grey seals were found deceased, one in Leodan, one in South Harbour, and one in Amulty. The decomposing adult female in Leodan was first found on the 4th of September and remained within the site for over half of the surveying period. In South Harbour an adult male, in late decomposition, washed onto the beach on the 24th of September and remained within the site area once the surveyors left the island. The third adult death recorded was mother 669, a new mum to the island. Female 669 pupped on Amulty and gave birth to pup 93 on the 23rd of October. She was then later recorded, on the 1st of November, mating with a male outside of Amulty cave (Figure 17). A day later, 2nd of November, she was surveyed as de ceased via the thermal drone and found in the same position as the day before during mating. It is assumed that she drowned during the mating period from the male hauled on top resulting in an extended period underwater. However, this mortality left pup 93 orphaned and since the pup was only 9 days old at the time of the mothers death, a small stage 3 pup with low fat content, the pup would not survive without intervention.

On the 3rd of November a small rescue team, including the two seal volunteers and Manx Wildlife Trust Marine Officer, travelled over to the pupping site to attempt to retrieve pup 93. The collection was successful and the pup was sent to Manx Wildlife Trust Rehabilitation Centre, located on the Isle of Man (Figure 18).

Figure 17. An unidentified bull holding female (ID:669) submerged during mating at Amulty. 01/11/24. MWT. Calf of Man 2024.

Figure 18. Pup 93 on the harbour at Port St Mary, Isle of Man, enroute to Manx Wildlife Trust rehabilitation facility. 03/11/24. MWT. Calf of Man 2024.

Pup Distribution

As seen throughout survey years the areas of the Puddle, Cow Harbour and Grants Harbour were the most popular pupping sites in the 2024 season. Sites on the north of the island and in this sector 1 area (Figure 12) are considerably less affected by prevailing weather events than the south of the

island. This makes these areas much safer pupping sites as shown by a higher number of pups being born in the north of the island and sector 1 being the pupping site of 38.10% of all the pups born on the Calf in 2024. Females are believed to select pupping sites based on the habitat (Twiss et al., 2000) with habitat features such as low gradient shores, tidal pool presence, sea access and decreased tidal and storm-surge influences providing the optimal pupping location (Anderson et al., 1979; Twiss et al., 2001; Weitzman et al., 2017). Studies indicate that females are less likely to choose sites subject to flooding and storm surges (Allen, Bowen & den Hyer, 2022). Cow Harbour, Grants Harbour, South Harbour and the Puddle all saw the highest pup numbers this season and we can see these optimum habitat features exhibited in all of these sites with their low gradients, tidal-pools and easy access to the sea.

Two new pupping sites have been recorded on the north of the Calf of Man, extending the known pupping locations from 15 to 17 (Figure 19).

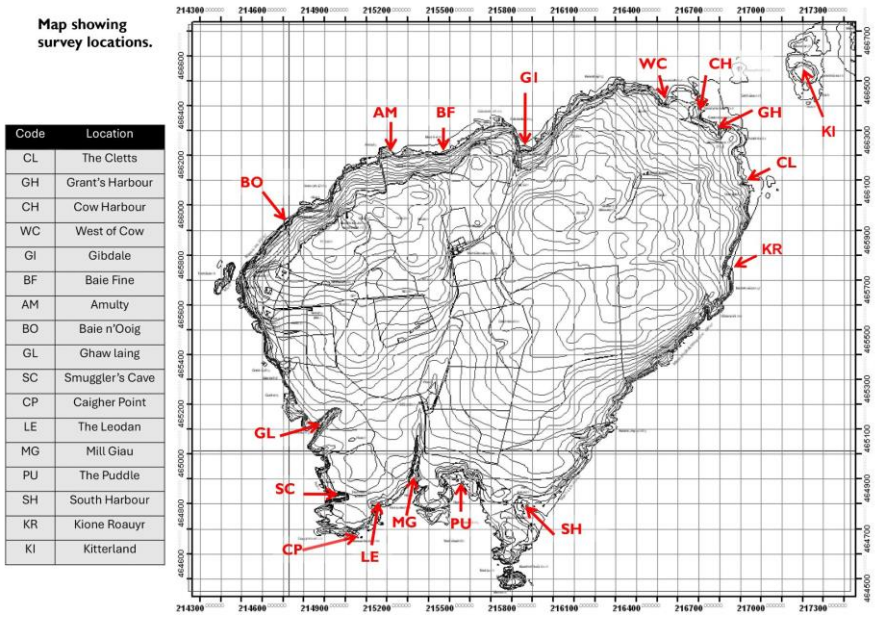

Figure 19. The new 2024 island site map showing the two additional puppings sites, Kione Roauyr & Kitterland.

These newly identified sites, known as Kione Roauyr, and Kitterland present unique challenges in terms of access, as Kione Roauyr is situated on steep cliffs with limited ground observation points and Kitterland is a separate islet surrounded by the fast-flowing currents of the Sound, a stretch of

water between the Calf of Man and the Isle of Man (Figure 20). As a result, both sites can only be reliably surveyed by drone.

Figure 20. The two new pupping sites during the 2024 season, Kione Roauyr (a) and Kitterland (b). MWT. Calf of Man 2024.

In September 2024, both sites were flagged by the seal surveyors as potential pupping sites due to their isolated location and suitable terrain for breeding seals. Monitoring of the area began on a bi-daily basis using drones as part of the northern survey, which included other established pupping sites. This approach allowed surveyors to efficiently observe the area and track any signs of pupping activity.

On 13th October 2024, the first breeding female grey seal was observed at Kione Roauyr. Sadly, she was seen with a stillborn pup. A second female was noted on 19th October 2024, also having given birth to a stillborn pup (Figure 21). Both females were new to the island's recorded breeding population, as neither was identified in Manx Wildlife Trust's existing catalogue of female seals. This indicates that these individuals are likely first-time mothers, highlighting the dynamic nature of seal populations on the island and possibly broader dispersal trends.

On 21st October 2024, a recently healthy newborn pup was discovered on Kitterland. Photographs by drone were taken of pup and mother and suckling was observed to confirm the relationship. The mother was identified as ID:646 from the 2024 Calf of Man breeding females' catalogue, who pupped on the Calf of Man at the Gidbale site in 2023. This pup was born during the storm Ashley which could be an influencing factor in why the mother has changed birthing site.

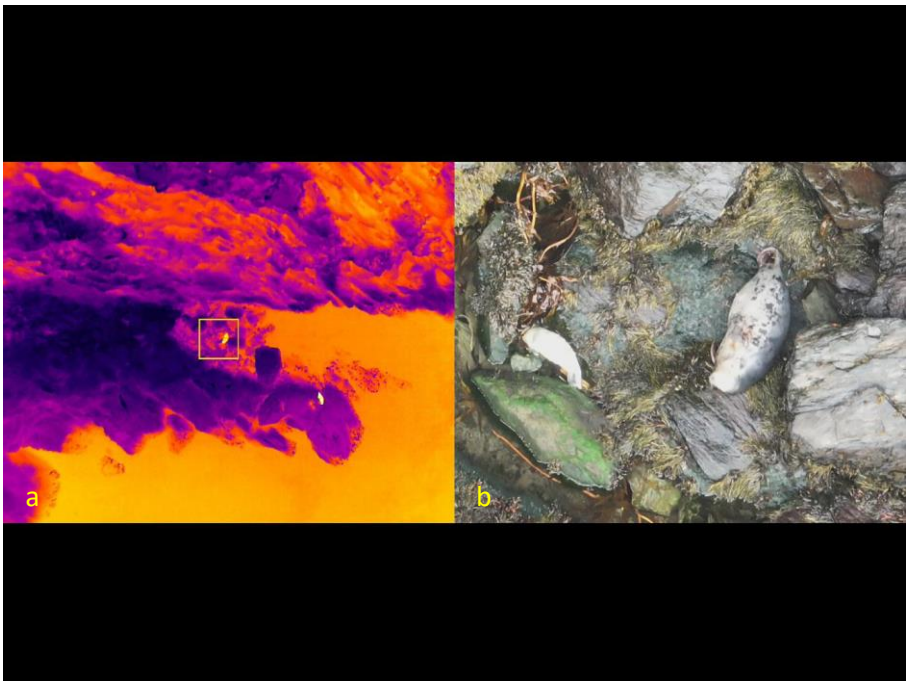

Figure 21. Thermal image (a)showing only one heat signature, confirming deceased pup. Standard photograph (b) of mother with deceased pup at Kione Roauyr. MWT. Calf of Man 2024.

Further study is required to evidence causation of stillborn on the island and the increase of pup mortality during the 2024 pupping season on the Calf of Man. However, the discovery of two new, likely inexperienced mothers at Kione Roauyr, combined with the stillborn pups, adds important data to our understanding of reproductive success in grey seals. Continued monitoring in the coming seasons will help determine whether both Kione Roauyr and Kitterland will develop into a successful breeding ground for seals in future years, and if these females return, contributing to our knowledge of seal fidelity to pupping sites.

The discovery of Kione Roauyr as a new pupping site emphasises the importance of continued drone-based monitoring, particularly in remote or difficult-to-access areas. In addition, this illustrates the added value in thermal imaging technology in the confirmation of proof of life when monitoring wildlife from safe distances. These results also underline the value of maintaining a comprehensive female seal catalogue for analysing patterns in site fidelity and breeding success. As our understanding of the island's grey seal population grows, this will enable more effective conservation strategies and management practices.

Some variants from previous survey data regarding pup distribution are due to improved observational methods at remote sites which are difficult to access by foot. KI and KR both hold no

previous recorded pup data, however this year due to deployment of the thermal drone, we were then able to regularly observe both sites. No effective observations are possible from observation points for either site, therefore previously only observable by boat surveys.

Site Fidelity

The average percentage of returning cows from the previous ten years (2012-2022) is 45% and annual variation is possibly the result of a combination of factors such as unknown dynamics in the seal population, developments in and access to photographic equipment and methods, observer skill, time availability and weather conditions. Historically on the Calf, looking at site fidelity on the Calf has focused on the number of different sites a female has used and the number of returning mothers at a specific site. In 2023 we decided to look at site fidelity in a different way, comparing whether returning mothers were using the same site or sector as their last pupping season. We replicated the sector method for the 2024 season. Over half of the 46 returning mothers used the exact same site as their last pupping season showing high levels of site fidelity across the Calf. Sites were also grouped into sectors under the belief there would be a higher number of returning mothers within a sector than to a specific site due to little distinction or separation to the site from the sea. This grouping of sites has been seen in other site fidelity studies on seal species (Baker et al., 1995). However, we saw a higher number of specific site fidelity which was not expected with a higher percentage of returning mums pupping in a completely new area than pupping within the same site. Site fidelity and choice in grey seals is not very well understood and there are conflicting theories to explain this behaviour (Giuggioli and Bartumeus, 2012).

During the 2024 seal pupping season on the Calf only 1 pup birth was recorded (ID:507 on 31/10/2024) at the Leodan (LE) pupping site. Last year 4 births were recorded between 25th September and 2nd November 2023. All 4 returning mothers who pupped at LE in 2023 were recorded birthing at alternative sites during 2024, namely ID:288, 503, 634, and 649. In 2024 ID:288 birthed at GL, ID:503 at AM, ID:634 at GI and ID:649 at PU. On the 4th September 2024 a deceased late-stage decomposition adult female grey seal was present at the entrance to the Leodan pupping site. Consideration was given as to ascertain if this was a contributing factor as to why returning mothers chose to give birth at alternative sites during the 2024 season.

Grey seals are known to be sensitive to environmental changes, particularly in relation to their breeding and pupping sites. Several factors could influence a female grey seal's decision not to give

birth at a site where a dead seal is present, rooted in both ecological and behavioural considerations. Seals are highly perceptive of olfactory and visual cues, which can indicate potential dangers or unsuitable conditions. The presence of a dead seal at a pupping site may trigger an instinctive avoidance response due to the potential association with disease or predation. Studies have shown that animals, including marine mammals, often avoid areas where they detect dead conspecifics, as this could signify a location of heightened risk (Wilson et al., 2017). While this behaviour has been observed in various species, grey seals likely follow a similar pattern of avoiding areas that are perceived as unsafe or compromised.

The presence of a deceased seal can also be perceived as a sign of disease, which could threaten the health of both the mother and her pup. Grey seals, like other pinnipeds, are susceptible to various infectious diseases, including viral and bacterial pathogens that can spread rapidly in colonies. The risk of transmission may be a significant deterrent, influencing a mother's decision to relocate to a safer site. This is consistent with findings in other colonial species, where mortality events can trigger avoidance behaviours to reduce the risk of disease transmission (Kovacs et al., 2012). In addition to this, the presence of a dead seal can create stress and disturbance within a group or colony, altering the behaviour of other seals and potentially deterring females from using the site for pupping. Research on pinnipeds has shown that stress can have significant impacts on reproductive success and survival rates (Engelhard et al., 2002). Therefore, a site where a death has occurred may become less attractive due to the heightened anxiety and altered group dynamics among the remaining individuals.

While there is limited direct research on grey seals avoiding pupping sites where dead individuals are present, similar behaviours have been documented in other species. For example, bottlenose dolphins (*Tursiops truncatus*) have been observed avoiding areas with dead conspecifics due to a presumed risk of contagion or predation (Bearzi et al., 2005). Additionally, observations in seal colonies have noted changes in haul-out behaviours when carcasses are present, indicating that the presence of death in the immediate environment influences site selection (Pomeroy et al., 2000). Further research specifically focused on grey seals could provide more concrete evidence of these avoidance behaviours, particularly in relation to their sensitive pupping periods.

All Island Census: Grey Seal Population on Calf of Man

During the 2024 grey seal pupping season, 5 island-wide drone surveys were conducted on the Calf of Man to assess the population of grey seals (adults and pups). These surveys mark a significant step forward in the use of advanced technology for wildlife monitoring, as the team employed a thermal imaging drone for the first time to conduct full island wide surveys. In previous years, island wide surveys were carried out by foot or alternatively by boat which were significantly more expensive and reliant on a third-party commercial operator. In addition to counting grey seals around and on the island, the survey also focused on identifying/assessing potential pupping sites.

Survey Methodology

This year's survey utilised a thermal imaging drone, a method previously untested for this purpose on the island. Several operational precautions were followed to ensure the success of the survey:

1. Communication and Safety: The pilot always maintained a suitable distance from the drone to ensure effective communication/transmission.
2. Elevation Requirements: The drone's altitude was kept above 50 metres above sea level (ASL) unless a specific investigatory need arose, and below the island's highest point +10m.
3. Battery Management: The aircraft's battery duration was closely monitored to guarantee safe return to the take-off point before depletion.
4. Signal Interruption Protocols: In the event of signal loss due to obstructions, the drone was programmed to automatically return to the take-off point.

The primary goal of this survey was to complete a comprehensive count of the grey seals across the island's entire coastline, including the smaller islets Thousla Rock and Kitterland.

The take-off and landing point for the drone was at Bushel's House (coordinates: 54.055851, -4.823895), the highest point on the island (127m ASL), selected for its optimal field of view. The survey team consisted of two members:

- Pilot: Responsible for the drone's take-off & landing, navigation, and camera recording.
- Spotter: Used to always keep the drone in sight, ensure awareness of any environmental changes and scribe notes on wildlife observations by pilot.

The team adhered to safety protocols throughout the survey, ensuring the drone maintained a safe distance from obstacles and followed the flight plan. Additionally, all personnel and visitors on the island were briefed on the survey and flight plan to ensure the safety of the operation. The drone flew over water within 50 metres of the shoreline, except when returning to the take-off point.

Survey 1: For the first whole island survey the method and operation was tested for viability and effectiveness. The entire coastline of Calf of Man was successfully surveyed over the course of three flights, necessitated by the drone's battery life. Each flight was conducted efficiently, with the drone returning to the take-off point for battery replacement when battery power reached 25%. It is recommended that future surveys program the drone to automatically return to take off point when it identifies that there is enough power reserve to return to home only. This is a programmable function.

The survey identified a total of 259 grey seals along the island's coastline. One newborn grey seal pup was observed at Gibdale Bay. Two previously unrecorded sites with potential for future seal pupping were identified—Kione Roauyr and Ghaw Yiarn. These locations had remained undetected in previous land-based surveys due to the island's topography, making them inaccessible from shore. These sites will now be incorporated into future aerial surveys.

The total survey duration, including walking from the observatory and setting up equipment, was 2 hours and 3 minutes. This represents a significant time saving compared to previous surveys conducted on foot, which require extended traversal of the island's cliff-top coastal pathways. The aerial survey greatly reduced risk to the surveyors, as they remained stationed at a single location, avoiding the hazardous terrain.

Survey 2: Since the first whole island drone survey on 13/09/2024, the seal team had identified a need to better understand the grey seal populations breeding productivity. It was proposed that the same protocols from the previous drone survey were followed with the addition of utilising the drones powerful zoom to differentiate each seal observed into one of four categories; 1. adult male, 2. adult female, 3. Juvenile/sub-adult, 4. pup. It was proposed this would extend the duration of the survey and additional battery resources.

This island survey was completed in 4 separate flights totalling 2.5 hours in duration. The survey identified a total of 308 grey seals along the island's coastline. Two newborn grey seal pups were

observed, one at GL and one at PU. These totals were broken down into the following categories: 34 adult males (11%), 203 adult females (65.9%), 24 juvenile/sub adults (7.8%), 47 pups (15.3%).

Survey 3: Surveyors completed the whole island survey and identified 456 grey seals. This is an island record for total grey seal numbers counted in one day. Surveyors were unable to acquire species category data due to logistics and weather.

Survey 4: The survey identified a total of 340 grey seals along the island's coastline. These totals were broken down into the following categories: 95 adult males (27.9%), 189 adult females (55.6%), 24 juvenile/sub adults (7.1%), 32 pups (9.4%).

Survey 5: The survey identified a total of 232 grey seals along the island's coastline. These totals were broken down into the following categories: 62 adult males (26.7%), 131 adult females (56.5%), 13 juvenile/sub adults (5.6%), 26 pups (11.2%).

Recommendations

The use of thermal imaging drones for seal population surveys has proven highly effective, offering both improved efficiency, enhanced safety and improved data accuracy. Based on the results of these surveys, the following recommendations are proposed:

1. Battery Management: Set the drone to automatically return to home when the aircraft identifies it only has enough battery resource to return to take off point. This is a programmable function.
2. Extended Survey Routes: Future surveys should include the newly identified potential pupping sites at Kione Roauyr and Ghaw Yiarn, ensuring comprehensive coverage of the island's seal population.
3. Category Individuals: Record seal observations to account for number of adult males, adult females, juvenile/sub-adults, and pups. This will inform population dynamics and breeding productivity for the island's transient seal population.

The application of thermal drone technology for island wide wildlife monitoring on Calf of Man has delivered significant benefits, including reduced survey time, increased safety for the team, discovery of newborn pups, categorisation of breeding adults, and the discovery of previously unknown pupping sites. This method not only enhances the efficiency of seal population

assessments but also demonstrates potential for wider applications in wildlife surveys across difficult-to-access areas. This innovative approach will continue to improve the accuracy and safety of wildlife monitoring operations on the island.

Birthday Analysis

There has been concern that pupping season is moving forward as global temperatures shift, with previous survey results showing individual more experienced mothers pupping earlier each year. A trend seen in a number of species, with these shifts recognised as an impact of climate change (Root et al., 2003). Studies have found advancements in the pupping season of up to seven days in response to a temperature increase of 2˚C (Bull et al., 2021). Conversely, in 2023 we saw 79% of the mothers that had pupped in 2022 pupped later in 2023. It is considered that this was due to an increase of severe storm events during the 2023 season.

In 2024, the pattern of early birthing has returned with 51% of returning mothers pupping earlier than the previous year. The majority of the early pupping mothers were known experienced individuals returning to the island. Of the 34% late pupping mothers, the majority were new or inexperienced mothers. One individual breeding female (ID:634) has been observed over a 2 year period (2023 and 2024) mating earlier. Commonly a mother will mate when their pup is weaning, often leaving the pup to fend for themselves independently after mating is complete. In both years she was observed mating whilst her pup was early stage 3 and continued to suckle until her pup reached weaning weight. This may account for an earlier birthdate each year, shifting her to birthing before the storms arrive.

Drone - Unmanned Aircraft System (UAS)

The use of drones in wildlife conservation has been a game-changer for conservationists and researchers. Drones provide a quick, easy, and cost-effective way to monitor wildlife from a distance. They can be used to track animal movement and behaviour, observe species in hard-to-reach areas, and identify illegal hunting and poaching in remote areas inaccessible by foot or road. Additionally, drones are being used to monitor the health and condition of wildlife, as well as to count and identify individual animals. Drones are also being used to assess habitat health, monitor environmental conditions, and detect changes in the environment. We utilised drone technology during the 2023 and 2024 season with the aim to access additional areas of the island's coastline which have previously had limited or no observation opportunities due to geographical constraints. During the 2024 season we found that the thermal drone deployments proved to be an effective method which led to:

1. Discovery of multiple new born pups in remote areas
2. Evidenced 2x new pupping sites within the Calf and Wart Bank Marine Nature Reserve
3. Located lost pups after storms events
4. Evidenced seal injury and welfare concerns across numerous sites
5. Confirmation of deceased seals
6. Improved data accuracy and collection capability
7. Reduced risk in ground surveying operations
8. Assisted with avian research regarding ground nesting birds and sea cave surveys

Further reading in Appendix A - The Role of Thermal Imaging Drones 2024

Additional Observations

Disturbance

In 2024, 12 notable disturbances were recorded during the season, outlined in the table below. Disturbance information was recorded in 2024 at SH, and GH specifically to identify potential impact on seals with pups in close proximity to the scheduled supply boat and commercial operators docking points. Out of 10 observations (9 SH, 1 CH) of the vessels docking on the Calf of Man, 8 led to disturbances of seals. As the boat is an essential resource to island operations as a re-stock supply vessel and docking is limited to tidal variants little can be done to minimise these occurrences when seals are using the harbours as pupping sites. However, additional docking was observed during

September due to fair weather, and this saw an increase of paying day visitors on the island in 2024 (218 visitors) compared to 2023 (199 visitors). Briefings by volunteer seal surveyors were introduced during the 2024 season (Figure 22). These briefs consisted of; location of seals in the area and advice on minimising impact on them, keeping a safe and appropriate distance from wildlife, keeping only to official paths and awareness of filming on the island for the purposes of monitoring wildlife. These briefs were also given to the boat skipper and all personnel assisting with the supply movements and day visitor movements.

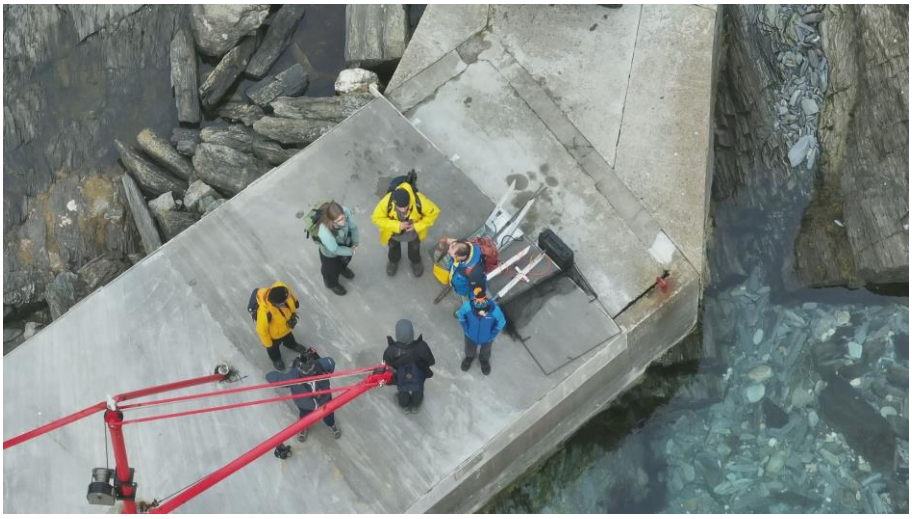

Figure 22. Volunteer Seal Surveyor holding a briefing with day visitors. 29/10/2024. MWT. Calf of Man 2024.

Table 2. Seal disturbance on the Calf in 2024

Date	Time	Site	Type	Severity	Comment
19/09/24	11:59	CH	Kayak x2	2	2x kayakers circumnavigated the island. At CH, 1x kayaker disturbed 1x grey seal in the water and flushed another from the rocks. Disturbance was brief as the kayakers then left the area to return to the main island. No pups present at this location on this date.
19/09/24	13:12	GH	Motorboat (Island supply boat and commercial operator)	1	A commercial boat approached GH to pick up day visitors, prompting an adult female seal (ID 652) and her pup (P06, born 10/09/24) to enter the water during high tide. The mother temporarily left the pup to investigate the boat, then returned to place the pup at the back of a cave, staying on guard until the boat departed. Once she confirmed

					the boat had left the dock, the female seal brought the pup back into the open cave gully. The disturbance lasted 11 minutes. One pup was observed at this location on this date.
21/09/24	09:58	Thousla Rock	Kayak x7	2	X7 kayakers in a group paddled close to Thoulsa rock. 20+ grey seals flushed into the water. No seals remained hauled out on the South side of Thousla rock post disturbance event.
21/09/24	10:01	Kitterland	Kayak x11	2	X11 kayakers in a group paddled close to the rocks on Kitterland. 5+ grey seals flushed into the water.
21/09/24	11:45	SH	Motorboat (Island supply boat and commercial operator)	2	A commercial boat arrived at SH to deliver paying day visitors to the island. The skipper and his assistant guided the visitors around a seal and pup at 11:45 to minimise disturbance. However, at 12:45, two visitors passed within 6 metres of the seals, causing the adult seal to move toward her pup on both occasions. The boat later moved to GH dock to pick up the remaining visitors.
24/09/24	15:11	SH	Motorboat (Island supply boat and commercial operator)	1	Island personnel parked a Polaris vehicle and a tractor with a trailer at the dock. A boat arrived, and water bottles, logs, and kit were unloaded into the vehicles, while waste and other items were loaded onto the boat. The process took about 30 minutes, with humans working within 5 metres of two mother-pup seal pairs on either side of the dock. Despite the proximity, there was only minor disturbance, and one adult and pup seal continued to rest and suckle, unaffected by the activity. Observation was maintained throughout.
28/09/24	09:46	SH	Motorboat (Island supply boat and commercial operator)	1	A tractor with a trailer was driven onto the SH dock, where a boat arrived and docked. Personnel and boat staff transferred kit from the vehicles to the boat, a process lasting about 20 minutes. Three mother-pup seal pairs and one bull grey seal were in close proximity to the dock. Although the seals observed the human activity, they did not move or react, aside from lifting their heads. Suckling and resting behaviours continued uninterrupted.

01/10/24	10:34	SH	Rib	3	A rib arrived at the SH dock as a tractor and trailer also drove onto it, causing seal 302 to move rapidly between her pup and an exit route before ultimately abandoning her pup. The rib left the dock, but as the tractor reversed, 302 entered the water, triggering seal 223 to do the same, also abandoning her pup. This led to a fight between 223 and 502, who was in the water near her pup. Seal 223 returned to her pup on land three minutes later. At 10:45, a supply boat arrived with day visitors, and 302 attempted to return to her pup via 2 different routes but was deterred by human activity and seal 502 at the waterline. She eventually reunited with her pup at 10:58 by a third route, navigating over steep rocks. The boat remained at the dock until the day visitors left at 13:50.
02/10/24	10:48	SH	Motorboat (Island supply boat and commercial operator)	3	Supply boat arrived at SH dock at 10:48 with day visitors. Volunteer seal surveyors briefed the day visitors on a particular aggressive adult female (ID:302) with pup beside the dock. They were also advised about drone and camera traps used on the island and to keep to paths at all times. Visitors ran past the female seal to avoid contact as she was lunging towards them on approach. She settled after the visitors had left.
09/10/24	12:10	SH	Motorboat (Island supply boat and commercial operator)	2	At 12:10 a pup was observed resting on the SH dock. The boat was due to arrive at the dock at 12:45. Estate wardens and Seal surveyors encouraged the pup to move off the dock and onto the beach. This disrupted adult female seal (302) who was with her pup beside the dock. All seals settled after the team left. A new pup was born on the beach at 10:30hrs. Unfortunately, this was a stillborn pup. The boat arrived at 13:31hrs with a visitor from Manx National Heritage (MNH) and a guest. On arrival the MNH guest scrambled over the rocks to take photographs of the harbour and flushed 4 seals into the water.

22/10/24	12:43	SH	Motorboat (Island supply boat and commercial operator)	3	Boat arrived at SH dock at 12:43. A new pup and mother were on the rocks on the main beach. As the boat skipper ran from his boat to the mooring ring above the rocks, the adult female seal was triggered and flushed into the water. This was a stage 2 pup abandonment. At stage 2 if the pup does not receive regular feeds from its mother, it is unlikely to survive. Fortunately, the following morning after 20 hours of absence, the mother returned to her pup and continued suckling.
02/11/2024	10:22	CH	Paddleboarder	2	Paddleboarder approached mother and pup at Cow Harbour to observe them. As a result, a total of 6 seals were impacted by his presence. Mother of the pup showed increased vigilance, stress and defensive behaviour in response to his approach to the pup.

Level of disturbance: 1 = mild vigilance (increased vigilance, lifting of heads); 2 = Seals enter water in response to perceived threat or physically move away; 3 = severe response (involving abandonment of pup or similar).

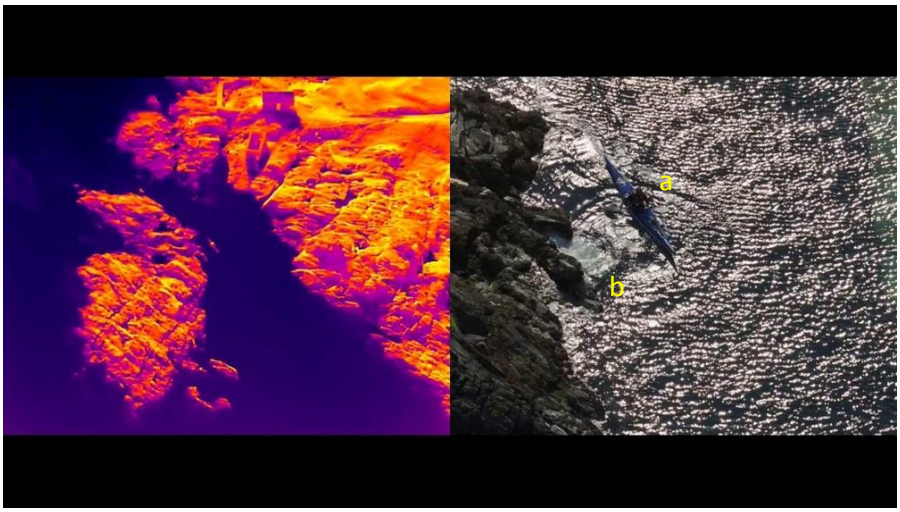

Figure 23. Kayaker (a) at Cow Harbour triggering a grey seal (b) flushing into the water. 19/09/24. MWT. Calf of Man 2024.

Figure 24. Commercial boat leaving GH. Adult female grey seal in protective position in entrance to cave gully (a), seal pup out of view inside cave (b). 19/09/24. MWT. Calf of Man 2024.

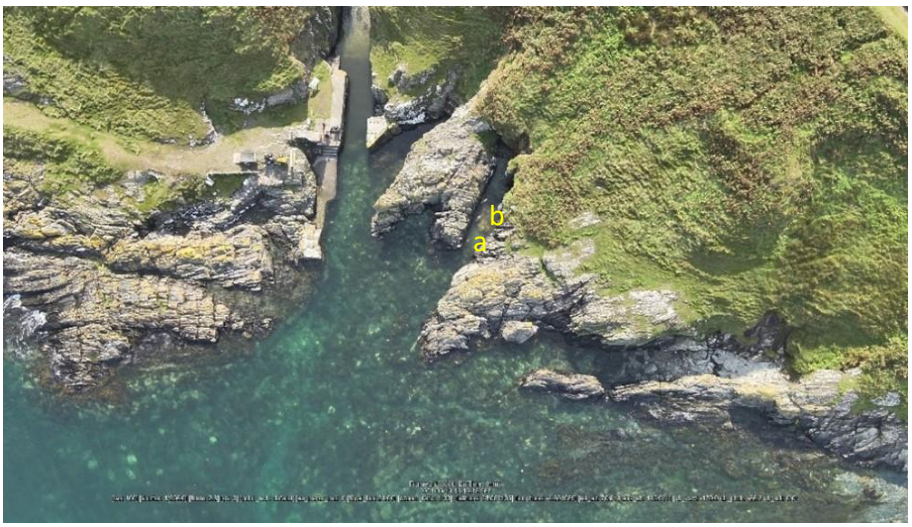

Figure 25. Adult female grey seal (a) and pup (b) returned to pre-disturbance positions in the mouth of cave gully. 19/09/24. MWT. Calf of Man 2024.

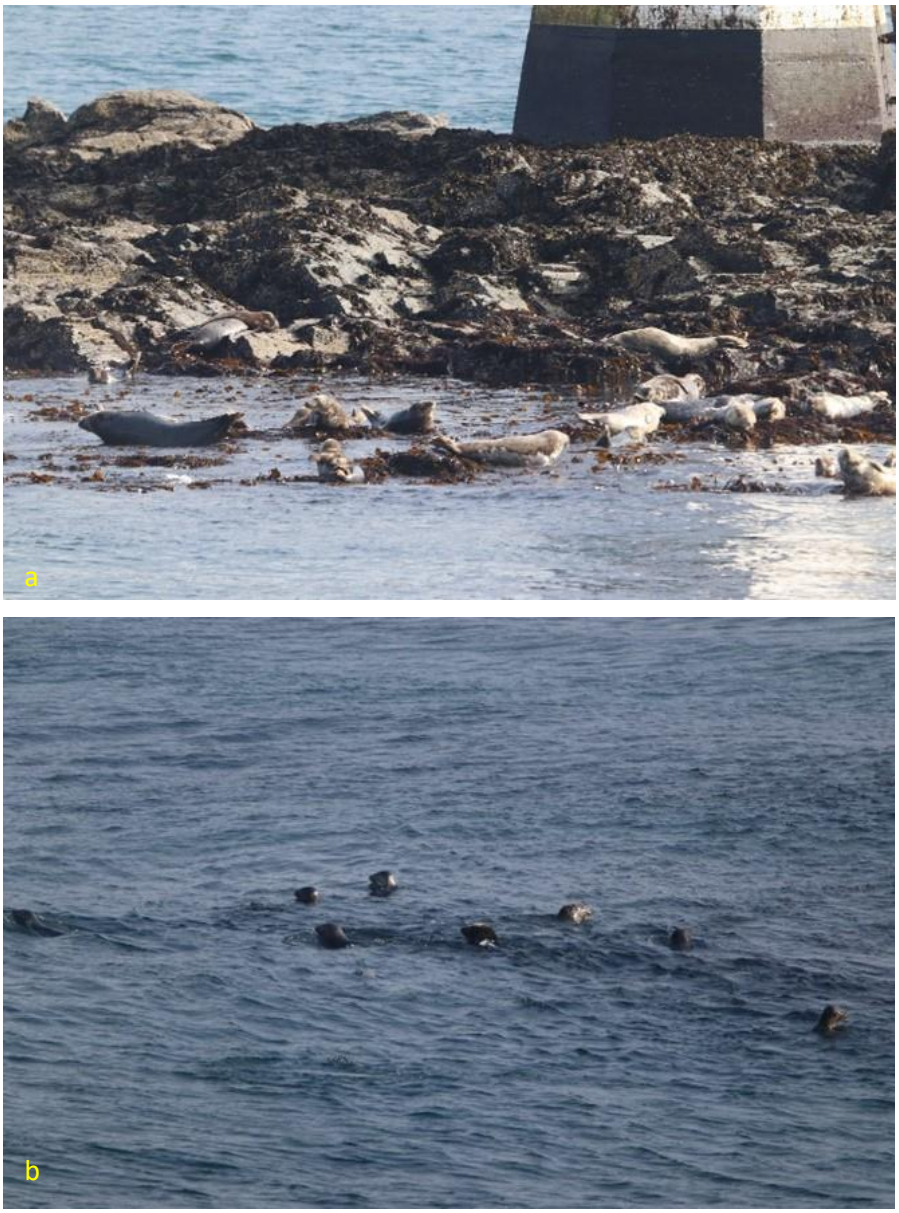

Figure 26. Grey seals hauled out on Thousla rock minutes before the kayakers arrived (a) and eight of the flushed grey seals in the water presenting high vigilance and stress, after the kayakers had passed (b). 21/09/24. MWT. Calf of Man 2024.

Figure 27. Kayak group arrive at Kitterland. 21/09/24. MWT. Calf of Man 2024.

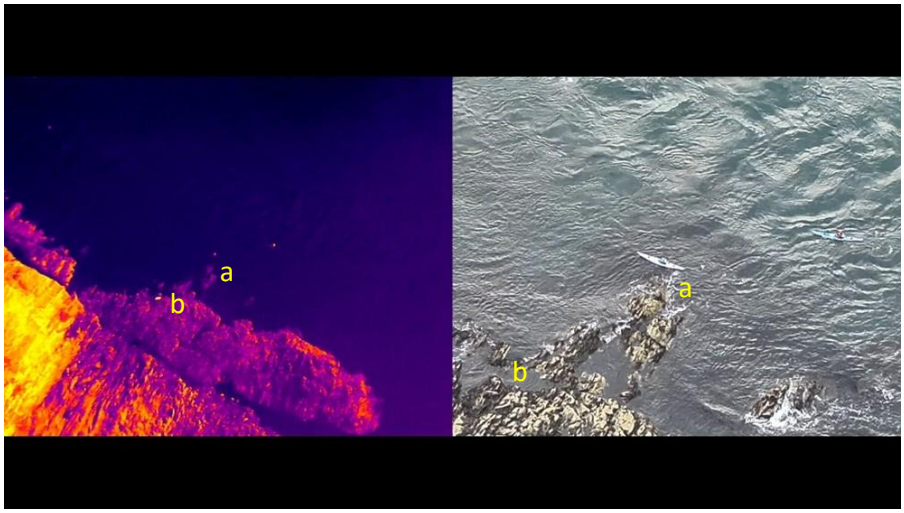

Figure 28. Thermal and standard drone imagery showing kayakers (a) at Kitterland in close proximity to hauled out grey seals (b). 21/09/24. MWT. Calf of Man 2024.

Figure 29. Camera trap image showing visitors arriving at 11:45, aware of the adult grey seal and her pup (a). 21/09/24. MWT. Calf of Man 2024.

Figure 30. High elevation drone image (on full zoom) showing x2 visitors (a) returning to the harbour dock at 12:45, aware of the adult grey seal and her pup (b). 21/09/24. MWT. Calf of Man 2024.

Figure 31. Two island personnel (a) moving delivery from the supply boat to the vehicles in close proximity to suckling grey seals (b). 24/09/24. MWT. Calf of Man 2024.

Figure 32. Camera trap image showing day visitor (a) running past aggressive adult female seal ID:302 (b) beside dock. 02/10/24. MWT. Calf of Man 2024.

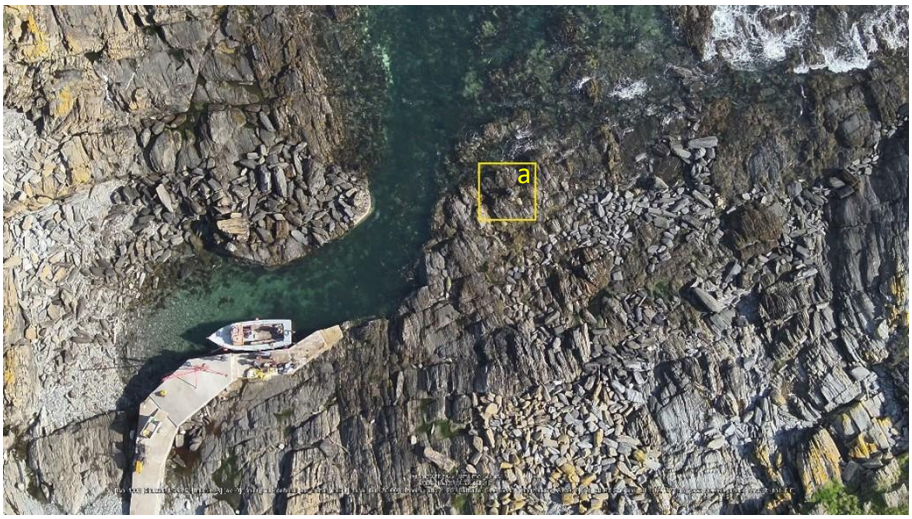

Figure 33. MNH guest (a) on rocks after flushing seals into the water. 09/10/24. MWT. Calf of Man 2024.

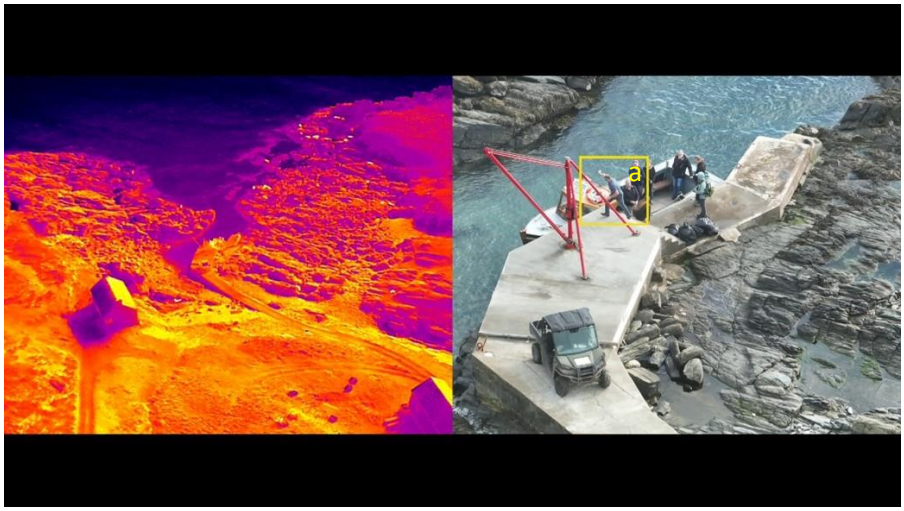

Figure 34. Boat skipper (a) running towards mooring ring above mother and pup grey seal on the rocks below. 22/10/24. MWT. Calf of Man 2024.

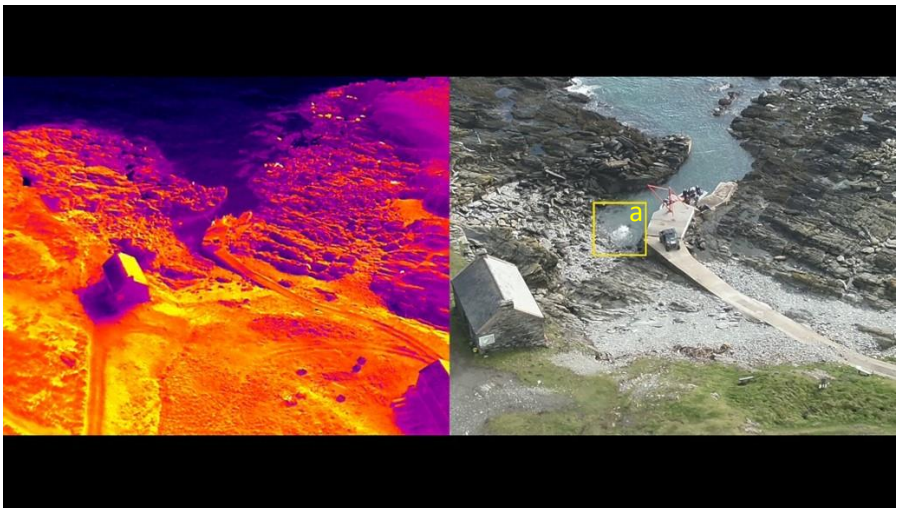

Figure 35. Grey Seal mother (a) entering the water during disturbance. 22/10/24. MWT. Calf of Man 2024.

Figure 36. Paddleboarder (a) approaching mother and pup grey seal (b) at Cow Harbour. 02/11/24.

Based on the observed disturbances in 2024, the following suggestions are proposed, aimed at reducing future impacts on the grey seal populations during the 2025 season.

1. Expand and Strengthen Visitor and Staff Briefings:
    - Enhance briefings with documentation and visual aids, such as maps and photos showing path routes and any notable areas, to make visitors more aware of seal-sensitive areas. Increase signage and install informative boards near docking points and along pathways to remind visitors of safe distances and potential impacts of disturbance.

- Build on existing briefings by conducting formal training sessions for skippers, crew, and personnel involved in supply and visitor movements. Cover topics such as seal behaviour and stress responses to better equip personnel in minimising disturbances.

2. Improved communication between island team and commercial boat operators:
    - Commercial operators visiting the island, to inform the island team in advance as to timings and docking schedule and to include day visitor numbers.
3. Introduce a nominal docking fee for commercial operations:
    - This small amount can be paid by the commercial operators via an account system at the end of the season and funds raised can be reinvested in signage and project upkeep.
4. Increase Monitoring and Data Collection:
    - Deploy more robust monitoring by volunteer seal surveyors during high-risk periods. Data on timing, location, and type of disturbance should be meticulously recorded to further understand disturbance patterns and make data-driven adjustments to visitor guidelines and docking schedules.
5. Implement Alternative Viewing Options:
    - Introduce designated viewing points away from critical seal areas, allowing visitors to observe wildlife at safe distances. Increase the use of wildlife cameras/live streams to provide educational content that visitors can access online or at MWT visitor/information centres, reducing the need for close contact.
6. Consider Seasonal Zoning of Harbour Access:
    - Designate certain zones within the harbours and hot spot areas as seasonal “seal zones” during the pupping period to encourage greater spatial separation between human activity and pupping sites. This can be focussed on discouraging kayakers from passing too close to the rocks when circumnavigating and/or visiting the island.

The use of ‘positive conservation messaging’ is key to achieving effective communication both in public documentation and in person briefings. Most effective methods from conservation project strategy suggest a move away from the authoritative ‘dos and don’ts’ approach and focus on a positive ‘lifestyle and enjoyment’ approach to influence behaviour change (example visitors briefing sheet in Appendix C).

Implementing these strategies could help mitigate the observed disturbances from 2024, reducing stress on the seal population while maintaining essential island operations and a more regulated visitor experience.

Live Web Camera

This was the first season to have utilised a live web camera, generating live video feed to Manx Wildlife Trust website. The initial purpose of the camera was to monitor the breeding populations of Manx Shearwater, *Puffinus puffinus*, within the Cletts site. The camera was later moved into the main beach of Cow Harbour for the purpose of the seal pupping season. The camera has provided a significant positive benefit to outreach and engagement, allowing the general public to view the beach at any time. This was especially significant when the first pup was born on Cow Harbour. We used two social media platforms, Instagram and Facebook, on both Manx Wildlife Trust and the Calf of Man Bird Observatory accounts. The social media posts did not only advertise the use of the live camera but it also engaged the general public with a seal pup naming competition. This brought further engagement to the post which encouraged people to watch the pup on the live camera. While it is recommended that the location of pups should not be disclosed; this is not an issue for the Calf since it is a remote island making it harder for people to distress pupping sites and local people will recognise the location of the pupping site through the live camera regardless.

Brown Rat observations during seal pupping season 2024.

As a registered UK Bird Observatory, the Calf of Man is a renowned destination for breeding seabirds and temporary landfall for spring and autumn migrating birds. The island used to be home to thousands of Manx shearwaters, burrow-nesting seabirds that come ashore to their young at night, until brown rats (*Rattus norvegicus*) landed on the island in the late 1700s. Brown rats all but wiped out the huge Manx shearwater colony.

Over the winter season 2012/2013 a team from Manx National Heritage, Manx Wildlife Trust, Manx Birdlife, the Department of Environment, Food and Agriculture, the UK's Food and Environment Research Agency and the Royal Society for the Protection of Birds came together in a joint effort to eliminate rats from the Calf of Man. The ongoing project aims to make the Calf safer for nesting seabirds and encourage the resurgence of the Manx Shearwater colony. Since the project was introduced over 1000 pairs of Manx Shearwaters have returned to successfully breed on the island.

However, despite these control measures, the predatory rats have remained a threat to ground-nesting seabirds and their chicks.

To evidence the presence and abundance of brown rat, the estate team currently manage a system of 100 non-lethal bait indicators over two strategic sections of the island and operate 30 remote camera traps island wide.

Every autumn, grey seals return to the island to give birth, making the pupping season a period of significant ecological activity. Interestingly, an increase in brown rat observations around these seal birthing sites has been recorded.

Brown rats are highly adaptable, omnivorous scavengers, known to exploit a wide range of food sources (Meehan, 1984). On islands like the Calf of Man, where food can be limited during certain times of the year, seasonal events like grey seal pupping provide a temporary but abundant source of nutrition. Grey seals give birth in large colonies, and the combination of birthing by-products (e.g., afterbirth, placental tissue) and the mortality rate of pups creates food opportunities for scavengers. Previous studies have documented similar behaviour in other scavenger species during pupping seasons, including seabirds such as greater black backed gulls and corvids.

Figure 36. Remote camera trap showing brown rat at MG on 20/09/2024 20:32. There were two pups born on this beach on this date. MWT. Calf of Man 2024.

Camera trap data collected during grey seal pupping season 2024 on the Calf of Man has shown an increase in the presence of brown rat activity on beaches in close proximity to the seal pupping sites.

Similar patterns of rat abundance in relation to marine mammal colonies have been observed elsewhere. On islands off the coast of New Zealand, brown rats were found to be more numerous around sea lion pupping sites due to the availability of afterbirth and deceased pups (King, 2005).

Figure 37. Remote camera trap showing brown rat at CH on 29/09/2024 03:12. There were two pups born on this beach on this date. MWT. Calf of Man 2024.

The Calf of Man estate team have been investigating the rat activity with a hypothesis that individual brown rats are accessing the island independently via the Sound from Kitterland and the Isle of Man. The observations of brown rats during seal pupping season on the island raises important questions about the broader ecological impacts on the Calf of Man's ecosystem. Brown rats are known to be invasive species on islands, often disrupting native species populations (Atkinson, 1985). The long-term implications for other species on the island, such as ground-nesting birds, could be detrimental. Increased rat numbers may lead to competition for resources and predation on vulnerable native fauna. The availability of abundant food sources during the seal pupping season could enable brown rat populations to grow beyond their usual capacity, potentially exacerbating their impact on the island's ecosystem outside of the pupping season. Understanding this dynamic is essential for managing both the grey seal populations and mitigating the effects of invasive species like the brown rat and prompt potential revisions of biosecurity protocols for the island.

Tagged Seals

During the 2024 season two tagged seal were identified on the island shown in Figures 38 & 39 below.

Figure 38. Seal observed at Cow Harbour with identification tag 122. MWT. Calf of Man. 2024.

Figure 39. Seal observed at Cow Harbour with identification tag 364. MWT. Calf of Man. 2024.

The first seal was observed at CH (03/09/2024) with a rear flipper plastic tag (122). This individual was released by Exploris Aquarium Seal Sanctuary in Portaferry, Northern Ireland. We are awaiting updates on release date data. The second seal was also observed at CH (05/11/2024) with rear flipper tag (364). This individual was released in Cornwall by British Divers Marine Life Rescue in 2019. The third Cornwall/Isle of Man grey seal link up to date.

Entanglements

During the 2024 season one entangled seal was identified on the island shown in Figure 40 below.

Figure 40. Seal observed at Baie n'Ooig with monofilament gill net entanglement around the neck area. MWT. Calf of Man. 2024.

This individual (ID:654) gave birth to her pup (P19) at Baie n'Ooig on 23/09/2024. Both Pup and mother survived, last seen at this location 28/10/2024.

Future Research

During the 2024 seal pupping season two main areas of future research have been identified;

A. Study of Mother/Pup Bonding Behaviours, Leading to Further Study of the Impact of Bonding Behaviours on Pup Mortality

B. Study of Genetic Diversity and Breeding Behaviours of Grey Seals on the Calf of Man

A. Mother and pup bonding behaviours – Key Questions:

1. Frequency of Pup-Initiated Interaction:
    - How often do seal pups initiate interaction with their mother versus other pups? This question aims to investigate the pup's role in fostering the mother-pup bond, as well as its social dynamics with other pups. Understanding these frequencies could

reveal important patterns in the pups' social and cognitive development and how peer interactions may supplement maternal care.

2. Frequency of Mother-Initiated Interaction:
    - How often do mothers initiate interaction with their pups? Maternal behaviour is central to pup survival, as it ensures access to food, protection, and guidance. By examining the frequency of mother-led interactions, this study will help determine how actively mothers engage in maintaining the bond, which may have implications for pup health and development.
3. Vocalization Patterns:
    - How often do pups vocalise?
    - What different vocalisations are there? Vocal communication plays a significant role in mother-pup interactions, particularly in reuniting after separation. Studying vocalisation patterns can provide insight into the emotional or physical states of the pups and their communicative strategies, which may influence maternal responsiveness.
4. Maternal Response to Vocalisations:
    - How often does the mother respond to her pup's vocalisations? Investigating maternal responses to pup calls can help assess the strength of the bond and the mother's attentiveness. A high level of responsiveness might indicate a strong protective instinct, while lower responsiveness could reflect stress, fatigue, or environmental pressures.
5. Water-Based Interaction:
    - How common is it for a mother to take her pup into the water?
    - When mothers take their pups into the water, how long do they stay in the water with them? Understanding how often and under what circumstances mothers lead their pups into the water is important for assessing the role of water-based interactions in pup development, particularly in relation to swimming skills, foraging behaviour, and the timing of weaning.
6. Socialising and Play Behaviours:
    - Other than feeding, are there any socialising or play behaviours observed between mother and pup? Play behaviour can be an essential part of early development, contributing to motor skills, social learning, and bonding. This question aims to

explore the extent and significance of non-nutritive interactions between mother and pup.

7. Pup Activity and Independence:
    - Is a pup that presents high interaction/activity during the first 3 growth stages more likely or less likely to become independent earlier than non-interactive/active pups? High levels of interaction or activity may indicate strong physical development, or an advanced social skill set, potentially leading to earlier independence. Alternatively, it may also suggest increased risk-taking behaviour, influencing mortality rates. This question will help assess how early developmental traits predict later outcomes.
8. Protective Zone Dynamics:
    - What size is the protective zone a mother keeps around her pup?
    - What are the variables that impact the size of this protective zone? Seal mothers often maintain a "protective zone" around their pups, deterring threats from other animals or conspecifics. Understanding the size and enforcement of this zone, as well as the factors that influence it (e.g., proximity to other seals, human disturbance, environmental conditions), can provide insights into maternal strategies for pup protection.

The findings from this study will be instrumental in identifying key bonding behaviours that influence pup survival. The correlation between interaction patterns and pup mortality can provide valuable insights into the critical factors affecting early pup development, such as maternal investment, social behaviour, and environmental pressures. This research has direct implications for wildlife management, conservation strategies, and habitat protection, especially in regions where human activities intersect with seal populations.

This research aims to contribute to the growing body of knowledge on seal behavioural ecology, particularly focusing on the complexities of mother-pup bonding. The insights gained could inform broader conservation strategies that prioritise the protection of critical habitats, minimise human disturbances, and ultimately enhance the survival rates of seal populations in the face of environmental and anthropogenic challenges.

B. Genetic Diversity and breeding behaviours of the Island Population – Key Questions:

1. How genetically diverse is the grey seal population on the island?

- Understanding the genetic diversity of the breeding population is crucial for assessing the long-term viability of the species on the island. Genetic diversity impacts the population's resilience to disease, environmental changes, and other pressures, making this a key area of study in conservation.

2. Proportion of Breeding Age Males and Females:
   - What is the proportion of breeding age males and females within the grey seal population on the island?
   - This question will explore the sex ratio dynamics and their implications for breeding success, competition among males, and the overall reproductive output of the population.
3. Returning Breeding Females:
   - Investigating further the factors that contribute to female site fidelity, including habitat quality, predation risks, and human disturbance, will help understand the stability and growth of the breeding population.
4. Beach Master Tenure:
   - What is the average tenure of a beach master during the pupping season at any given site?
   - The tenure of dominant males (beach masters) at specific sites during the pupping season plays a key role in reproductive success. Longer tenures could indicate dominance, better access to females, and a higher likelihood of passing on their genes. This question aims to quantify beach master stability and the factors that influence it.
5. Challenges to the Beach Master:
   - How often is the beach master challenged by another breeding male?
   - Breeding males often face competition from other males, which can lead to fights and displacement. This question will assess the frequency of these challenges and how they impact the breeding success of both the beach master and rival males.
6. Post-Mating Behaviour of the Beach Master:
   - Once the beach master has mated at his site, does he:
     1. (a) Stay at the same site?
     2. (b) Move to another site?
     3. (c) Rest away from breeding females
   - This question will explore the post-mating strategies of beach masters and how these behaviours influence their future reproductive opportunities, energy expenditure, and

interactions with other males. Understanding this behaviour could inform the balance between mating efforts and maintaining dominance during the breeding season.

This study will combine behavioural observations, population surveys, and genetic analysis to assess the breeding dynamics and genetic health of the grey seal population on the island. The results will provide insights into population structure, mating competition, and the factors driving reproductive success, all of which are critical for conservation management.

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Appendix

Appendix A - The Role of Thermal Imaging Drones 2024

Conservation studies of grey seals (*Halichoerus grypus*), especially in terms of monitoring populations and breeding success, are essential for understanding the health and stability of marine ecosystems. Traditional survey methods involving ground-based teams with handheld long lenses have long been the standard approach. However, recent technological advancements, particularly the deployment of thermal imaging drones, offer significant improvements over conventional methodologies. During the 2024 Calf of Man grey seal pupping season, Manx Wildlife Trust (MWT) deployed a DJI Mavic 3T drone for the purpose of surveying grey seals. The following text discusses the benefits of thermal drones in the context of grey seal population studies, demonstrating how they enhance data collection, reduce disturbance, increase safety, and improve efficiency.

Reducing Seal Disturbance: A Crucial Factor in Wildlife Surveys

Minimising disturbance to wildlife during surveys is paramount in ensuring the accuracy of the data collected. Grey seals, like many other marine mammals, are highly sensitive to human presence, particularly during critical times such as the pupping season. Disturbances can cause seals to abandon their young, disrupt breeding activities, and alter behaviour in ways that may skew research results (Bishop et al., 2015). Traditional survey methods require researchers to approach seal colonies on foot or by boat, often within proximity that can cause stress to the animals.

In contrast, drones such as the DJI Mavic 3T allow for data collection at significant distances, mitigating the need for close human contact. A study by Pomeroy et al. (2015) demonstrated that using drones at altitudes of 50–100 metres over seal colonies resulted in minimal behavioural changes, compared to the pronounced disturbances caused by humans on foot. The thermal imaging capabilities of drones enable researchers to identify and count seals through their heat signatures from an unobtrusive distance, even in poor visibility conditions. This ensures seals are not disturbed, leading to more accurate behavioural observations and population counts.

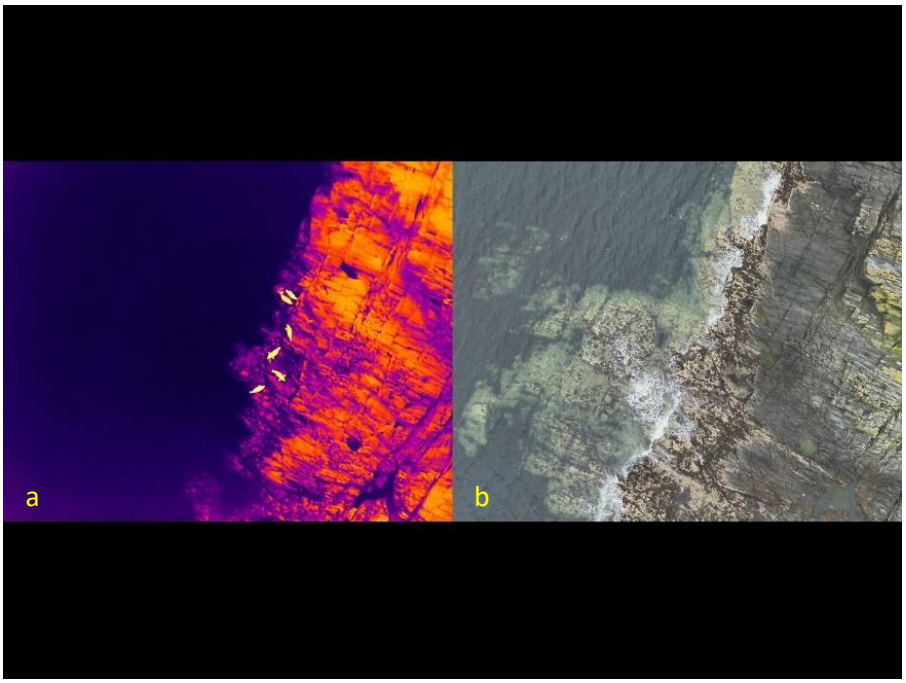

Fig 1. Simultaneous thermal (a) and standard (b) digital drone images taken at elevation exceeding 50m, comparing the effectiveness of grey seal location identification. MWT. Calf of Man 2024.

Enhancing Safety for Researchers in Remote and Hazardous Areas

Surveying grey seals often involves accessing remote coastal environments, which can be dangerous due to rugged terrain, slippery rocks, and harsh weather conditions. Researchers working in these areas face significant risks, from physical injury due to falls to sudden changes in tides, which can trap surveyors in difficult-to-reach locations (Sayer, 2020). The need to manually traverse rocky beaches or unstable cliffs also increases fatigue, which can impact data collection quality.

Thermal imaging drones offer a solution, in part, to these safety concerns. The drone's ability to cover large areas from a safe distance eliminates the need for surveyors to physically approach hazardous locations. Instead, researchers can conduct aerial surveys from stable vantage points, greatly reducing the risk of injury. For example, in a study conducted on the Farne Islands, drone-based surveys allowed researchers to avoid dangerous rocky outcrops while still obtaining comprehensive data on seal populations (Johnston, 2019). Furthermore, the drone's advanced stability features and intuitive controls mean that even in high winds or difficult weather conditions, surveyors can safely gather data without putting themselves at risk.

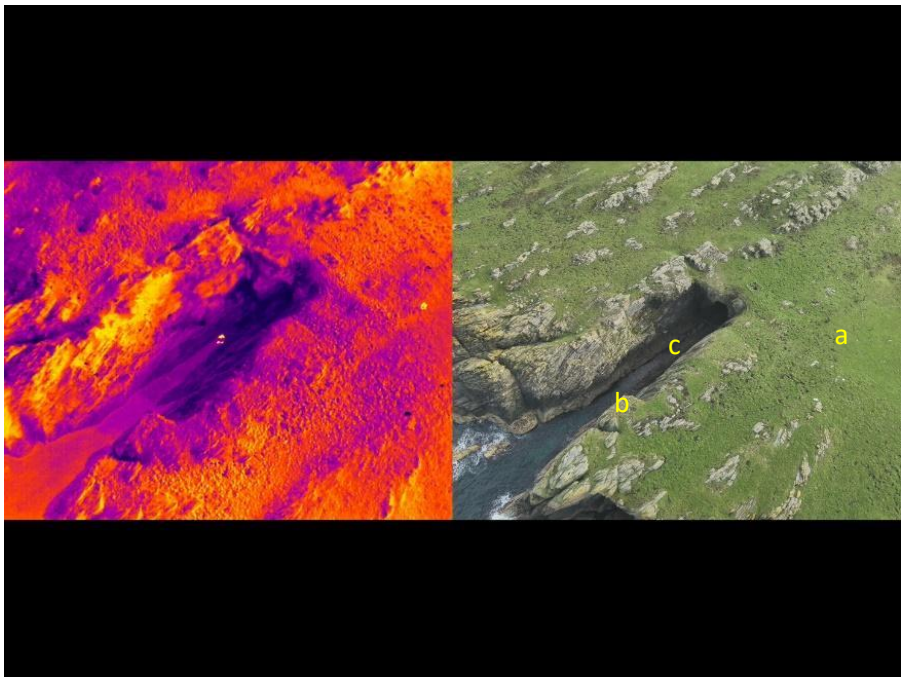

Fig 2. Simultaneous thermal and standard digital drone images taken at elevation exceeding 50m, showing position of surveyors (a), historical observation position for surveyors (b) and grey seals at sensitive site (c). MWT. Calf of Man 2024.

Time Efficiency: Revolutionising Survey Methods

Time constraints in fieldwork often limit the scope of data collection, especially in remote and challenging environments. Traditional methods of population surveying, which rely on ground-based teams using handheld lenses, are labour-intensive and slow. A surveyor on foot may spend hours traversing the breeding grounds of grey seals, and the limited field of view provided by long lenses often necessitates multiple passes over the same area to ensure accuracy (Bishop et al., 2015).

In contrast, thermal imaging drones can drastically reduce the time required for population surveys. A single flight, covering several kilometres of coastline, can capture high-resolution thermal images of hundreds of seals in just minutes. In a study comparing manual and drone-based survey techniques, Hodgson et al. (2018) found that drone surveys were 4.5 times faster than ground-based methods while yielding similar accuracy. This reduction in survey time not only improves efficiency but also allows researchers to conduct repeat surveys over short time intervals, capturing data at multiple stages of the breeding season.

Improved Identification and Data Quality: Thermal Imaging and Beyond

Accurate identification of individual seals and their breeding status is critical for understanding population dynamics and breeding success. Traditional ground-based methods rely heavily on the visual acuity of the surveyor and are susceptible to misidentification, particularly in environments where seals may be camouflaged by their surroundings or obscured by vegetation and rocks (Hiby & Thompson, 2010). This can result in inaccurate population counts, especially for species like grey seals, where adults and pups can be difficult to distinguish from a distance.

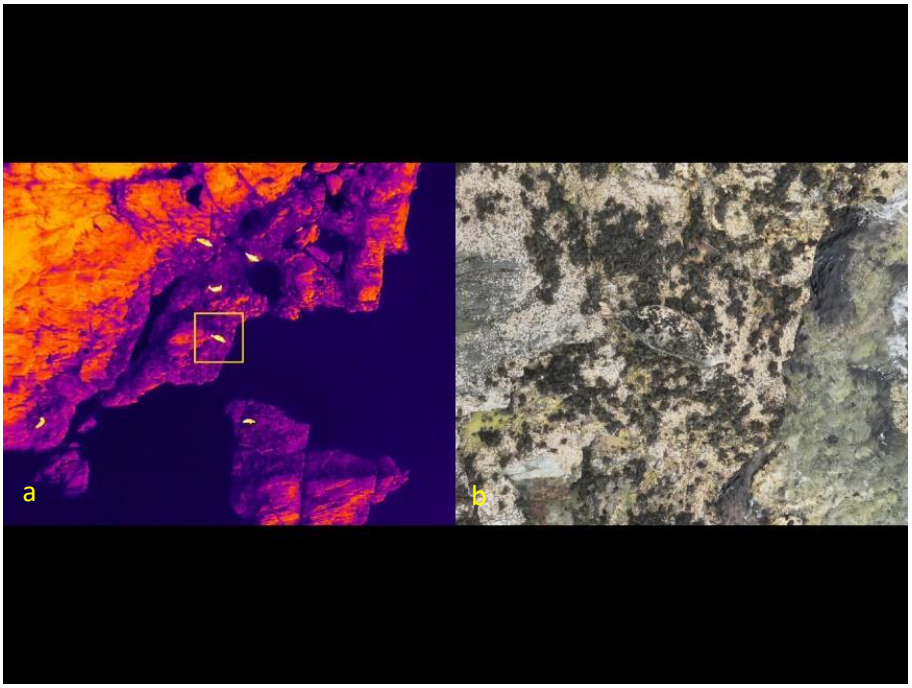

Fig 3. Showing effectiveness of thermal imaging seal location identification (a) compared to full zoom standard imaging of grey seal camouflage (b). Images taken simultaneously at elevation exceeding 50m. MWT. Calf of Man 2024.

The DJI Mavic 3T, equipped with dual visual and thermal imaging cameras, significantly improved the identification process for MWT in 2024. Its thermal imaging system captured the heat signatures of seals, making it possible to differentiate between individuals even when they are hidden from direct view by natural obstacles. For example, during a seal survey on the Isle of May, researchers using thermal drones were able to identify pups hidden in dense vegetation that were missed by surveyors on foot (Johnston, 2019). Moreover, the high-definition visual camera provides detailed imagery that can be cross-referenced with thermal data, allowing for the accurate identification of mother-pup pairs and the tracking of individuals over time.

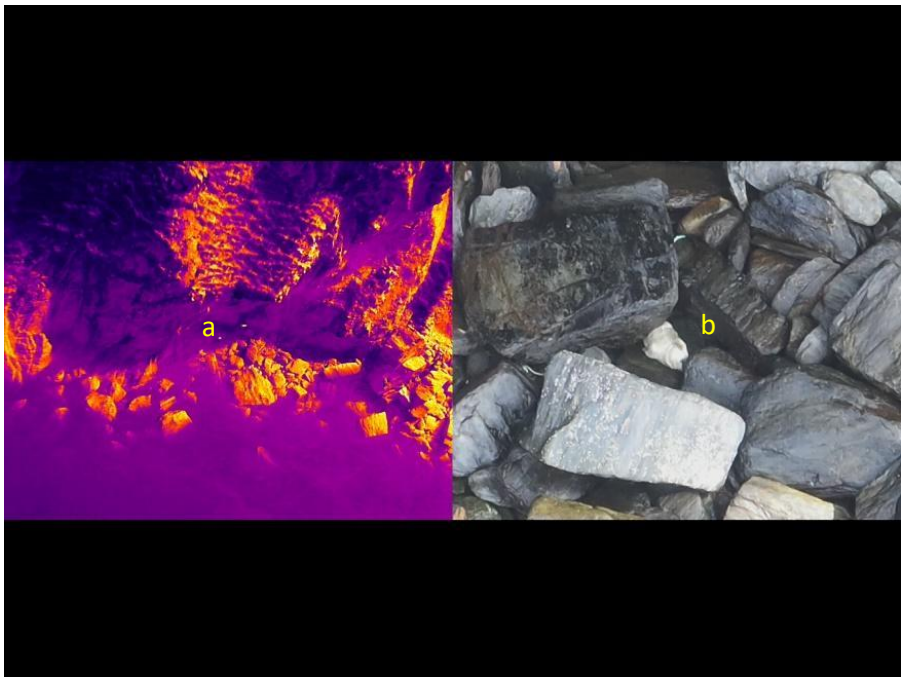

Fig 4. Simultaneous thermal and standard digital drone images taken at elevation exceeding 50m, showing thermal heat spot of partially hidden seal pup (a), and full zoom standard imaging of partially hidden seal pup (b). MWT. Calf of Man 2024.

This dual imaging approach not only increases the accuracy of population counts but also allows for the collection of additional data on seal health and behaviour, such as detecting signs of illness or injury through temperature anomalies. In turn, this provides more comprehensive insights into the overall health of the population and its breeding success.

A Paradigm Shift in Marine Mammal Surveying

The integration of a thermal imaging drone in 2024 (model: DJI Mavic 3T) into grey seal population surveys represents a major advancement in conservation research for MWT. By reducing disturbance to the animals, enhancing the safety of researchers, improving the efficiency of surveys, and providing more accurate data, this drone offered a transformative tool for wildlife monitoring. As demonstrated by numerous studies, the deployment of drones in challenging environments has not only streamlined the data collection process but also improved the quality of information gathered, enabling more effective conservation strategies.

Given the challenges of climate change and human impact on marine ecosystems, the use of advanced technologies like thermal drones will likely become increasingly important in future wildlife research. As drone technology continues to evolve, its applications in conservation science

will expand, offering new possibilities for studying and protecting vulnerable species such as the grey seal.

Appendix B – Developmental stages of grey seal pups

Stage	Age	Characteristics	
Stage 1	0-2 days	Thin baggy-skinned body Yellow stained or white natal fur Conspicuous umbilical cord Docile & poorly coordinated	
Stage 2	3-7 days	Smoother bodyline, few loose folds Neck still distinguishable Umbilical cord atrophied Aware & coordinated	
Stage 3	7-15 days	Rounded or barrel shaped body Neck thickened/indistinguishable Partial moulting from head or flippers May be aggressive on approach	
Stage 4	16-20 days	Rounded body Partial moulting from torso Head & flippers moulted May be aggressive on approach	
Stage 5	18-25+ days	Fully moulted to short fur coat (< 100cm^2 natal coat remaining) May be aggressive on approach	

Appendix C - Example Visitors Briefing Sheet

Welcome to the Calf of Man. You've arrived during a particularly sensitive time: the grey seal pupping season. These beautiful creatures come to our shores to give birth, and it's essential that we do everything we can to minimise disturbance to the seals and their pups. Your cooperation is key in ensuring the safety of these animals.

Key Guidelines for Visitors:

1. Stay on Designated Paths
    - The island has marked trails designed to keep you a safe distance from seal habitats. Please stick to these paths at all times.
    - Walking off-path can disturb hidden seal pups or interfere with their mothers, leading to stress and abandonment.
2. Respect Seal Space
    - Seals and their pups need peace and quiet. Avoid approaching seals where possible, even if they appear curious or indifferent to your presence.
    - Always keep a safe distance. If a seal becomes agitated, moves away, or reacts to your presence, you're too close.
    - Where possible, please avoid loud noises or sudden movements, especially around mothers with pups.
3. Limit Your Time Near Seals
    - Even from a distance, it's best not to loiter for too long around seals. Prolonged presence can cause stress, leading to disrupted feeding or increased pup mortality.
4. Photography & Drones
    - The island's estate and surveying teams, conduct wildlife monitoring using overt and covert remote and drone photography. These operations are carried out professionally and with minimal wildlife disturbance.
    - Personal drone use is strictly prohibited as it can severely stress the seals.
    - Feel free to take photos, but do so quietly, with a long lens and without flash or aggressive camera movements.
5. No Touching or Interfering
    - Seals are wild animals and touching or attempting to "help" a seal pup can do more harm than good. If you spot a seal pup that seems abandoned, injured or in distress, report it to a warden immediately. Seal mothers often leave their pups for extended periods, and interference can cause the mother to abandon her pup altogether.
6. Report Any Issues
    - If you notice seals in distress, people getting too close, or any concerning behaviours, report them to a warden or member of staff right away. Early intervention is key in protecting the seals.

Why It Matters:

Grey seal pups are extremely vulnerable during their early weeks. Stress caused by human presence can prevent mothers from nursing or lead them to abandon their pups. By following these guidelines, you're playing a vital role in ensuring the survival of these young seals and the long-term health of the population.

Thank you for your care and cooperation in protecting this special habitat and its wildlife.