Calf of Man Seal Survey

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Introduction

Background

The British Isles are home to two species of seal, belonging to the family Phocidae, otherwise known as “true seals": Grey seals (*Halichoerus grypus*) and the common or harbour seal (*Phoca vitulina*). Both species of pinniped are protected, under Appendix III of the Berne Convention, EC Habitats and Species Directive, the 1976 Wildlife Act and Conservation of Seals Act 1970. All seal species are protected under the Manx Wildlife Act 1990. Prior to these protections, both species were regarded as pests to fisheries, hunted for meat and, ultimately, overexploited, resulting in their decline (Mowat, 1984). Since the enforcement of such protective legislation, both species have undergone large increases and both populations are now considered stable; with the IUCN noting these species as ‘Least Concern’.

Grey Seals are the predominant species of seals along British coastlines, with UK waters hosting up to 50% of the world’s grey seal breeding population. In terms of diet, grey seals feed on a wide variety of food sources, with previous reports demonstrating that they are opportunistic, eating what is available to them (Lundström *et al.*, 2010); ranging from benthic and demersal fish species to octopus and lobsters (Mcconnell *et al.*, 1999). The females annual reproductive cycle begins when they reach reproductive maturity at four years old, ending at approximately 30 years of age. Breeding season for the UK population of grey seals begins from September through to November across breeding sites, with variation in breeding dates suspected to correlate with sea surface temperature. Females move to breeding sites where they produce one pup a year. Grey seal pups are considered precocial, with pups feeding for up to 18 days; within a month pups typically undergo shedding, before growing adult fur and leaving to sea to fend for themselves. The survival rates of first year pups range from 50-85%, regarding starvation and extreme weather conditions as the main cause of death. During the breeding period, males actively compete for mates and territory. After mating season seals return to the ocean to feed in preparation for moult, approximately from December to March (Thompson *et al.*, 1991).

Seals in Manx Waters

Seals are highly mobile marine species, mainly solitary and spend 80% of their time at sea. The Irish Sea hosts a large proportion of the grey seal population, estimating 6,976 individuals to use these waters. This passage provides access across some of the major breeding sites in the UK, with the Isle

of Man, located in the centre of the Irish Sea, highlighted as important haul out location. It is estimated up to 405 individuals occupy this island, with this site considered as a key stopover site due to its positioning, providing rest and opportunities to feed (Kiely, O *et al.*, 2000). The Calf of Man, owned by Manx National Heritage, is a small islet located South of the main isle. It is regarded as an important pupping and haul out site and therefore has been the focus of monitoring the grey seals throughout pupping and breeding season, with annual surveys completed since 2009 to present. This has been conducted through the Manx Wildlife Trust and Manx National Heritage, with seasonal surveyors which live on the island through this period (Howe and Parsons, 2017). The rocky coastline of the Calf of Man provides ideal conditions and sites; as seen in Figure 1.

Figure 1. A map of the Calf of Man, obtained from the Manx Wildlife Trust, with markers added to indicate the 14 main breeding sites surveyed on the island.

Study Background and Focus

Marine mammals, such as seals, are top predators within the marine ecosystem, and as a result they play a key function in dictating marine community structure and the balance of population dynamics in this environment. One of the threats to the marine ecosystem is widespread commercial fishing, which harvest marine stocks and damage habitat. This can have particularly deleterious consequences on the state of marine ecosystems (Sayer *et al.*, 2019). Past research has thus used the presence of large marine mammals, such as seals, which place at the top of the food chain, as an indicator of biodiversity and ecosystem health; a useful method to assess marine environments (Curtin and Prellezo, 2010). However, monitoring the movement and distribution of grey seals has been a challenging task. Studies have trialled methods such as satellite telemetry, tagging, paint dye and brands, but whilst these studies allow for detailed data collection into foraging movements, these methods are limited by their costs and invasiveness (Sayer *et al.*, 2019). Therefore, the development of photo identification methods is one which is highly effective. This technique is not invasive and causes little disturbance. This method generates significant insights into movement, life history and abundance, previously used successfully on a range of marine mammals in order to track long term movements and reproductive output (Karlsson *et al.*, 2005); what's more, grey seals are ideal candidates for this method, with each grey seal having their own unique fur pattern of dark and light markings (Paterson *et al.*, 2013).

The use of photographic identification has been used to therefore monitor seals since surveys began in 2009, a grey seal catalogue has been built for the Calf of Man, with the main aims to:

1. Collect photographic identification images of seals, to compare and match individuals to the catalogue database, to determine whether/which individuals return. To monitor site fidelity, reproductive output and life history.

2. Produce a seal pup census throughout the pupping season; monitoring pups, tracking developmental stages and identifying mothers.

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 14 sites along the north and south coastlines utilised for pupping, which are now the pupping sites monitored throughout the survey season (Figure 2). 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.

Code	Location
CL	The Cletts
GH	Grant's Harbour
CH	Cow Harbour
WC	West of Cow
GI	Gibdale
BF	Bay Fine
AM	Amulty
GL	Ghaw Lang
SC	Smugglers Cave
CP	Caigher Point
LE	Leodan
MG	Mill Giau
PU	The Puddle
SH	South Harbour

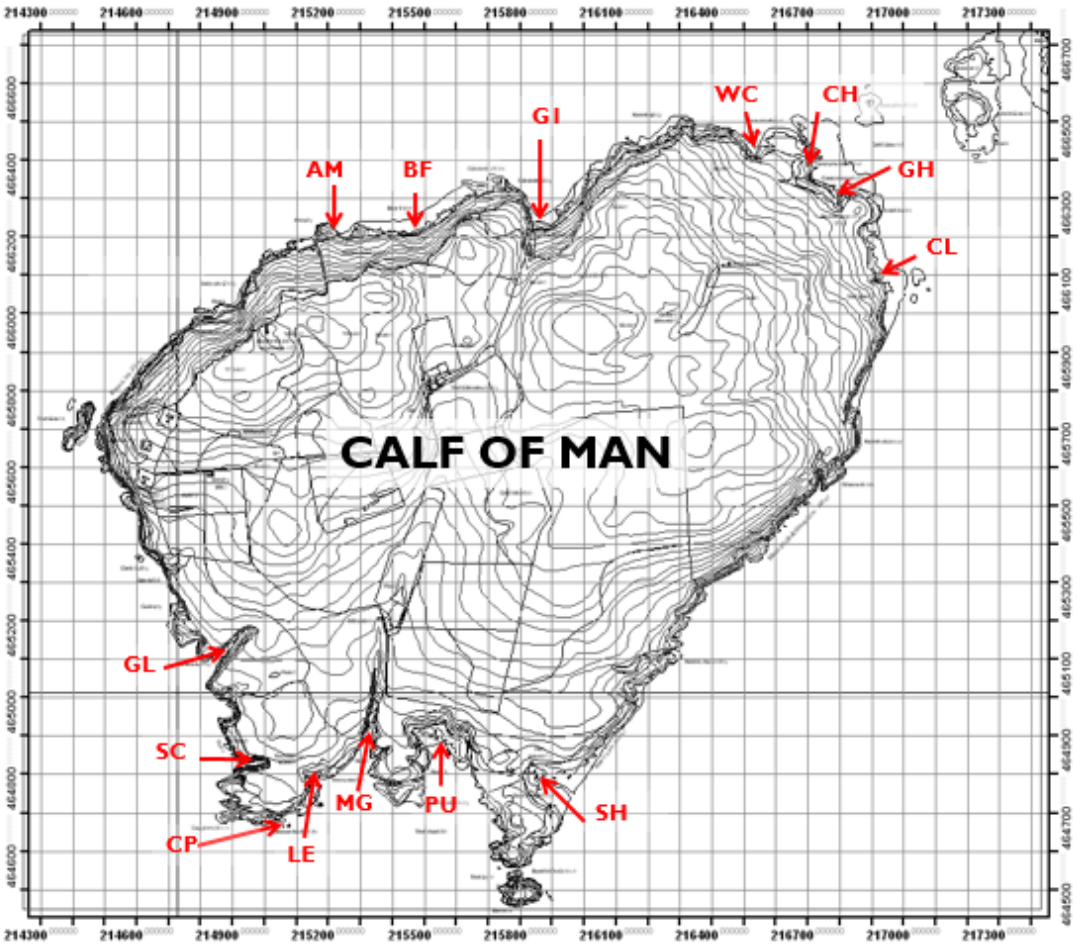

Figure 2. Map of Calf of Man showing the 14 different grey seal pupping locations used for surveys. Table provides full names of sites and corresponding codes.

Data Collection

The breeding season on the Calf of Man occurs between September and November (Stones *et al.,* 2013), so data collection is carried out during this period, which this year was from 4th September to 13th November by volunteers Lauren Stokes and Catrin Ferguson, with guidance from Manx Wildlife Trust Marine Officer Dr Lara Howe. Of the 14 sites, two survey routes of seven sites were formed, consisting of North sites (AM-CL) and South sites (GL-SH) (Figure 2). To be able the 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. Island wide surveys were completed on three occasions by foot (29/09/2022, 20/10/2022, 13/11/2022) and once via boat (20/10/2022) which was carried out by the seal volunteers and assistant warden Chloe Hurst and volunteer Mike Prior. These consisted of a whole island count of adult seals and pups along the coast of the island in addition to pupping sites.

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 along with in addition to their activity (hauled-out or in water) and photographed using a Canon EOS 70D DSLR camera fitted with a 70-300mm 1:4-5.6 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 of preferably of both the head and flank of each side. Using high-quality photographs of individual increases chances of re-identify from previously identified individual 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.

In addition to a camera, the Pulsar Helion 2 XP50 Thermal Imaging Spotter Scope Camera was used. Poor visibility at sites makes it hard to identify the presence of seals and pups, one site in particular "Smugglers Cave" being notorious for this. The thermal imager assists as it detects temperature differences between the seals and the surrounding, and thus highlight seals in red and yellow, being warmer than the surrounding rocks. Through this we were able to accurately count the number of seals and pups even when we were unable to see them ourselves.

Pup Development Stages

The photographs of the pups through their developmental stages was assessed using a system of classification into five stages (see Appendix A), 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 to monitor the growth of seal pups, and the success rate of pups born, all of whom were named beginning with a single letter of the alphabet (the letters 'X, Y, Z') as per the ongoing system on the Calf of Man.

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 484 females and 61 males before the 2022 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 pups, including confirmation of

abandonment, filial relationships, dates pups were born and even presence of pups. As monitoring sites was done on an alternate basis, and for only around 30 minutes at each site, the camera trap allowed us to continually monitor seals and pups without disturbance. A total of five camera traps were deployed at four location; two at Grants Harbour and one at The Puddle, Mill Gaui and Cow Harbour. Cameras stayed at the same site, however their locations at the sites changed during the survey period. Cameras were placed five to ten metres from the pupping sites before breeding season begun (Figure 3) and set on time lapse, for one photo to be taken every 30 minutes, with photos taken between daylight hours of 6:00 – 20:00 for the full survey season. Using these settings allowed reduced memory storage and battery drainage, which reduced the amounts of times cameras had to be checked, thus minimising potential human disturbance to seals.

Figure 3. Photo showing camera trap present at site GH. The camera is highlighted with a yellow square. (Manx Wildlife Trust, 2022)

Boat Survey

A limitation that had been identified previous years was the possibility that pups were born at locations that were not visible during land surveys. Although preferred seal pupping site habitat is rocky beaches previous studies have also found seals pupping in caves, that would not be visible during cliff top surveys (Stringell *et al.,* 2014). This would potentially mean that there was a under reporting number of pups born on the island. To overcome this, this season we undertook a boat survey around the island after the peak of the pupping season, with the route taken seen in Figure 4. The date was decided on when the most pups were likely to be seen, but also considered weather

conditions. This trip had the aim of identifying pup born outside of pupping sites, identify any other areas that could potentially be used for pupping as well as check at established pupping sites there were no additional pups seen that were out of view during land surveys. Starting at WC the boat went around the island, stopping at pupping sites to count pups and check the possibility that even at pupping sites certain obstruction could have meant pups were out of view. In addition, we also did another full seal count survey.

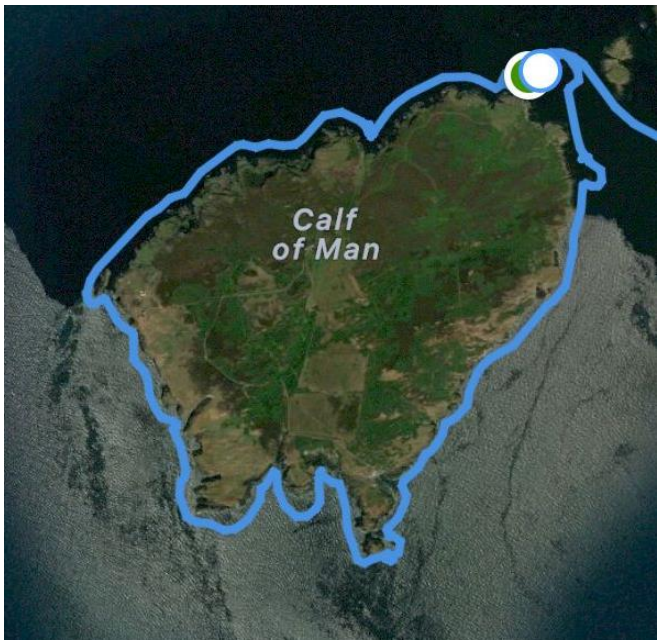

Figure 4. Map showing route taken for boat survey. Map produced using app 'eBird'. (Rob Fisher, 2022)

Data Analysis

To visually represent the data, GPS points corresponding to births were displayed in QGIS. GPS points were also used to show the number of pup and females at each site in QGIS, with the size of the point corresponding to the number. The program Microsoft Excel 2017 was used to analyse results for pup and female analyses. 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 65 pups were recorded as born on the Calf of Man over the duration of the survey period (Appendix C). Although slightly higher than previous years, it should be noted this survey season had an additional 2 weeks than previous years whereby an additional two pups were born. Figure 5 compares the number of pups born each year and the trend of pup production overall, with pup numbers increasing since 2009 (n=29) to a peak pup number in 2016 (n=84), and since has remained in the sixties. A trendline has been placed which shows the trend of the data over the past 13 years, with an R^2 value of 0.9044 the line is a good fit to the data.

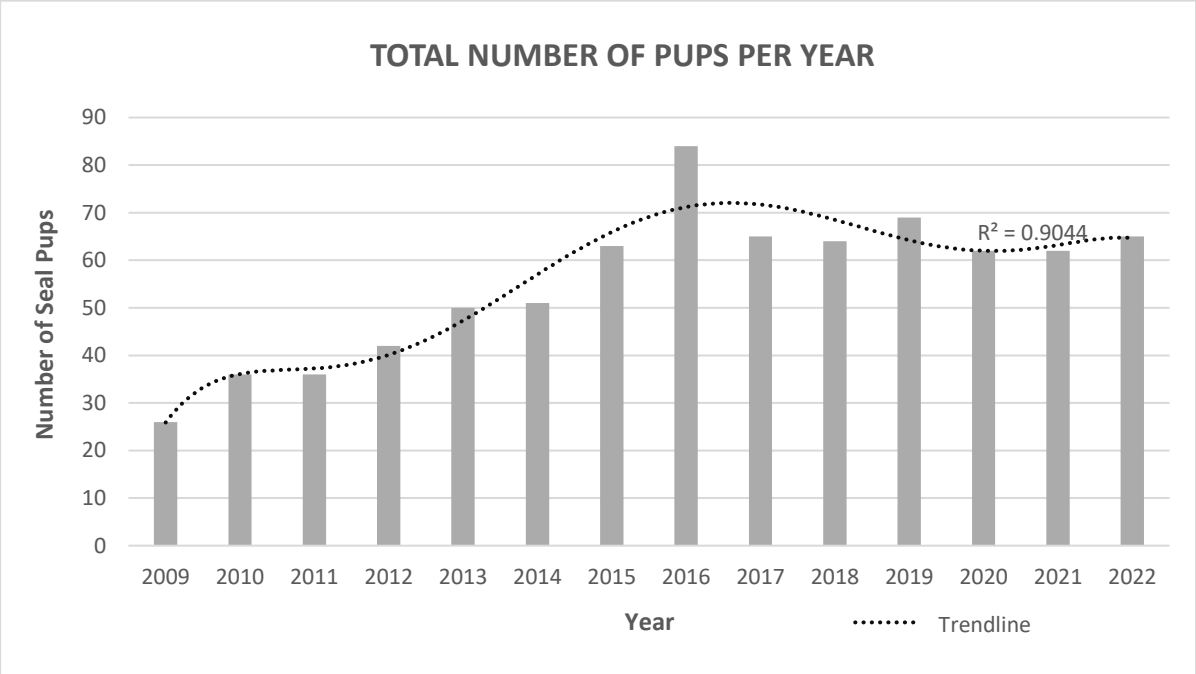

Figure 5. Graph showing the trends in seal pup production from 2009 – 2022, data collected by volunteers during the annual Manx Wildlife Trust seal pupping surveys on the Calf of Man.

The number of new pups observed each week of the survey is displayed in Figure 6, giving an indication of the spread of pupping dates over the duration of the season as well as the comparison of the previous year's averages for the same dates. The survey period this year started earlier than before (04/09/2021), but despite this the first week saw a below than average births from the previous two years. The peak pupping period for the previous year averages and for the 2022 season was on the same week 29/09/2021-05/10/2021, although the number of pups in 2022 was considerably higher (n=18) than the previous average (n=11.38). The overall trend from the 2022 data shows that there were more pups born in the first 5 weeks (01/09/2022-05/10/2022) than the

previous year's average (n=38, n=30.8 respectively), but 2022 saw less pups but in the following six weeks (06/09/2022-16/11/2022) than the average (n=28, n=30.93 respectively). This suggests the pupping period is moving forward, which concurs the earlier mean pupping date of the 2022 season, being four days earlier than the average as seen in Table 1.

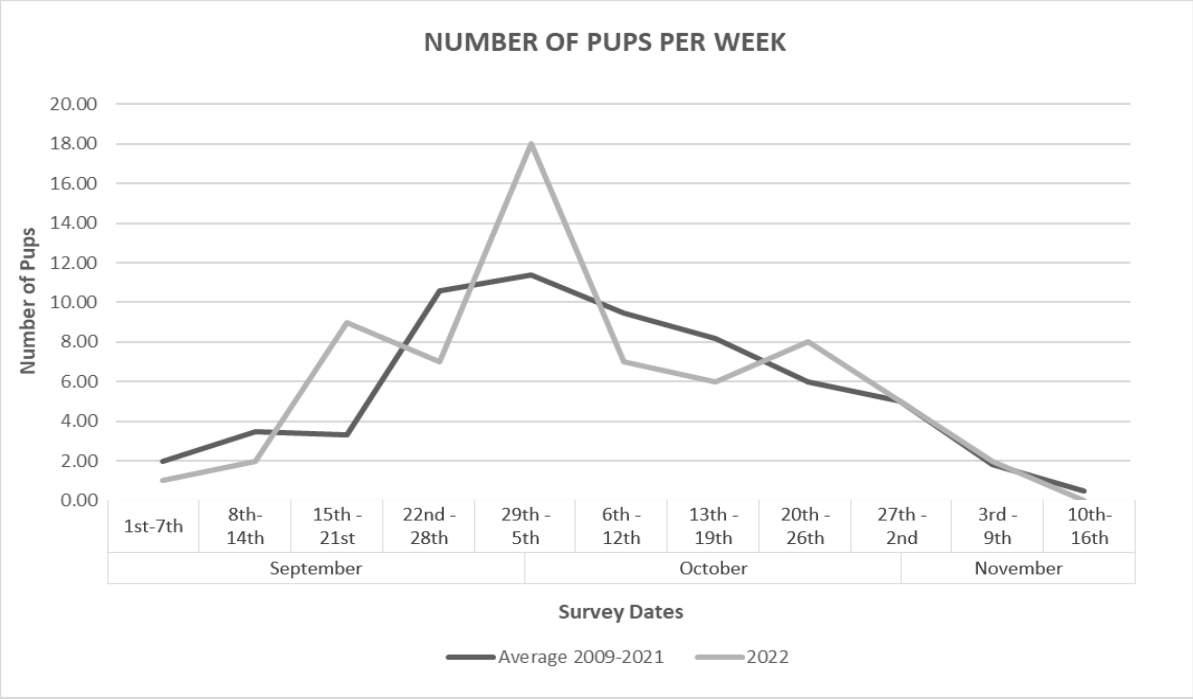

Figure 6. Graph showing the spread of pupping dates over the 11 weeks of the survey. This is compared to the mean spread of pupping dates from the past 12 years.

Table 1. Table of average birthdate in 2022 compared to the average for previous year.

AVERAGE BIRTHDATE DATE 2022	AVERAGE BIRTHDATE PRE-2022
5th October	9th October

Of the 65 pups, 3 were confirmed as having died during the survey period, making up only 4.62%, lower than the average pre-2022 (5.69%) (Figure 7, Table 2). Stage 5 pups are classed as pups that have fully weaned and have moulted of their lanugo coat. A total of 38 pups were tracked all the way through to Stage 5 of development, the highest number recorded in line with 2018 and 22.63% higher than the average for the previous years (Figure 7, Table 2). Of the pups that made it to stage 5, mothers have had an average of 6 breeding seasons, although seasons varied from 1-11. Of the stage 5 mums which had been seen for two or more seasons, 90.48% had used the 2022 breeding site previously, with mothers pupping on average on two sites (Table 3).

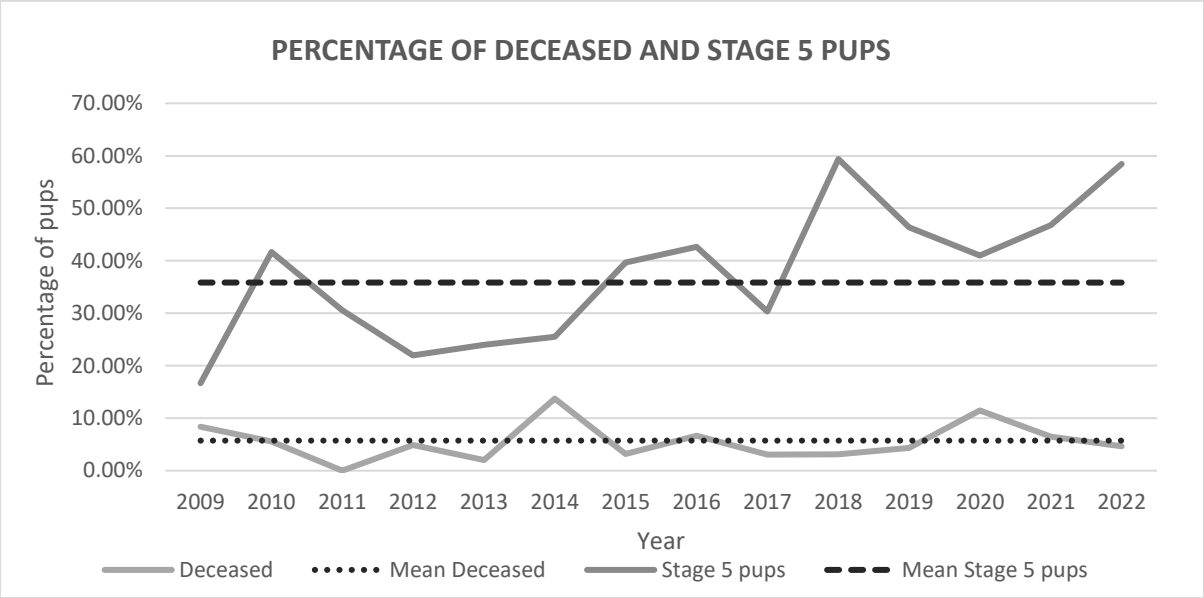

Figure 7. Percentage of pups confirmed as deceased each year, compared to the mean between 2009 and 2021, as well as the percentage of pups successfully tracked through to Stage 5 of development each year and the mean of previous years.

Table 2. Table showing number of pups deceased and stage 5 pups each year as well as the corresponding percentage per year. Information is used in graph for Figure 7

YEAR	TOTAL PUPS	DECEASED PUPS	*PERCENTAGE OF DECEASED PUPS*	STAGE 5 PUPS	*PERCENTAGE OF STAGE 5 PUPS*
2009	24	2	8.33%	4	16.67%
2010	36	2	5.56%	15	41.67%
2011	36	0	0.00%	11	30.56%
2012	41	2	4.88%	9	21.95%
2013	50	1	2.00%	12	24.00%
2014	51	7	13.73%	13	25.49%
2015	63	2	3.17%	25	39.68%
2016	75	5	6.67%	32	42.67%
2017	66	2	3.03%	20	30.30%
2018	64	2	3.13%	38	59.38%
2019	69	3	4.35%	32	46.38%
2020	62	7	11.48%	25	40.98%
2021	62	4	6.45%	29	46.77%
Average pre-2022	***53.69***	***3.00***	***5.60%***	***20.38***	***35.88%***
2022	**65**	**3**	**4.62%**	**38**	**58.46%**

*Table 3. Summary of mothers of stage 5 pups. *Not including females where 2022 was their first recorded breeding season. **Using females that had pupped for 2 seasons or more*

		Max	Min
Average number of breading seasons	6	11	1
Average number of sites used	2	4	1
Used 2022 site previously	90.48%	-	-

Pup Distribution

Pups were seen in 11 of the 14 main pupping sites as seen in Figure 8, with Amulty (AM), Ghaw Lang (GL) and Cagier Point (CP) being the exception. It should be noted however than despite CP being flagged as a potential pupping site, no pups have been seen here since 2009. One pup was born outside of the pupping area, in a location called Fold Point (FP) since 2014. Grants Harbour (GH) the single most popular site, contributing to 23.08% (n = 15) of the total pup productivity for this year, the highest record for pups at GH. Out of the 11 pupping sites used for the 2022 season, Figure 8 demonstrates that eight of these sites saw higher than average pup numbers, with particular note to sites GH and MG, which saw over four pups higher than average. For the first time there were more pups born in the North sites (n=35, 53.85%) (Bay Fine - Cletts) than born in the southern sites (n=30, 46.15%) (Ghaw Lang - South Harbour) (Figure 9).

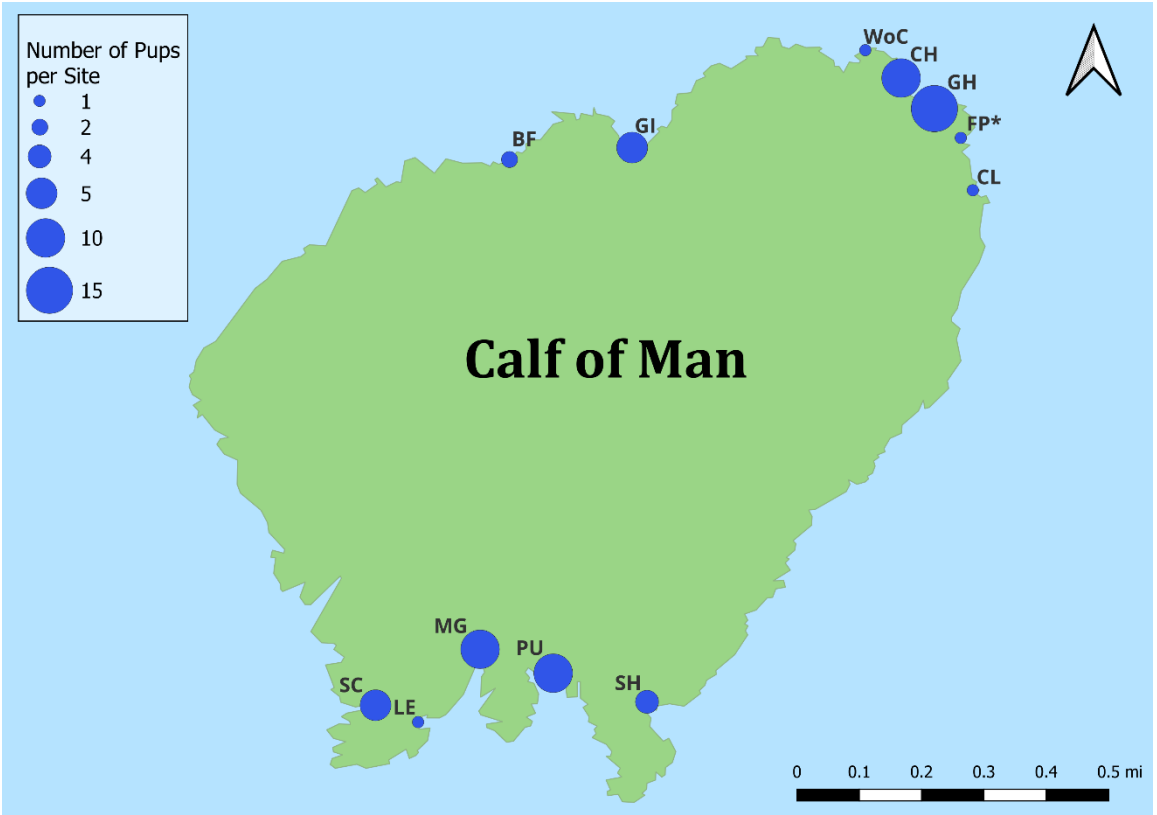

Figure 8. Map showing the distribution of pups around the Calf of Man in the 2022 pupping season, produced using QGIS software. The relative size of the blue dot corresponds to the number of pups. Map produced in QGIS.

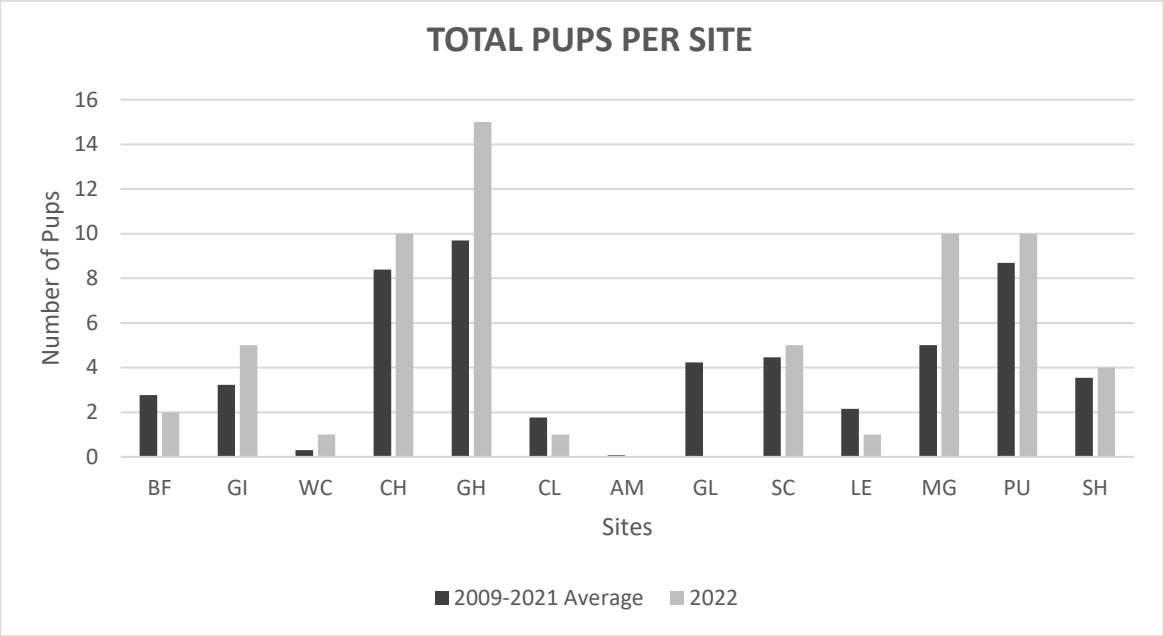

Figure 9. Graph shows number of pups born at each site, compared to mean of previous years.

From the 65 pups born this year a total of 3 pups (4.62%) were deceased, 45 pups (69.23%) reached stage five, or seen until the last survey day but had not yet reached stage five and 17 (26.15%) were classed as missing (Table 4). Missing pups were lanugo pups seen, recorded and tracked during a survey until their last sighting, but had not reached stage 5. Other sites are explored to see if the pups could have moved, but in these cases no additional pups were seen outside of known pups at the current stage. It is unknown if these pups survived or not. There was no site that had a higher number of deceased pups (Figure 10), although there were more deceased pups in the south than the north. Of the 12 pupping sites, 8 sites had pups that reached stage 5 (Figure 11). Grant's Harbour had the highest number of stage five pups whilst Smugglers cave had the highest of pups that went missing, followed by Gibdale and Grants harbour, despite having the highest survival rate (Figure 10). It should be noted however, difficulties with visibility at these sites could have contributed to this. The success rate of sites was calculated using pups that reached stage 5, or seen the last day of survey over the total number of pups per site. The South had a higher success rate of pups (n=79.31%) than the northern sites (n=62.86%).

Table 4. Number and relative proportions of deceased pups, missing pups and stage 5 pups/ pups seen until last day of survey.

	DECEASED	MISSING	STAGE 5 PUPS & PUPS SEEN ON LAST DAY
Total	3	17	45
Percentage	4.62%	26.15%	69.23%

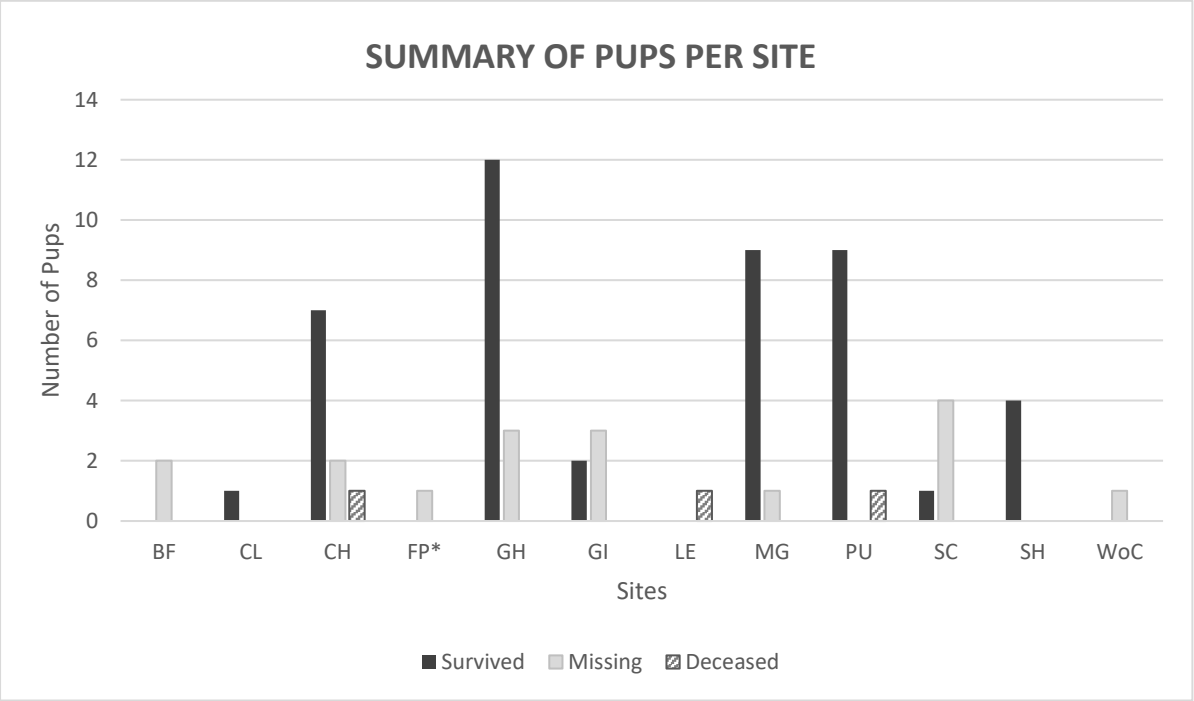

Figure 10. Graph shows number of pups that were deceased, missing or reached stage 5 at each site. Pups seen on last day of survey were also included as they did not reach stage 5 by the end of survey.

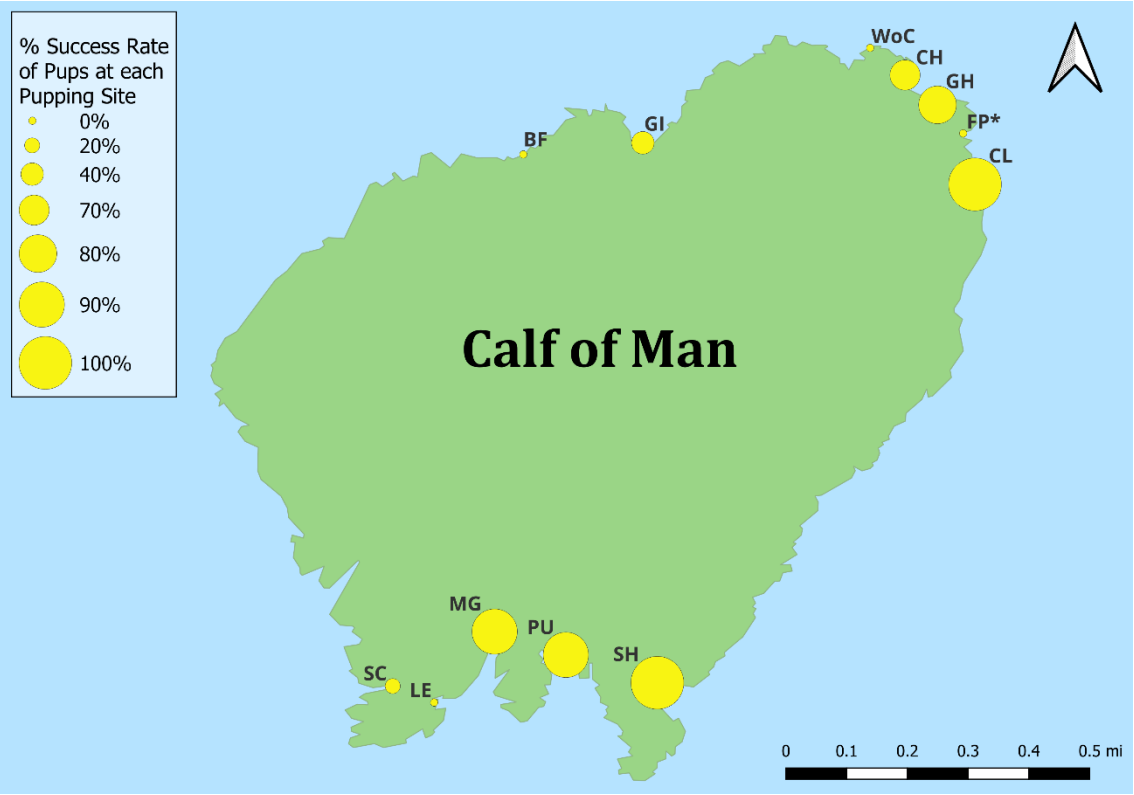

Figure 11. Map shows percentage of pups at each site that were seen from stage 2 until fully weaned. The relative size of the yellow dot corresponds with the percentage range at each site, with exact numbers seen in Table 5. Map produced in QGIS.

Adult Distribution

Seal numbers varied from site to site across the survey season (Figure 12), with the greatest number of seals recorded at The Cletts, with an average seal count of 20 per survey, and The Puddle, averaging 21 seals per survey. Sites with the lowest number of seals were Amulty, Giau Lang and Caigher Point (average seal count per survey <1). Site use recorded this season, most or least populous, follows the same pattern as observed across the island last year. Furthermore, the North survey route had an average seal count of 55 per survey, whilst the South survey route had an average seal count of 39 per survey. Overall, an average of 47 seals were recorded per survey. Across all survey sites there is a clear sex-bias per survey, the seal count was 89% females and 11% males.

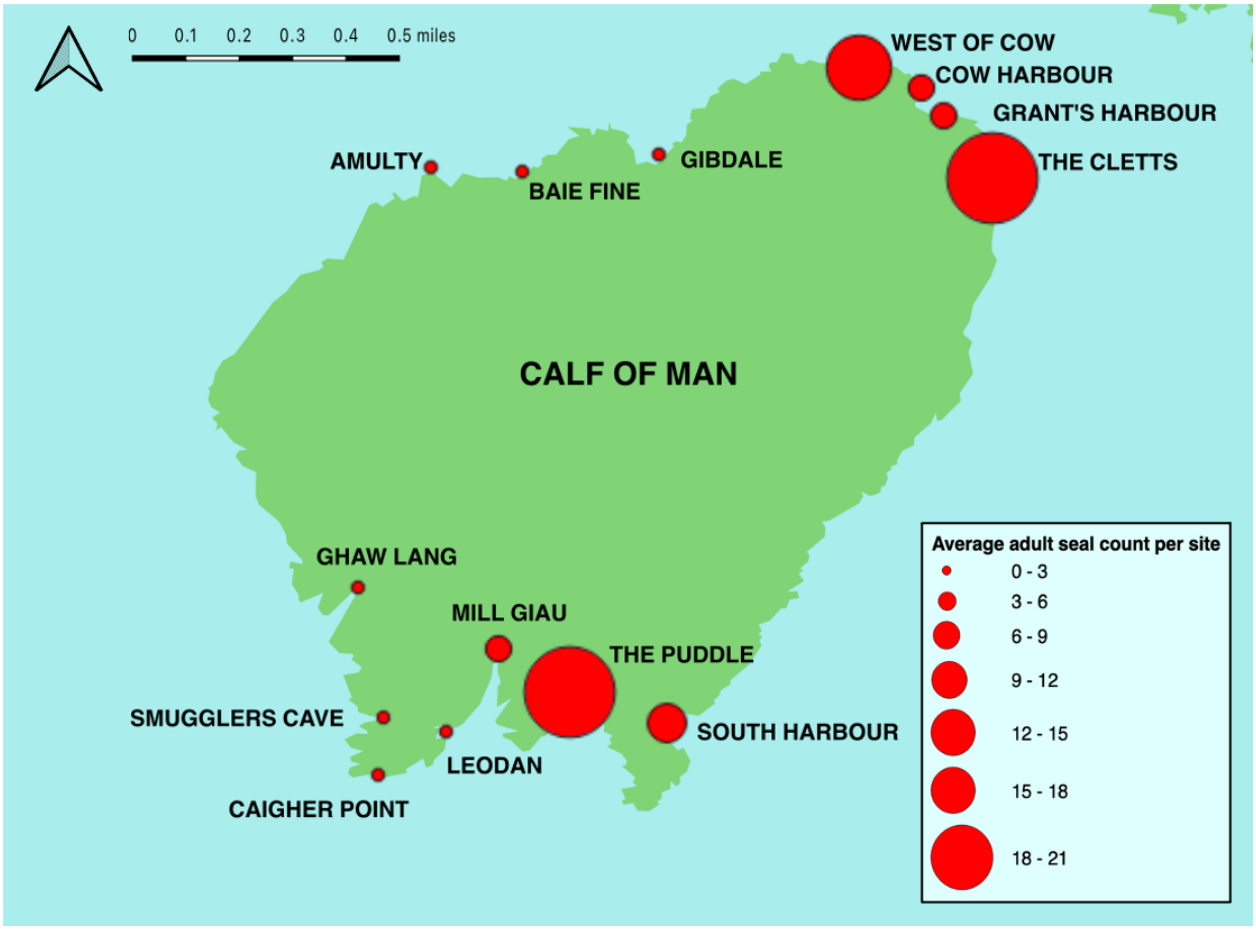

Figure 12. A map of the Calf of Man, with point size representing the average adult seal count per site, with a legend demonstrating the size scale and corresponding count average. Map produced in QGIS.

Photo Identification

Mothers

In total, 65 mothers were recorded across the 2022 survey season. From the catalogue, 35 of these mothers were matched and identified and 23 mothers were new and added to the catalogue. Subsequently, 7 mothers were unable to be identified or recorded, either not observed or photographed, marked as unknown (Figure 13). Of the 35 mothers matched, 28 were recorded to have pupped on the Calf of Man previously.

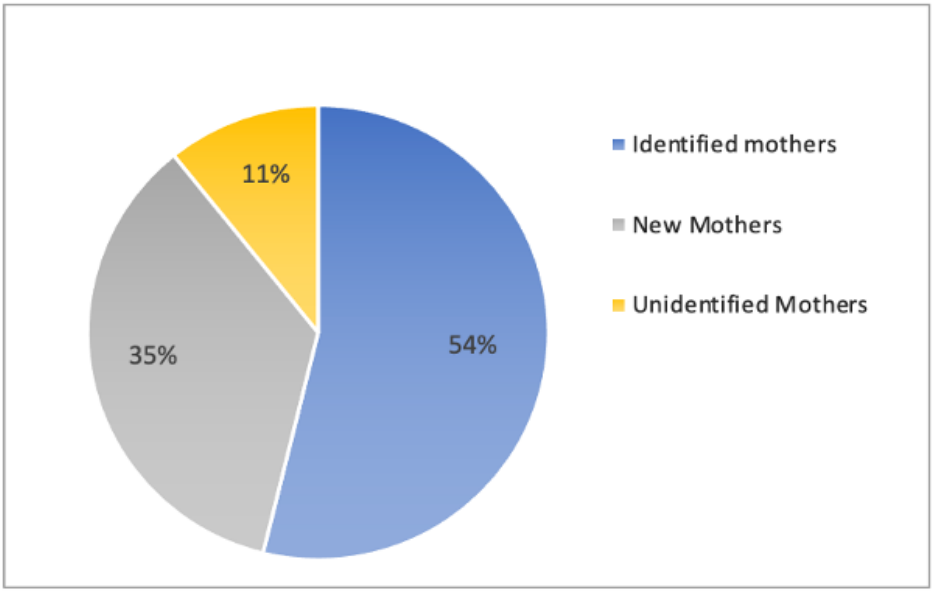

Figure 13. A pie chart representing the proportion of mothers which were identified, unidentified or new.

Non-pupping females

During the survey season non-pupping females were also identified, matched and added to the catalogue. In total 175 individuals were matched and added, 63 non-pupping females were matched with the catalogue, with 112 new females added to the catalogue (83 as LRN and 29 as full). Some females were not photographed at all or at the right quality, therefore a match could not be confirmed; meaning the number of non-pupping individuals matched and added to the catalogue does not reflect the actual number of individuals sighted. What's more, 2 duplicates were identified in the catalogue and corrected for. Currently, there are 621 individuals in the Calf of Man seal catalogue.

Males

Males are typically harder to identify due to lack of markings and dark colouration, therefore matching within the catalogue is minimal. Across the survey season, males were recorded, with 4 males matched with the catalogue and 13 added. Thus updates the catalogue from 61 males to 74 males known.

Site Fidelity

Site fidelity measured for 2022 mothers is 47%. This excludes mothers which have been matched to the catalogue but have not pupped before (n=1). What's more, for this analysis of site fidelity CH, GH and WoC were treated as one site. There is little distinction and separation between these sites, with these sites noted as separate only for ease of surveying. Therefore, for this analysis, these sites are considered as one pupping site (Table 5).

Table 5. Table demonstrating the number and percentage of returning 2022 mothers and how many sites they have used to pup.

Number of sites	Number of Seals	Percentage (%)
1	15	44.12
2	11	32.36
3	2	5.89
4	3	8.82
5	1	2.94
6	2	5.87

Figure 14 shows how site fidelity varies across locations. This was calculated using mothers which pupped in 2021 and this year, looking at the fidelity to pupping sites. Site fidelity ranges from 0% to 100%. But it is important to understand that some sites are visited by much fewer mothers in comparison to more popular sites, this influences site fidelity percentages.

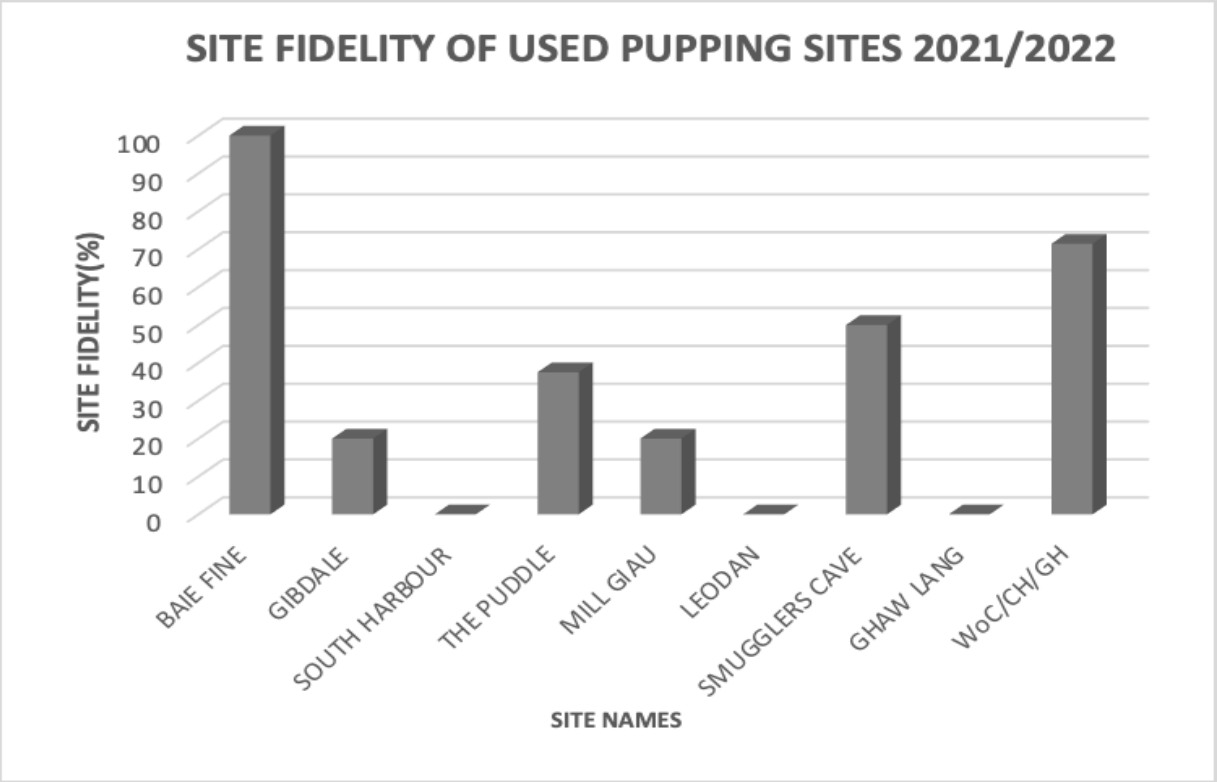

Figure 14. A graph demonstrating site fidelity for the sites used to pup in 2022. WoC, CH and GH have been considered as one site.

Birthdate Analysis

Data collected over previous years can be used to analyse changes in pupping date. Of the returning mothers which have pupped before on the Calf of Man, 69% pupped earlier than past years (Table 6, Figure 15).

Table 6. Birthdate analysis of 2022 returning mothers. The table presents the difference in pup date between 2022 dates and in most recent years for each individual. The difference between dates has been calculated, with positive numbers indicating earlier birth dates and negative numbers indicating later birth dates in 2022.

Individual Number	2022 Pup Date	Previous Pup Date	Difference to 2022
004	01/10	21/09/2021	-10
005	03/10	01/10/2020	-2
014	1/10	02/10/2021	1
017	06/09	26/10/2017	50
019	8/09	07/09/2021	-1
040	4/10	01/10/2021	-3
046	19/09	26/09/2020	7
062	19/09	25/09/2021	6
107	29/09	28/09/2017	-1
120	11/09	15/09/2021	4
127	25/09	16/09/2021	-9
150	04/10	05/10/2020	1
181	21/09	22/09/2020	1
194	29/09	29/09/2021	0
195	20/09	03/11/2015	44
203	21/09	21/09/2020	0
221	06/10	08/10/2021	2
223	27/09	30/09/2021	3
230	12/10	15/10/2021	3
248	17/09	19/09/2021	2
256	05/10	24/09/2020	-11
278	25/10	26/10/2021	1
290	03/10	30/09/2021	-3
298	17/10	22/10/2021	5
302	02/10	09/10/2021	7
303	28/09	25/09/2021	-3
306	24/09	30/09/2021	6
373	13/10	16/10/2021	3
406	20/10	01/11/2021	12

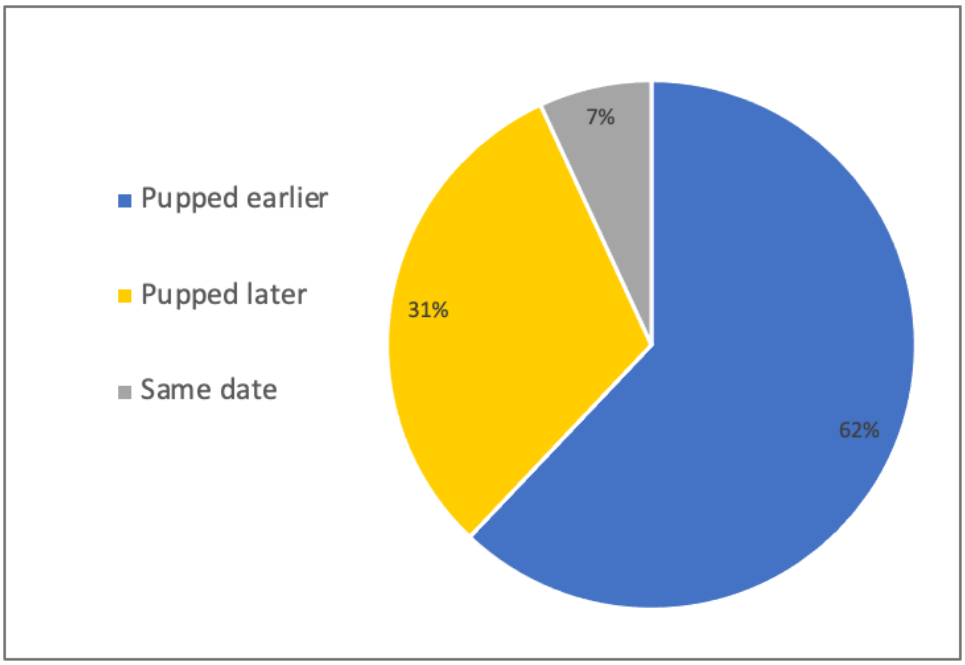

Figure 15. A pie chart representing the proportion of returning mothers which have pupped earlier, later or the same date in 2022.

Discussion

Pup numbers

The total number of pups recorded on the Calf of Man this season was 65, with the past five years pup numbers being within the sixties. This suggests the Calf of Man seal population has reached carrying capacity, defined as the maximum number of animals that can be maintained in an area without habitat deterioration (Fritz and Duncan, 1994). Reasons for reaching carrying capacity include foraging conditions, habitat quality and the conspecific-attraction hypothesis (Russell *et al.,* 2019; Stamps, 1988). This corresponds with previous research that has shown the growth of the seal population in areas besides the central and southern North Sea have now dropped to less than 1% growth, compared to the growth in the 1980s of 6% (Russell *et al.,* 2019; Thomas *et al*., 2019). Looking at the trend of pup production since the surveys began, between 2009 and 2015 the seal pupping numbers increased each year, although this could also be down to longer survey periods as well as increased and improved survey effort. In 2016 there was a peak in pup numbers with the highest number of pups being recorded (n=85) before decreasing and levelling out in the following years to pup numbers within the sixties. Such trends have been seen in other pupping population, including in The Outer Hebrides, the Inner Hebrides, and Orkney (Thomas *et al.,* 2019) whereby there is an increase in pup production, until overshooting the carrying capacity (as the Calf of Man in 2018) and then levelling out to the carrying capacity.

As noted in past reports, two limitations of this study are the land only surveys; where it is possible pups are born outside the visibility of these surveys, and the length of the survey period as pups may be born after this period. This year to investigate the potential effect of these limitations, a boat survey was undertaken, and the survey period extended for 10 days compared to the previous year. The boat survey allowed for the assessment of the potential additional pupping habitats and confirmation of pups being born outside of the pupping areas, with particular attention on the West and Eastern sides which are only surveyed once a month for 'whole island surveys'. The trip confirmed there was very little, if any, suitable habitat outside of the predetermined pupping sites, due to the sheer cliffs and lack of beaches which made it not possible for seals to haul out. Although there were seals hauled out in other areas, these were small and likely to be covered in high tide (as seen in Figure 16). Although initially this seems to confirm that there are no pups born outside the pupping areas, there was a pup born this year at a location by Folds Point. In between GH and CL, this is not a pre-established pupping site, but has been seen to have a pup before in 2014. It is

recommended that this site is monitored during future surveys, and if pups are consistently born here, this may need to be added as a pupping site. It is also recommended that boat surveys continue to monitor the potential of pups born outside established pupping sites, as other years may see alternate results.

Figure 16. Examples of the habitat on the East and West coastline of the island, showing sheer cliff edges with little to no haul-out habitat

Survey seasons have usually run until the beginning of November, with the previous four years ending before the 4th of November just before the Calf shutdown due to weather conditions potentially hindering leaving the island. This year it was possible to stay until the 13th of the month, a further 10 days compared to the previous two seasons. During this time only an additional two pups were born (3.08%), but seals did start hauling out to moult. This not only made observations difficult due to obstruction, but also risked large number of seals 'flushing', which can result in injury to the individuals. Pups are occasionally born outside of the breeding season (Westcott and Stringell, 2003) for example, the southwest of Britain breeding season for grey seals is between September-October (Morgan, Morris & Stringell, 2018), but the 2021 survey season on Skomer Island saw pups born in November, although this only contributed to 1.1% of the total number of pups (Büche, 2022). The results of this survey, supported by previous studies (Morgan, Morris & Stringell, 2018; Büche, 2022), provide evidence that pups born outside of the pupping season for the Calf of Man; early September – early November; is low, and that the dates of previous surveys have covered the bulk of the pupping season. This along with the expense of disturbing a large number of hauled seals, suggests that there is little benefit to extending the survey season.

Pup trends

Weekly Trends

The weekly pup distribution spanned over an 11-week period, starting at the beginning of September. The trend from the 2022 season is variably different to the previous seasons average. Rather than a gradual increase until peak, and then a decrease, weeks fluctuated with a large spike of births on the fifth week, with pup numbers double that of the previous highest weeks total of nine. This variability could have been due to weather conditions. It has previously been hypothesised that some seal species can delay parturition in relation to adverse weather conditions (Temte, 1994; Morin 2020). On the date 'Storm Ian' hit, surveys confirmed no pups were born, but in the following two days, six pups were born, including at site PU, one of the worst hit breeding sites of the storm. Additional evidence for this hypothesis is weak, and therefore it is not possible to prove this hypothesis. Instead, it could be that as there were a high number of births at sites with good visibility (GH, CH, MG, PU), there was a more accurate representation of when pups were born in comparison to previous years.

The peak for the 2022 season and the previous year's average peak did fall on the same week albeit for a shorter period. Overall, when looking at the distribution, 56.93% of pups were born in the first five weeks (1st September – 5th October) in the 2022 season and 43.08% born after this period. When comparing this to the previous seasons average - with 50.30% and 49.70% respectively - more pups were born at the beginning of the season for 2022. This, along with the average birth date being early, suggests that the birth period for pups is moving forwards. Trends such as these have been seen in other breeding seal populations including in a long-term study of pup births on Sable Island (Bowen *et al.,* 2020) as well as on Skomer Island with the birthdate in 2020 being earlier than previous years (Wilkie & Zbijewska, 2021).

Since 2020, the start date for the survey season has been in early September, with the aim to catch the beginning of the pupping season. This so far has been successful, with this year the first pup being seen on the first survey day, 06/09/2022 confirmed as a stage 1 pup (<2 days old) and the second pup being born on the 8th. Not only is it advised that future survey seasons should aim to start at the beginning of September, but also if the pupping season is moving forward in response to climate change (Bowen *et al.,* 2020; Bull *et al.,* 2021), the start date of the survey season should continuously be monitored in order to catch the start of the pupping season.

Mortality

Pup mortality was only recorded when the remains of a deceased pup was visible to surveyors. Three pups were confirmed deceased this season, representing 4.62% of the pups born on the Calf of Man in 2022, less than the average and for the past two years. This year there were strong winds blowing into the south of the island, creating high tides and rough sea states (Figure 17). Bad weather conditions increase morality 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), with 2022 on the Calf being a potential indicator of this. Despite this, after storms this season no deceased pups were seen on the Calf, but there were reports of higher-than-average deceased pups seen on the Isle of Man (Howe, 2022). It is feasible however that some pups died during the survey but were not recorded as no remains were seen. Of the 62 pups, 17 (26.15%) were classed as 'missing' during the survey, so it is possible that some missing pups were, in fact, deceased.

The main causes of mortality in grey seal pups are starvation, infection, septicaemia, stillbirth and trauma (Baily, 2014). Of the three pups confirmed as deceased, one Pup, 'Zodiac', was stillborn as afterbirth was still attached to mother and pup. 'Yonder', the only pup born at LE, was first seen on the 10/10/2022 as a recently born pup (Stage 1). Two days later however on the next survey, the pup was confirmed as deceased with no mother in sight. Without a post-mortem we are not able to confirm the cause of death, although most seal pup deaths occur at stage 2, the stage 'Yonder' was when seen deceased (Quaggiotto *et al*., 2018; Russell *et al*., 2019). The third deceased pup was seen at CH and thought to be abandoned pup 'Xia'. Again, this could not be confirmed, but the deceased pup looked malnourished, and camera trap footage showed pup 'Xia' had gone missing the day before. Abandonment, leaving to starvation is one of the major causes of mortality in grey seal pups (Kovacs, 1987). If it was 'Xia', the pup would have been 10 days old and likely died from starvation.

Pup Distribution

Pup abundance was the highest at GH (n=15), which historically has been one of the most popular sites, although this year saw the highest number of pups recorded for this site (Figure 10). In fact, MG also saw a historically high number of pups born. Another observation this year, unlike previous years, was a higher pup count on the North side of the Island than the South. The reason for this is believed to be due to strong winds blowing into the south of the island, causing high tides and storm surges into the southern pupping sites, as demonstrated in Figure 17, whereby storm caused the

available hauling area to dramatically decrease. The south-westerly winds meant the island itself protected the northern pupping sites, which in comparison saw relative calm seas. In the case of MG, the long gully seems to provide protection, dispersing the waves as they enter and they therefore do not cause as much impact as they do on other sites, PU for example (Figure 17a, 17b). In addition, after the pebble beach there is a long grass verge, allowing for pups to seek protection high up, even when a high tide comes in. Females are thought to select a pupping site based on habitat (Twiss *et al.,* 2000) with optimal pupping habitats featuring low gradient shores, the presence of tidal pools or access to the sea, with no tidal or storm-surge influences. (Anderson *et al*., 1979; Twiss *et al.,* 2001; Weitzman *et al.,* 2017). A study of grey seal habitat selection on Sable Island found dangerous environmental conditions were the most likely influence of birth site selection (Allen, Bowen & den Heyer, 2022), presumably because these provide safer environments for pups. This could explain the high number of pups at GH, CH, GI and MG. These sites provide shelter, reduced flooding and have large areas for the pups to use during high tides. The Sable study indicates that females are less likely to use sites subject to flooding and storm surges, which could be why site GL wasn't used this season, and why pups were born at SH or PU (excluding the miscarried pup) after these storms occurred.

Figure 17.a) Photo of site Puddle 1 (PU1) taken in 2021 showing usual haul out habitat available. b) Photo of the same site (PU1) in September 2022, showing high tide due to storm. c) Photo of overall view of the Puddle site, with example of waves crashing into site due to storm

The sites which had the highest success rate of fully weaned pups are seen in Figure 10 and 11. Most of the sites with a high success rate of 70% have been identified above as also having high quality habitats that protect pups. Pups in habitats likely to be flooded by high tides or sites negatively affected by storms are more likely to be separated from their mothers (Allen *et al.*, 2022). Premature separation from mothers vastly reduces pup survival (Anderson *et al.,* 1979). As well as separation, studies have found that pups raised in floodable habitat were lighter at weaning by about 1 kg – 1.5kg than those raised in non-floodable sites (Weitzman *et al.,* 2017; Allen *et al.,* 2021). Pup survival increases with increased weight at weaning (Bowen, den Heyer, Mcmillan, & Iverson, 2015; Hall, McConnell, & Barker, 2001) and therefore floodable sites could see a lower success rate of pups. As above, females are said to select sites of high habitat quality, particularly protection from environmental factors. The high pup numbers at these sites could be why we saw a high survival rate this year compared to the previous three years**,** despite the storms. It should be noted however, although Cletts shows a 100% success rate, there was only one pup that was born there, seen on the last day of survey as stage 3, and may not be conclusive of the safety of the site. Similarly, low success rates at certain sites, including BF, GI and SC could be due to poor visibility of the sites, making it harder to track pups until stage 5, rather than a low success rate.

Additional Observations

Allosuckling

During this year's surveys on the Calf, two instances of allosuckling were observed; whereby a mother feeds a non-filial pup as well as providing protection and care (Maniscalco *et al.,* 2007). Cases of allosuckling have been recorded in the past three years on the Calf of Man, as well as in other studies of grey seals (McCulloch *et al.,* 1999) and many other pinniped species (Franco-Trecu *et al.*, 2010, Maniscalco *et al.,* 2007). Whilst it has been frequently recorded, little is understood about the behaviour. Roulin (2002) has come up with five hypotheses for the behaviour: (1) Allonursing results from misguided parental behaviour. (2) Females reciprocate by nursing each other's offspring. (3) Females nurse related juveniles for inclusive fitness benefits. (4) Females nurse alien offspring to evacuate milk that their own offspring did not drink. (5) Inexperienced females that lactate spontaneously without reproducing themselves or that have lost their litter nurse alien offspring to improve their maternal skills.

First instance of allosuckling occurred during October at Puddle. Although considered as one large site, for ease of tracking seal pups the site has been split into PU1, PU2 and PU3. Pup Yuki was seen at PU1 with mother till stage 2/3 before swimming to PU2. During this time, 302 had given birth to

Yahoo, who was at stage 2 when Yuki arrived. Yuki was observed hauling out to PU2 and on arrival 302 immediately allowed Yuki to suckle alongside Yahoo. Camera traps were set up to monitor this interaction over four days, with photos collected confirming that Yuki was not visited by mum during stay at PU2. After remaining at this site for 3 days, Yuki left and appeared at PU3 with mum two days later. To observe such instant acceptance by 302 and nursing behaviour contrasted significantly to the common aggression mothers usually show towards alien pups.

The second instance where allosuckling was observed was at Grants Harbour, where two pups 'Zip' and 'Zag' were seen suckling from one female, 312 (Figure 18). Pups 'Zip' and 'Zag' were both first seen on the 20/10/2022, as stage 1 pups, in a small cave in a gully at GH. At the first sighting, two females were seen with the pups, suspected to be the mothers, one being 312 and the other being a new mother. After the first sighting, 'Zip' was seen suckling with 312 and swimming together but the additional female was not seen again with 'Zag', nor any other female. In order to confirm filial relationships, additional camera traps were set up looking into the cave as well as a stake out at the site to try to catch 'Zag's mother and confirm filial relationship. The results however, showed seal 312 had been allowing both pups to suckle from her. Although the condition of 'Zag' showed that they were not fed often, being smaller and moulting early, signs of malnourishment and abandonment. Of the hypothesis presented by Roulin (2002) misguided parental behaviour is the most likely reason for this female to allow the non-filial pup to suckle, whereby recognition errors and/or inattentiveness by lactating females can lead her to allow a non-filial pup to suckle (de Bruyn *et al.,* 2010). Although mothers and pups identify each other through vocalisation and olfactory cues, this does not prevent instances of allosuckling (McCulloch, Pomeroy & Slater, 1999). Separation of mother and pups and density of pups has been shown to lead to allosuckling behaviour (McCulloch & Boness, 2000). Although there were only two pups, the area was very small, which could have led to confusion from the mother to identify her pup when returning from a feeding trip. Along with this, pup 'Zap' was abandoned by their filial mother, which could have also led to the allosuckling behaviour, as previously observed in harbour seals when a pup is abandoned (Arso *et al.,* 2021).

Figure 18. Photograph of mother 312 showing allosuckling behaviour with biological pup, 'Zip' and non-filial pup 'Zag'. Taken at Grants Harbour on the 2022 (Manx Wildlife Trust, 2022).

Pup Abandonment

During the 2022 survey, a total of two pups were considered to have been prematurely abandoned, known as 'Zap' and 'Xia'. Pups were classified as abandoned if the mother was not seen with, and/or nursing a pup who hadn't reached weaning age. Abandonment typically occurs in the early stages, whilst the pup is reliant upon milk and has a full lanugo coat. Observing a pup that was not putting on weight, as well as trying to suckle from other pups and rocks, also indicated a pup was abandoned and malnourished. Due to the malnourishment, pups moult at a much earlier age (pre stage 4), and can be identified as they are smaller, weaker and thinner than a typical stage 4 pup. To confirm abandonment, additional camera traps were vital to monitor the pup. Once an individual was identified as potentially without it's mother, camera traps were set up to constantly monitor the area (1 photo every minute) for 48 hours.

As mentioned above, pup Zap was abandoned by their mother (Figure 19b), with the potential mother only seen on one occasion, not long after the pup's birth. Whilst it is hard to confirm the reason for abandonment, in this case, two pups were born close together within a small inlet and cave. Mothers of young pups show aggression to other females that get close to their pup, as well as aggressive encounters between females when one is trying to gain access to enter the sea, which is why areas with small gullies and inlets have a high risk of mother and pups being separated (Stephenson, Matthiopoulos & Harwood, 2007). Mother 312 may have shown aggression towards

the mother of 'Zag', something that was seen briefly at the first sighting of the pups, thus causing mother and pup to be separated and hindering the mother having the ability to bond with the pup. Without this important bonding between mother and pup, the mother may abandon the pup (Robinson *et al*., 2015), which could have been the reason behind this case.

The second pup abandoned was 'Xia'. This pup was never observed with a mother and during observations showed thin body condition and attempts to suckle on rocks and other pups (Figure 19a). It is unknown why the pup was abandoned, possibly due to an inexperienced mother, or pup wandering from natal site leading to mother and pup becoming lost and separated**.** One observation is that of the two years that pups have been recorded as abandoned (2021 and 2022), all abandonments were at northern sites CH and GH, which are next to 'The Sound'. A study in 2007 found a high level of disturbance of seals hauled out at The Sound, mainly due to recreational vessels passing through (Peters, 2007 (as cited in Howe, 2018)). Human disturbance can decrease survival rates of pups, particularly if disturbed within the first few hours of birth, which may result in the abandonment of the pup (Burton *et al*., 1975; Robinson *et al*., 2015). It should be noted however, that since the study, government and charity organisations, including the Manx Wildlife Trust, have worked to raise boat users' awareness of seals and other marine protected species in order to minimise this disturbance (Howe, 2018). Although the exact causes of abandonment could not be identified, due to the measures put in place, human disturbance may have played a role. Pup abandonment should continue to be monitored including sites where abandonment takes place, with the possibility of identifying any contributing factors, including if anthropogenic disturbance which may be responsible. This could then potentially lead to actions being taken to reduce the occurrence of abandonment.

There was an attempt to rescue 'Xia' to be taken to a seal rescue and rehabilitation centre on the Isle of Man. Preparations were made with a vet coming to the Calf but unfortunately the beach was crowded with other mothers and pups, including one that was blocking the entrance to the gully where 'Xia' was. It was deemed to be unsafe to attempt a rescue. Not long after, a deceased pup was seen at CH, strongly thought to be Xia.

Figure 19.a) Abandoned pup 'Xia' suckling off other pup, a clear indication of pup abandonment. Also demonstrates size difference between pups. b) Pup 'Zag' showing early stages of moulting despite being several days old and underweight from abandonment.

Adult Distribution

Regarding the size of the adult grey seal population, Figure 12 shows the average seal count spread across the various sites on the Calf. This map visually demonstrates how populous each site is, although the surveys are not a full representation of site usage, the use of daily surveys over the season allow us to calculate a fairly good representation during the breeding season. Following similar trends to previous years, The Cletts, Puddle and West of Cow remain to be the more popular sites visited by adults. The popularity of these sites is perhaps owed to site quality and habitat. These locations provide large rocky coastlines for hauling out, suspected to be the main attraction of these sites (Weitzman, den Heyer and Bowen, 2017). However, studies do suggest that preference of site for hauling out and feeding may be determined by simple sociality; an interesting theory that hypothesises that annual associations between same sex non-cooperative aggregations, such as, female seals, may provide another explanation for why seals choose certain sites (Pomeroy *et al.*, 2005).

The Isle of Man and the Calf of Man are considered key sites for the British grey seal population, with a large proportion of individuals utilising Irish and Celtic waters for passage and foraging, therefore these islands are used frequently by visiting seals (Howe, 2018). As suggested, the island hosts a high number of transient individuals. Therefore, the development of this catalogue will be a useful method of monitoring movement and site usage. For instance, in 2022, 29 mothers were identified as returning mothers to the Calf of Man, with 112 new non-pupping females added to the catalogue, with 63 non-pupping females matched with previous visitors. Surveying throughout the

breeding season, alongside whole island surveys may be a useful technique to monitor how many individuals are returning, remaining or passing through as a stopover site; an interesting avenue of research to identify how seals utilise these sites (Sayer *et al.*, 2019). Furthermore, Grey seals are known to use different sites to support different periods of their annual cycle, therefore, collecting monthly counts and understanding usage throughout the year would be very informative, for example, for SACs. What's more, studies reveal how poorly conserved undesignated areas can cause further negative consequences later on in the annual life cycle, emphasising the need to understand which areas are used and where protection is needed (Curtin and Prellezo, 2010). This highlights how the use of photo identification on the Calf of Man and further monitoring throughout the year has the potential to inform site connectivity and the application of designated sites (Hays *et al.*, 2016). Catalogues such as these have the potential to assess site usage and large-scale movement patterns, further informing SACs and conservation efforts.

Site Fidelity

From the long-term data collected on individual seals which use the Calf of Man site, fecundity and site preference patterns can be investigated. Using this data, we can look at site fidelity for the year as well as for each site. As seen in Figure 14, it is clear that site fidelity from years 2021 and 2022 varies significantly, with some sites in 2022 having 0% to 100% fidelity. Additionally, from the analysis 76.5% of mothers appeared to utilise two or fewer pupping sites. This data describes varying faithfulness to sites between 2021 and 2022, however, it does imply that returning mothers are committed to a selection of sites to pup. From the literature, there are numerous contrasting theories which attempt to explain site fidelity behaviour in grey seals. Several influences may affect the choice to remain or move to a site. Studies propose predictability of habitat type, reproductive success and natal connections as suggested factors which dictate this behaviour (Thompson *et al.*, 1996). However, as forementioned, there are contrasting findings; with site fidelity and choice poorly understood (Giuggioli and Bartumeus, 2012). An additional factor is suggested by Weitzman, den Heyer and Bowen, who dictates a comprehensive synthesis of these theories, and further implies that choice of site fidelity may be based on external cues: local density and social interactions (Weitzman, den Heyer and Bowen, 2017). An increasing number of studies begin to suggest that social interactions and "public information" are main components which inform decision making (Pomeroy *et al.*, 2001). This may be exhibited in grey seals, during the breeding seasons as seals aggregate to sites, females may use social cues such as local density to determine site choice and habitat quality (Weitzman, den Heyer and Bowen, 2017). Additionally, this paper suggests that the performance of neighbouring individuals at sites may impact site choice, this has

been seen in similar species; e.g. New Zealand sea lions (Weitzman, den Heyer and Bowen, 2017). This may be an acting mechanism on the Calf of Man, perhaps causing the annual trend seen in site aggregations; for example, the trends seen from year to year, with adult distribution most abundant at three main sites: The Cletts, West of Cow and the Puddle. What's more, as pupping season begins, it could be suggested that seals will choose pupping site based on where their conspecifics choose to breed. This is an interesting field of research, looking into social cues to inform decision making. The combination of all these influences may allow a fuller understanding as to why seals may follow predictable site use.

Birthday Analysis

Over recent years, it has become increasingly apparent that there has been a shift in the timing of birthdates. Last year's report shows 71% of the returning mothers pupped earlier, similar to this year's findings of 62% earlier births. This trend has been evident in numerous species, with a shift in phenology recognised as a consequence of climate change (Root *et al.*, 2003). With sea surface temperatures rising, scientists are beginning to see the impacts on marine organisms (Bull *et al.*, 2021); with research focussing on the consequences for marine mammals, such as the grey seal population (Sydeman *et al.*, 2015). Studies on grey seals demonstrate an association between temperature increase and the advancement of pupping season. Research has found increases by 2°C to advance dates by seven days (Bull *et al.*, 2021), alternatively, research in the Farne island finds a 1°C lower temperatures associated with a 13-day delay in breeding (Coulson, 1981). It is suggested that temperature determines physiological processes related to implantation, hypothesising that sea surface temperature fluctuations will influence breeding times. Alternatively, another hypothesis attempting to explain this trend in birthdates at a population level, rather than at an individual level, is the age structure hypothesis (Coulson, 1981). In grey seals, older adults have larger home ranges and are prone to much larger-scale movement in comparison to younger individuals. Recent research therefore suggests that older individuals are able to move to sites which have more favourable environmental conditions; thus increasing the average population age at these locations (Reijnders, Brasseur and Meesters, 2010). Taking this into consideration, coupled with trends seen in older grey seals such as more successful weaning and earlier reproduction, it is plausible that climate change affects phenology and population dynamics through alterations to age structure (Bull *et al.*, 2021). This contrasting theory provides a different outlook to consider when explaining phenological responses and shifts (Langley *et al.*, 2020). This could explain variability seen at different sites, with changes in age composition as a response to fluctuations in sea surface temperature.

Further Recommendations

Isle of Man Pupping Season Survey

To gain a greater understanding about the seal population for the Isle of Man, we would suggest the implementation of breeding seal surveys on the Isle of Man as well as the Calf. Although the Calf of Man is the main pupping site for the Isle of Man, there are also important pupping sites on the mainland, including the Maughold Coast and between Bradda Head and Stroin Vuigh (Howe, 2018). An observation by surveyors has been that pregnant females are seen on the Calf of Man, but do not appear to pup here. This is possibly because they use the mainland, but without monitoring pupping in the Isle of Man we are unable to confirm this. In addition, the sharing of data between the Calf and Isle of Man would provide additional data about site fidelity, pup survival rates, pup movements between the islands and the possibility to compare factors that could affect the pupping season, such as the impact of human disturbance.

Citizen Science Surveys

As previously stated, the land only surveys may not capture the full picture for the pupping season, as pups may be born outside the visibility of these surveys. Although the introduction of boat surveys has reduced this limitation, the number of boat surveys that are able to be conducted during the breeding season is limited. During the season there are other boat users that come around the island, including fishing boats, kayakers and divers. With the appropriate briefing on what pictures would be beneficial and suitable behaviour when around pupping seals, the additional photographs could benefit the survey results. In addition, this could also assist the potential Isle of Man surveys with the inclusion of visitors to beaches to photograph mothers and pups, again on the condition that they are briefed, possibly with signage, on how to act appropriately around the seals.

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Appendix

Appendix A – Developmental stages of grey seal pups

Table 10. Details of the timings and recognition features of the five stages of a grey seal pup development. Developed by Kovacs and Lavigne (1986); Radford et al., (1978).

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 B – Glossary of Terms

Term	Definition
Allosuckling	When a female feeds a pup that is not her own offspring.
Anthropogenic	An environmental change cause or influenced by people.
Carrying Capacity	The maximum population size of a species in an environment.
Conspecific-Attraction Hypothesis	Individual space use is dependent on the distribution of others of the same species
Filial relationship	A link between the parent and their direct offspring.
Hauled-out	When seals come out of the water and spend time on dry platforms.
Lanugo	The white hair that covers seal pups before their first moulting.
Moulting	When seals shed their hair and replace it with a new growth of hair.
Pelage	The hair covering a seal's body.
Pinnipeds	A suborder of carnivores referring to the group of fin or flipper footed marine mammals
Post-Mortem	An examination of a carcass to determine cause of death
Weaning	The process or causing young to stop feeding on their mother's milk.

Appendix C – Calf of Man Births 2022

Table 7. Overview of the pups recorded on the Calf of Man in the 2022 breeding season. The data shows when the pups were first seen, last seen and when they were recorded as being Stage 5 pups. The complete spreadsheet including information on developmental stage timings can be found on the MWT hard drive.

Pup Number	Pup name	Date first seen	Location	Mother ID	Stage 5	Date last seen
1	Xanadu	06/09/2022	GH	017 Eva	24/09/2022	26/10/2022
2	Xavier	08/09/2022	GI	019 Orange Spot		28/10/2022
3	Yaretzi	11/09/2022	BF	120 Bullseye		18/09/2022
4	Zabeth	16/09/2022	CH	487	05/10/2022	25/10/2022
5	Yoda	17/09/2022	SC	248	06/10/2022	06/10/2022
6	Yogi(Bear)	19/09/2022	MG	62		14/10/2022
7	Zumba	20/09/2022	GI	367		30/09/2022
8	Zola	20/09/2022	GH	195	09/10/2022	21/10/2022
9	X marks (the spot)	19/09/2022	SC	046		26/09/2022
10	Yasmin	21/09/2022	SC	139		05/10/2022
11	Yam	21/09/2022	MG	181	12/10/2022	22/10/2022
12	Yom	21/09/2022	MG	203	16/10/2022	16/10/2022
13	Zazu	24/09/2022	GH	306	13/10/2022	21/10/2022
14	Xema	24/09/2022	MG	491	16/10/2022	22/10/2022
15	Yoshi	24/09/2022	Fold Point*	499		01/10/2022
16	Yeti	25/09/2022	SC	127		06/10/2022
17	Zodiac	25/09/2022	PU			
18	Yum	27/09/2022	MG	223	19/10/2022	26/10/2022
19	Yuck	29/09/2022	GI	500		05/10/2022
20	Ziggy	29/09/2022	MG	490	28/10/2022	28/10/2022
21	Yolanda	29/09/2022	MG	194	19/10/2022	19/10/2022
22	Xebedee	29/09/2022	MG	107	24/10/2022	26/10/2022
23	Xantus's	29/09/2022	SC	Unknown		02/10/2022
-	LE1	29/09/2022	LE	Unknown	29/09/2022	29/09/2022
24	Yoghurt	28/09/2022	PU	303	20/10/2022	22/10/2022
25	Zulu	01/10/2022	GI	503	27/10/2022	27/10/2022
26	Yuki	01/10/2022	PU	492	24/10/2022	26/10/2022
27	Zorro	01/10/2022	CH	4	21/10/2022	25/10/2022
28	Zeal (the Seal)	01/10/2022	CH	14	17/10/2022	23/10/2022
29	Yacob	02/10/2022	PU	488	24/10/2022	24/10/2022
30	Yahoo	02/10/2022	PU	302	24/10/2022	28/10/2022
31	Xion	03/10/2022	GH	5	15/10/2022	21/10/2023
32	Yawnies	03/10/2022	CH	290		09/10/2022
33	Xia	03/10/2022	CH	Unknown		09/10/2022
34	Yaya	04/10/2022	GH	40	25/10/2022	25/10/2022
35	Yelrah	04/10/2022	SH	489	20/10/2022	20/10/2022
36	Yellow-browed	04/10/2022	MG	150	24/10/2022	26/10/2022

Deceased pup

Stage pup last seen

New pups not seen at S1 and no apparent Mother

37	Xanthia	05/10/2022	GH	256	27/10/2022	31/10/2022
38	Zebra	07/10/2022	GH	502	02/11/2022	08/11/2022
39	Zambia	09/10/2022	GH	501	31/10/2022	31/10/2022
-	GH1	09/10/2022	GH	Unknown		09/10/2022
40	Yonder	10/10/2022	LE			
41	Xander	10/10/2022	PU	494	28/10/2022	28/10/2022
42	Zante	10/10/2022	PU	497	30/10/2022	30/10/2022
43	Yodel	10/10/2022	PU	493	26/10/2022	26/10/2022
44	Zale	12/10/2022	PU	230	01/11/2022	11/01/2022
-	SH1	12/10/2022	SH		12/10/2022	12/10/2022
45	Xemena	13/10/2022	CH		03/11/2022	03/11/2022
46	Yoblet	13/10/2022	CH	373	29/10/2022	29/10/2022
47	Xamini	13/10/2022	GH	498	02/11/2022	02/11/2022
48	Yoyo	11/10/2022	GH	221		25/10/2022
49	Xerus	15/10/2022	GH	403	06/11/2022	06/11/2022
50	Zeus	17/10/2022	CH	298	10/10/2022	10/10/2022
51	Yaw	20/10/2022	GH	406	12/11/2022	12/11/2022
52	Zip	20/10/2022	GH	312		04/11/2022
53	Zag	20/10/2022	GH	Unknown		04/11/2022
54	Zink	21/10/2022	BF	Unknown		24/10/2022
55	Xylophone	22/10/2022	MG	495	13/11/2022	13/11/2022
56	Yabadabadooo	22/10/2022	SH	496	13/11/2022	13/11/2022
57	WoC1	22/10/2022	WoC	Unknown		22/10/2022
58	Xenia	25/10/2022	CH	278		13/11/2022
59	CH1	27/10/2022	CH	Unknown		27/10/2022
60	Yule	30/10/2022	SH	504		11/11/2022
61	Zeke	30/10/2022	SH	440		11/11/2022
62	Yelly	31/10/2022	GH	505		12/11/2022
63	Zauren	31/10/2022	CL	506		12/11/2022
64	Yug (Fawkes)	05/11/2022	PU	507		13/11/2022
-	MG1	07/11/2022	MG		07/11/2022	07/11/2022
65	Yuca	08/11/2022	GI	508		13/11/2022