

# Grey Seal (*Halichoerus grypus*) Pup Production and Distribution in North Wales during 2017

Report No: 293

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Report number: NRW Evidence Report No. 293.

Publication date: 2023

Contractor: Ocean Ecology Limited

Contract Manager: T.B. Stringell

Title: **Grey Seal (*Halichoerus grypus*) Pup Production and Distribution in North Wales during 2017**

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Technical Editor: T.B. Stringell

Peer Reviewer(s) K. Ramsay, C.W. Morris, C.P. Lindenbaum, T.B. Stringell

Approved By: K. Davies

Restrictions: None

## Recommended citation for this volume:

Robinson G.J., Clarke L.J., Banga R., Griffin R.A., Porter J., Morris C.W., Lindenbaum C.P. & Stringell T.B. (2023). Grey Seal (*Halichoerus grypus*) Pup Production and Distribution in North Wales during 2017. NRW Evidence Report No. 293. 66pp. Natural Resources Wales, Bangor.

# Contents

About Natural Resources Wales .....	2
Evidence at Natural Resources Wales .....	2
Recommended citation for this volume: .....	3
Contents.....	4
List of Figures .....	5
List of Tables.....	7
1. Crynodeb Gweithredol .....	8
2. Executive Summary .....	9
3. Introduction .....	10
3.1 Grey Seal ( <i>Halichoerus grypus</i> ) Distribution and Conservation Status.....	10
3.2 Breeding Ecology and Current Pup Production Estimates for North Wales.....	10
3.3 Aims and Objectives .....	11
4. Methods .....	13
4.1 Study Area and Site Selection .....	13
4.2 Survey Methodology .....	14
4.3 Analysis.....	20
5. Results .....	26
5.1 Survey Effort .....	26
5.2 Total Pup Production and Breeding Season Duration.....	28
5.3 Breeding Distribution and Habitat Preferences .....	29
5.4 Estimates of Uncertainty.....	41
6. Discussion.....	44
6.1 Pup Production Estimate .....	44
6.2 Spatial Distribution of Pupping Activity .....	44
6.3 Habitat Preference.....	45
6.4 Data Limitations .....	46
6.5 Pup Production within the Pen Llŷn a'r Sarnau SAC.....	47
6.6 Conclusions .....	48
7. References.....	49
8. Appendices .....	52
Appendix 1. Site Prioritisation.....	52
Appendix 2. Stakeholder Engagement .....	53
Appendix 3. Photo Catalogue .....	53
Appendix 4. Pup matching protocol to determine pup identity as either new or that of a previously recorded individual .....	54
Appendix 5. Survey effort timeline by survey area .....	55
Appendix 6. Bubble plots by area to show pupping activity at all sites .....	59
Data Archive Appendix .....	65

# List of Figures

Figure 1: Map to show the North Wales region and survey areas used to form the basis of surveys throughout the 2017 pupping season. ....	13
Figure 2: Fourth-order polynomial curve (dotted line) fitted to pup count data collected on the South Lleyn peninsula in September 2017 to estimate earliest potential date of birth and start of the pupping season, as the point at which the curve intersects a pup. ....	23
Figure 3: Survey effort per survey area during the 2017 North Wales grey seal census. Effort represents the mean number of days between each survey. High effort = <10 days, Medium = 10-25 days & Low = >25 days. ....	27
Figure 4: Stacked bar chart illustrating the number of sites across the listed survey areas accessed by moving vessel, kayak or walkover throughout the 2017 pupping season, North Wales. ....	28
Figure 5: a) Spatial distribution of pupping sites across the North Wales region during the 2017 breeding season and b) the main areas of pup production identified. ....	30
Figure 6: Total pup production at each survey area across the 2017 breeding season, indicating the number of age class I-IV (dark blue) and age class V (light blue) pups recorded. ....	31
Figure 7: Total number of pups of age classes I-IV (dark blue) and age class V (light blue) observed in each survey area in each month of the North Wales 2017 breeding season.....	32
Figure 8: Total pup production per habitat type over the 2017 grey seal survey in North Wales. ....	37
Figure 9: Total number of pups of age classes I-IV (dark blue) and age class V (light blue) observed in each habitat type in each month of the North Wales 2017 breeding season.....	37
Figure 10: Total observed pup production across the North Wales region from surveys conducted in 2001 (Westcott, 2002), 2002 (Westcott & Stringell 2003), 2004 (Stringell et al 2014) and 2017 (this survey).....	38
Figure 11: Total pup production at each survey area within the North Wales region in 2002 (light blue bars: Westcott & Stringell 2003), 2004 (dark blue bars: Stringell et al 2014) and 2017 (grey bars: this survey). * indicates areas that were not surveyed in previous years. ....	40
Figure 12: Flow chart of the process for the pup matching protocol.....	54
Figure 13: Map to show total observed pups along the westernmost section of the South Lleyn in 2017 and all recorded potential sites. Pie chart to show the proportion	

of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded within the South Lley. .... 59

Figure 14: Map to show total observed pups on Bardsey Island in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded on Bardsey Island. .... 60

Figure 15: Map to show total observed pups at Holy Island (North) in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded within Holy Island (North). .... 61

Figure 16: Map to show total observed pups on The Skerries in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded on The Skerries. .... 62

Figure 17: Map to show total observed pups at Carmel Head in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded along Carmel Head. .... 63

Figure 18: Map to show total observed pups at The Ormes in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded at The Ormes. .... 64

## List of Tables

Table 1: Pup aging classification used during the 2017 survey based on Smith (1966) with example imagery. ....	18
Table 2: Pup identification methods. ....	20
Table 3: Potential sources of error in pup production estimates including a brief description and the methods used to quantify the level of error. ....	22
Table 4: The total number of sites of each habitat type surveyed (n=332) and number of sites where pups were recorded (n=82) during the 2017 grey seal survey in North Wales. Data are expressed as total numbers and percentage of total number of pupping sites surveyed. Note that ‘islands’ refers to smaller rocky outcrops separated from the main survey areas that are classified as single potential pupping sites.....	36
Table 5: Observed pup production at each survey area within the North Wales survey region, including minimum estimates (i.e. all Age Class I – IV observed), counts of weaned pups (age class V), individual estimates of error per area and by source of error, and a maximum upper estimate, which combines the minimum estimate with class V pups and all sources of error. NB: The ‘Estimate Observed pup count’ is based on the assumption that all Age Class V pups originate from outside of the survey area boundary or were already counted. The ‘Maximum Upper Estimate’ is combined upper estimated in which all sources of error are added to the observed counts and weaned pups (Age Class V) included in count per area. ....	42
Table 6: Dates of surveys conducted in September for each survey area. Cells marked with ‘X’ denote the survey date.....	55
Table 7: Dates of surveys conducted in October for each survey area. Cells marked with ‘X’ denote the survey date. ....	56
Table 8: Dates of surveys conducted in November for each survey area. Cells marked with ‘X’ denote the survey date.....	57
Table 9: Dates of surveys conducted in December for each survey area. Cells marked with ‘X’ denote the survey date.....	58

# 1. Crynodeb Gweithredol

Nid oes dealltwriaeth dda o statws morloi llwyd yng ngogledd Cymru oherwydd mynediad anodd i natur gymhleth yr arfordir a diffyg monitro o ran cynhyrchiant lloi bach yn ddiweddar. Cynhaliwyd y cyfrifiad llawn diwethaf o loi morloi llwyd yng ngogledd Cymru yn 2004. Er mwyn sefydlu amcangyfrifon mwy diweddar o gynhyrchiant lloi bach a nodi safleoedd geni newydd ar hyd yr arfordir, cynhaliwyd arolwg llawn ar y tir rhwng Aberystwyth ac Aber Afon Dyfrdwy yn hydref 2017.

Arolygwyd yr holl safleoedd gweithredol lle mae lloi bach yn cael eu geni, a'r rhai sydd newydd eu nodi, mewn cyfnodau 7 i 10 diwrnod ar gychod, caiacau môr ac ar droed. Defnyddiwyd drôn i gynorthwyo'r arolygon o loi bach ac i fesur gwallau samplu yn Ynysoedd y Moelrhoniaid – techneg fonitro gymharol newydd a oedd yn ategu dulliau traddodiadol. Roedd ymgysylltu parhaus â rhanddeiliaid â grwpiau lleol ac aelodau o'r cyhoedd hefyd yn gymorth i nodi genedigaethau newydd a lloi marw oedd wedi mynd yn sownd; ymwelodd tîm yr arolwg â'r rhain yn ddiweddarach er mwyn dilysu a chasglu data. Mae'r canlyniadau'n awgrymu bod 279 o loi bach unigol o ddsbarth oedran I-V wedi'u geni ar draws 79 o safleoedd geni gweithredol drwy gydol y tymor. Mae hyn yn dangos cynnydd o hyd at 180% yn y nifer o loi bach a gynhyrchwyd a chynnydd o 145% yn nifer y safleoedd geni o gymharu â chyfrifiad 2004, er y dylid ystyried yr ymdrech arolygu fwy wrth ddehongli'r canlyniadau hyn. Mae'r canlyniadau hyn yn cyd-fynd â chynnydd sylweddol yn niferoedd y morloi llwyd yn ne-orllewin Cymru ar hyd arfordir Sir Benfro a ledled y DU. Roedd yr arolwg manwl a chydweithredol hwn yn ddull samplu cadarn a systematig drwy gydol y tymor geni. Cynhyrchodd ddata pwysig sydd wedi cynyddu'n sylweddol ein dealltwriaeth o statws morloi llwyd yn nyfroedd gogledd Cymru.



## 2. Executive Summary

The status of grey seals in North Wales is poorly understood due to difficult access to the complex nature of the coastline and absence of recent pup production monitoring. The last full census of grey seal pups in North Wales was in 2004. To establish more recent estimates of pup production and identify new pupping sites along the coastline, a full ground-based survey was undertaken between Aberystwyth and the Dee Estuary in the autumn of 2017.

All active and newly identified potential pupping sites were surveyed in 7 to 10 day cycles by boat, sea kayak and on foot. A drone was used to supplement pup counts and to quantify sampling error at The Skerries – a relatively novel monitoring technique that complemented traditional methods. Ongoing stakeholder engagement with local groups and members of the general public also assisted in the identification of new pup births and dead pup strandings, which were later visited by the survey team for verification and data collection. Results suggest that 279 individual pups of age class I-V were born across 79 active pupping sites throughout the season. This indicates an increase in pup production of up to 180% and an increase of 145% in the number of pupping sites in comparison to the 2004 census, although increased survey effort should be considered when interpreting these results. These results concur with substantial increases in grey seal abundances in South-West Wales along the Pembrokeshire coastline and across the UK. This focused and collaborative survey was a robust and systematic sampling approach throughout the pupping season. It generated important data that has significantly increased our understanding of the status of grey seals in North Welsh waters.

## 3. Introduction

### 3.1 Grey Seal (*Halichoerus grypus*) Distribution and Conservation Status

Grey seals (*Halichoerus grypus*) have a cold temperate to sub-Arctic distribution in North Atlantic waters over the continental shelf (Hall, 2002). The northeast Atlantic population is largely concentrated around the UK and Ireland but is also found around Iceland, the Faroe Islands, and along the European mainland coast.

Approximately 34% of the world's grey seal population resides in the UK, comprising between 117,500 and 168,500 individuals (SCOS, 2017). Around 3-4% of the UK population resides in Wales, with the majority of these occurring in South-West Wales along the Pembrokeshire coastline. The Welsh population of grey seals, however, may be under-represented in UK population estimates (SCOS, 2017), given that these estimates largely use data from Pembrokeshire and West Wales in the early 1990s (Baines et al., 1995) and pup production here has increased dramatically since then (Bull et al., 2017; Morgan et al., 2018; Strong et al., 2006).

The International Union for Conservation of Nature (IUCN) lists the global grey seal population as "Least Concern", with estimates suggesting that the population is increasing worldwide (Bowen, 2016). As the number of grey seals in Pembrokeshire has been increasing over the last few decades (Bull et al., 2017; Morgan et al., 2018; Strong et al., 2006), it is assumed that this is also the case for North Wales, although systematic monitoring of grey seals in North Wales has not been carried out since 2004 (Stringell et al., 2014).

### 3.2 Breeding Ecology and Current Pup Production Estimates for North Wales

Males may live for over 20 years and begin to breed from about age 10. Females often live for over 30 years and begin to breed at about age 5 (SCOS, 2017). Grey seals form polygynous breeding groups of varying sizes and sex ratios, depending on the nature of the habitat, and breeding site fidelity is relatively high (Pomeroy et al. 2000; Twiss et al. 1994).

The timing of breeding varies around the UK, getting progressively later in breeding colonies distributed clockwise around the coastline (JNCC, 2005). The grey seal pupping season in Wales typically runs from August to December, peaking in September and October and the weaning period is short (Bull et al., 2017, Westcott & Stringell, 2004). Lactation lasts around 17 - 23 days on average, and weaning is abrupt when females come into oestrus towards the end of lactation and mating occurs (SCOS, 2017).

Grey seals usually breed at sites varying in topography and habitat, ranging from open shingle beaches to rocky shores and sea caves. In Wales, the species notably

uses sea caves as pupping sites, with previous work having shown that more than 50 % of pups are born in cryptic habitats such as sea caves (Baines et al., 1995, Stringell et al., 2014).

The most recent data for pup production from the major breeding sites in Wales provide estimates of 96 pups produced in North Wales in 2004 (Stringell et al., 2014), 465 pups in North Pembrokeshire in 2005 (Strong et al., 2006) and an average of 345 pups born on Skomer and adjacent mainland sites between 2012 and 2016 (Lock et al., 2017).

Grey seals receive protection in Wales under various national and international legislation (NRW, 2018). The species is protected nationally by the Conservation of Seals Act 1970 to 12 nautical miles from shore. The species is protected internationally under the EC Habitats Directive (Council Directive 92/43EEC), which is transposed into UK law through the Conservation of Habitats and Species Regulations and the Conservation of Offshore Habitats and Species Regulations 2017. These Regulations require the designation of Special Areas of Conservation (SAC) to protect species, such as the grey seal, listed on Annex II of the Directive. Thirteen SACs are designated within the UK for which grey seal is a qualifying feature, including the following in Wales:

- Pembrokeshire Marine / Sir Benfro Forol SAC;
- Cardigan Bay / Bae Ceredigion SAC;
- Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau SAC.

Of these Welsh SACs, the Lleyn Peninsula and the Sarnau SAC falls within the North Wales project area. One of the key responsibilities of the statutory nature conservation agency in Wales (Natural Resources Wales) is to report on the condition of the grey seal populations within these SACs. This is largely achieved by counting pups and documenting the distribution of pups and pupping sites (see CCW 2009 for site conservation objectives and monitoring attributes, and JNCC 2005 for UK Common Standards Monitoring guidance). Given that each female produces a single pup, pup counts provide a key tool for population modelling of the current and projected total adult population size (Cordes & Thompson, 2013; SCOS, 2017).

## 3.3 Aims and Objectives

The project aimed to identify potential and active pupping sites throughout the North Wales and to estimate pup production for the 2017 season, thereby improving our understanding of grey seal population status in North Wales.

### 3.3.1 Primary Objectives

The primary objectives of the project were to:

1. Survey and map the distribution of pupping sites to identify all active sites in North Wales, confirming the continued use of historical pupping sites and identify any new pupping sites;

2. Estimate the abundance of pups in North Wales during the 2017 pupping season;
3. Generate a pup production estimate specific to the Pen Llyn a'r Sarnau SAC; and
4. Collect data on the habitats utilised by grey seals across North Wales.

### **3.3.2 Secondary Objectives**

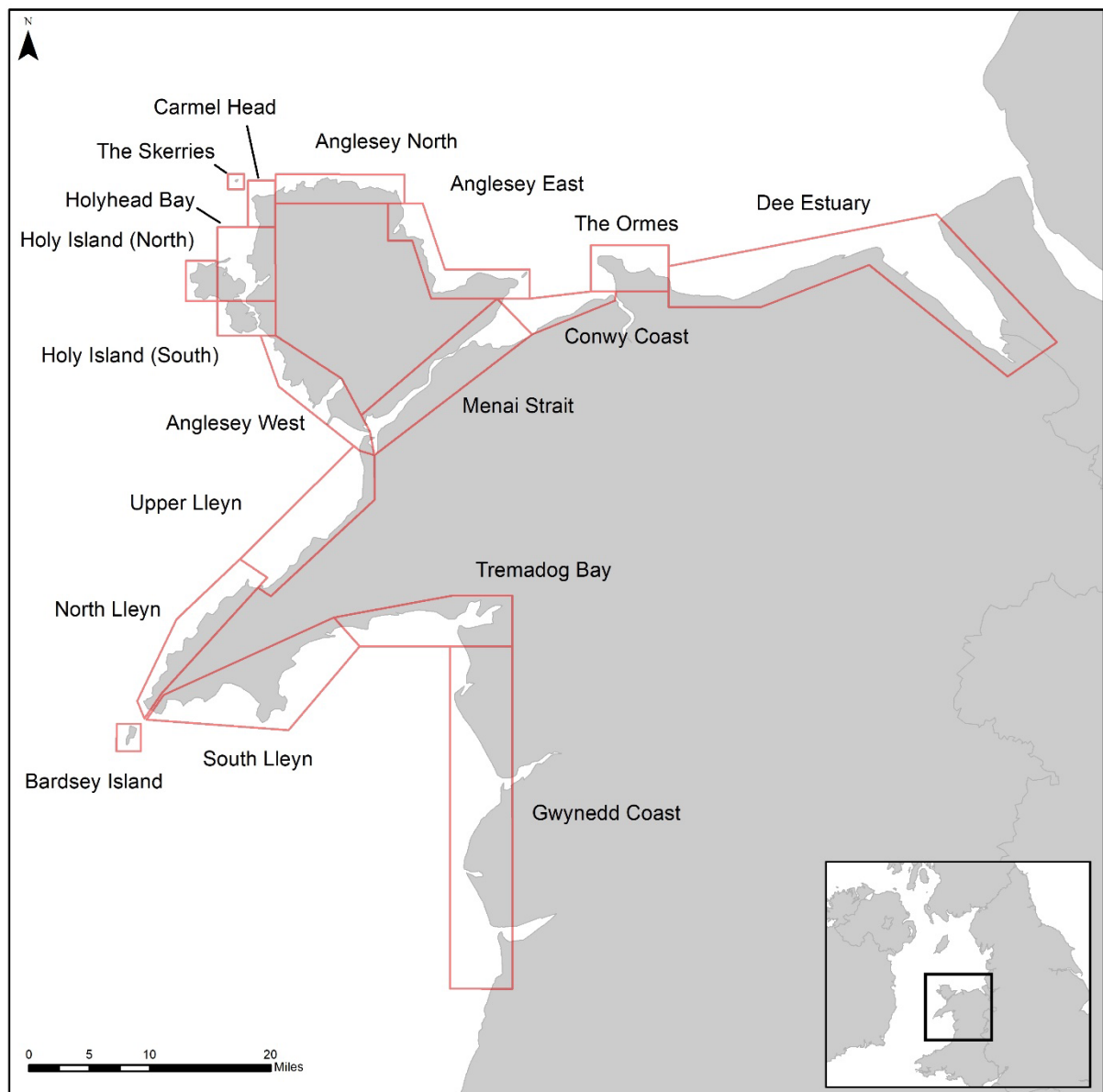
Secondary objectives of the project were to:

1. Provide recommendations on improvements to future monitoring and surveillance methods for grey seals in North Wales;
2. Investigate modern survey techniques with the use of an Unmanned Aerial Vehicle (UAV) to supplement traditional methods; and
3. Gather evidence describing any human activities or impacts affecting the different types of supporting habitat being selected by breeding grey seals.

## 4. Methods

### 4.1 Study Area and Site Selection

In order to define manageable locations for targeted surveys, the North Wales coastline was divided into survey areas consistent with a previous census undertaken in 2002 (Westcott & Stringell, 2003), with additional areas identified during the 2017 season (Figure 1). Holy Island was listed as an individual survey area in previous surveys, but due to the complex habitat characteristics and tides here the area was split into “North” and “South” components for this survey.



*Figure 1:* Map to show the North Wales region and survey areas used to form the basis of surveys throughout the 2017 pupping season.

A total of 126 potential and previously recorded pupping sites along the North Wales coast were defined based on data provided to Ocean Ecology Limited (OEL) by Natural Resources Wales (NRW). These data were derived from two previous grey seal pup censuses undertaken across North Wales in 2002 and 2004. Following a review of existing literature on the grey seal population within North Wales, examination of satellite imagery and surveyor experience of the region, an initial evaluation of the entire North Wales region was undertaken on foot and via vessel-based assessments on a Rigid-Hulled Inflatable Boat (RHIB).

Previous work has characterised grey seal breeding sites in North Wales as largely comprising habitats subject to zero or very minimal disturbance from both other seals and humans (Westcott, 2002). Survey effort was focused on those areas of the North Wales coastline with the greatest expected pupping importance. Details on how the team prioritised survey areas are given in Appendix 1. The chosen survey areas were surveyed either on foot or by RHIB to identify new pupping sites and to log all sites containing characteristic habitats.

Sites with historical evidence of pups were revisited and site descriptions updated where appropriate (e.g. notes on obvious erosion over time or where rock falls and cave wall / ceiling collapse had occurred). Throughout the duration of the grey seal pupping season, OEL maintained contact with local stakeholders to ensure that any encounters with either live or dead seal pups across the region, particularly those which had been previously excluded based on the above criterion, were reported and investigated by the OEL survey team. Further information on the stakeholder engagement process is provided in Appendix 2. This process enabled any pups, either live or dead, from areas not surveyed to be recorded and investigated where appropriate; survey effort was redirected when pupping activity was reported in any areas that had not been subject to targeted monitoring.

## 4.2 Survey Methodology

Field methods were developed in line with previous studies undertaken across North Wales (Westcott, 2002; Westcott & Stringell, 2003; Stringell et al., 2014), monitoring programmes elsewhere in Wales (Baines et al., 1995; Poole, 1996) and published guidelines for ground-based grey seal monitoring (Westcott, 2008). Surveys were largely conducted using coastal walkover surveys and vessel-based surveys. A trial survey using an unmanned aerial vehicle (UAV) was also conducted to assess the efficacy of this method in comparison to the principal methods used (Ocean Ecology, 2018a). Local information was sought to inform the survey team on site access and sites were typically accessed within a three-hour window either side of low water where possible. However, as day length shortened and the frequency of poor weather increased, survey timings became more flexible.

## 4.2.1 Coastal Walking Surveys

The Wales and Anglesey Coastal Paths were a primary means of access for walkover assessments. Additional permissions from local farmers allowed surveyors to pass through private land to reach both previously recorded pupping sites and new potential pupping sites. Mainland walkover surveys were conducted along all surveyed areas of coastline, excluding Holy Island and the South Lleyn Peninsula due to restricted access along areas of steep cliff. Sites identified with cryptic coastline (large boulders, bedrock shelves, cliff overhangs, caves) that could not be fully accessed on foot were noted for further investigation using a vessel and sea kayak.

## 4.2.2 Vessel-Based Surveys

Vessels were used to survey areas of coastline not accessible on foot and when conditions were suitable, sea kayaks were deployed for further investigation. Vessels used included a RHIB procured and operated by OEL for the duration of the survey period, “DeeBuoys II”, the survey catamaran “Top Cat” operated by Top Cat Marine Safari and the RHIB “Interceptor” operated by SBS RHIB Charter.

Vessel-based surveys were undertaken in Beaufort Force (Bft) 3 winds or less. Some sites were sheltered from prevailing winds and could be surveyed in higher wind speeds. The Skerries and Bardsey Island required wind speeds of Bft 0 – 2 for surveying due to their exposed nature and accessibility restrictions.

## 4.2.3 UAV Trial

A single UAV trial was conducted on October 27th, 2017 at The Skerries. High resolution images across the extent of The Skerries were captured and stitched together using licenced processing software. The flight was undertaken by a qualified UAV pilot under a Permission for Commercial Operations (PfCO) granted by the Civil Aviation Authority (CAA). The flight was conducted with the permission of Trinity House in line with CAA regulations set out in Air Navigation Order 2016 (ANO, 2016). The captured data was reviewed in situ to monitor for potential signs of disturbance by grey seals, as described in Pomeroy et al. (2015).

## 4.2.4 Survey Duration

The survey duration (i.e. the grey seal breeding period in North Wales) was determined from existing data collected during previous studies (Westcott, 2002, Westcott & Stringell, 2003, Stringell et al., 2014). Based on a review of these studies it was assumed that all pupping activity would be recorded from mid-August to mid-December. It was therefore originally planned that surveys would be conducted between the 10th of August and the 30th of December, although due to adverse weather conditions and other survey constraints, surveys were not initiated until the 10th of September.

## 4.2.5 Survey Intervals

An interval of 7 to 10 days between site visits was decided upon to ensure that sufficient data were recorded for each individual pup during its development, and to allow for a buffer period to account for periods of bad weather. Due to periods of adverse weather lasting up to 8 days throughout the survey period, however, this was not always possible. Survey areas were therefore prioritised based on the presence or absence of pups within an area on the previous visit. Sites at which pups had been recorded during the latest survey were prioritised for re-surveying within the 7 – 10 day window, while sites at which no pups had been recorded were revisited when weather allowed and once all ‘high priority’ sites had been surveyed. Where pupping activity was recorded at a ‘low priority’ site, the site was then raised to high priority for future surveys. Wherever possible multiple survey areas were surveyed simultaneously by splitting personnel into teams in order to maximise survey coverage within daylight hours.

## 4.2.6 RSPB Bardsey Island

Due to adverse weather conditions, Bardsey Island could not be sampled by vessel by the survey team for much of the survey period. Bardsey Island Ecology Monitoring Officer, Jo Porter, therefore carried out a weekly low water grey seal count on behalf of OEL. Data collected from this site included site, count and age class of all recorded grey seal pups. No photographs of pups or associated females were obtained, which restricted OEL’s ability to assess pup movement on the island (see Section 0). Instead, pup matching at Bardsey Island was conducted using only the difference in age classes on each visit (See section 0). This was deemed an acceptable method based on the regularity of survey effort at Bardsey Island by Jo Porter and the very low level of marked pup movements observed throughout the 2017 pupping season in other survey areas. OEL undertook only one full pup count on the main island during the pupping season. The data collected during this visit was excluded from the main dataset due to the consistency of the RSPB data collection over this period, with the exception of two identified pups which were observed by OEL surveyors at pupping sites inaccessible by foot and therefore not regularly surveyed by the RSPB.

## 4.2.7 Data Collection

A GPS fix was taken at each site where potential pupping habitat, live pups, dead pups or a pup rescue was recorded. Sites were assigned a habitat type (cliff backed shingle beach, open beach, cave, rocky shore or gully) and mapped in ArcGIS v10.2.2 after GPS fixes were taken in the field.

## 4.2.8 Photography and Field Notes






Where grey seal pups were encountered, high resolution photographs of the pup and its assumed mother (where possible) were taken. One pup at a time (and its mother, when present) were photographed using a DSLR camera. Where possible, surveyors captured multiple angles of all seals to supplement the pup / mother matching process. Based on guidance provided in Westcott (2008), this ranged from



passively waiting for individuals to change position, or where safe to do so, use a surveyor to provide a distraction and encourage the seal to change its position. Where and when possible and after all other essential data had been collected, surveyors also captured photographs of any other female grey seal pelages for contribution to NRW's grey seal photographic identification catalogue, the EIRPHOT database (see Langley et al., 2018 for information on EIRPHOT).

Written descriptions of body condition and behaviour were completed for each pup and its assumed mother to ensure that each pup was correctly matched / identified in subsequent site visits and photographs. Individual pups were assigned an age class in the field and photographs were later quality checked to ensure that age class assessments were correct. All photographs collected have been provided in a separate catalogue as Appendix 3 to this document. Age classification was undertaken consistent with Smith's (1966) fivefold system of pup classification (Table 1). The sea state, wind direction and a count of all other grey seals present were recorded at each site where pups were present.

Table 1: Pup aging classification used during the 2017 survey based on Smith (1966) with example imagery.

Age Class	Age (days)	Description	Example Image
I	1-5	Body contour thin, neck well defined, skin in loose folds around body. Coat often stained yellow by prenatal excreta. Umbilical cord conspicuous, pink or brown not dried (variable character). Claws soft, whitish. Voice a weak bleat. Docile.	
II	6-10	Outline smoother, with neck still recognisable, but no loose folds on body. Cord atrophied, or a conspicuous scar. Claws dark and hard. Voice loud, snarling when handled.	
III	11-15	Outline rounded to barrel-shaped. Neck indistinguishable and navel inconspicuous. Vigorous attack and escape reactions to handling.	
IV	16-20	As III but with patches of white natal fur moulted to reveal first-year pelage underneath. These pups are either weaned or approaching weaning.	
V	21+	Fully moulted to first-year pelage. All weaned and often segregated (with some IV's) from breeding area.	

### 4.2.9 Dye Marking

To reduce the chances of duplicate pup counts and to better quantify the levels of pup movement among sites in North Wales, pups were dye-marked using sheep-stock spray wherever possible. Pups < 3 days old were not dye-marked so as not to potentially affect pup-mother bonding, and pups with highly aggressive mothers were also excluded due to Health and Safety concerns, although these were noted for marking on the next site visit. Photographs of dye-marked pups and of adult females, particularly mothers of pups, were also captured to assist future identification by visually comparing pelage patterns.

### 4.2.10 Pup Identification

Following quality control of pup identification, a protocol was developed to assist in the matching / identification of resighted pups to previous records and identifying new individuals not yet recorded. This protocol is provided as a flow chart in Appendix 4. This protocol was developed on the assumption that pups remained at a site, with the oldest pups present at a site assumed to be those present in the previous site survey, if within the estimated weaning period. This assumption, together with the recorded pup descriptions, dye marking and imagery obtained, informed the identification process; this was undertaken by a single OEL analyst to reduce error due to subjectivity.

Information on the pup identification features used in the identification process is presented in Table 2.

Table 2: Pup identification methods.

Method	Description
Age class development in the number of days between sightings (Essential)	Two pups sighted on consecutive site visits match in terms of age class development.  E.g. If an age class 3 pup was recorded on a site, and an age class 2 pup had been documented 7 days previously, it is likely that the age class 2 pup has developed successfully in to the recently sighted age class 3 pup within 7 days (Pup Match).  Alternatively, if an age class 3 pup was recorded on a site, and a new-born age class 1 pup had been documented 7 days before, it would be unlikely that the pup had developed to an age class 3 in that time (No Match – New Pup).
Photographic or written documentation of spray mark colour and location on body (Supplementary)	A photograph or description of a spray mark could successfully be matched between two pups on consecutive site visits.
Photographic or written documentation of cuts and bruises (Supplementary)	A photograph or description of pup injury could successfully be matched between two pups on consecutive site visits.
Associated female (mother) photo ID (Supplementary)	Associated female previously photographed interacting with a pup matches an associated female's pelage pattern captured on a consecutive visit.
Pupping site (Supplementary)	Pup is sighted on the same site on consecutive surveys.

## 4.3 Analysis

### 4.3.1 Observed Pup Count

A count of age class I-V pups during the 2017 breeding season throughout the North Wales region was determined using all successfully identified pups. This count includes individual pups that were resighted multiple times during the survey and could be confidently matched / identified to previously recorded individuals, and unmatched age class I to V pups that were only recorded once throughout the survey. Each pup, whether it was resighted and matched or a single sighting and unmatched, accounted for a count of one to the total.

### 4.3.2 Minimum Estimated Pup Production

Unmatched age class V pups were subtracted from the observed pup count to present a minimum estimated pup production. This was based on the assumption that age class V pups in moult or having moulted may have been misidentified as a new observation or entered the pupping site from elsewhere and therefore counted multiple times (See Section 0)

### 4.3.3 Maximum Estimated Pup Production

A theoretical maximum estimate of pup production for the season was also calculated by augmenting the observed pup count with quantifiable sampling bias and potential sources of error including unidentified age class V, duration of pupping season, pupping habitats and site access. These biases, are described in Section 0.

### 4.3.4 Estimated Date of Birth

Where age class I pups with an umbilical cord or presence of fresh placenta were observed, the date of birth was assumed to be the previous day. Birth dates for all other pups were calculated using formulas in excel to backdate the first sighting of each pup using the age class of the pup and the number of days grey seal pups are estimated to remain in each age class following E.A. Smith's fivefold system of pup classification (Smith, 1966; Table 1). Dead pups were excluded from analyses and discussed where appropriate, as they did not contribute to overall pup production in the region.

### 4.3.5 Start and End Date of Pupping Season

The start date of the North Wales pupping season was taken as the earliest calculated date of birth across the entire region (See Section 0), and the end date was taken as the estimated date of birth of the final pup observed across the region. Surveys continued after this date, however, to record pup development beyond the final date of birth.

### 4.3.6 Methods for Estimating Uncertainty

Acknowledging there was likely to be a degree of error associated with the observed counts that are made in the field, an attempt to best quantify these errors was made during analysis of the raw counts. A summary of these sources of error is presented in Table 3, and while quantifying uncertainty in the data depends on a number of assumptions, it is considered that the methods used represent a reasonable assessment of uncertainty in the raw counts. These sources of error and the methods to quantify such errors were applied to the data following standardisation of raw counts and provide the upper and lower estimates of total pup production (see results Section 0). A detailed review of the error values is also provided in Results Section 0.

Table 3: Potential sources of error in pup production estimates including a brief description and the methods used to quantify the level of error.

Source of Error	Description	Estimation Method
Unmatched Age Class V	Due to the inability to monitor all sites at regular intervals as a result of weather, it could not be assumed that pups recorded in Age Class V only, had been previously recorded. Age Class V pups may represent new individuals at a site following movement from other pupping sites outside of the survey area in focus.	Unless evidence was available to link them to a previously sighted Age Class I-IV (i.e. 'matched') pup, all 'unmatched' Age Class V pups were recorded as new individuals. These Age Class V pups were included in the global pup production count but excluded from the lower pup production estimate.
Duration of Pupping Season	Potential for pups weaned prior to start of survey season to go unrecorded	Fourth-order polynomial curve fitted to data from relevant sites (i.e. where pupping began earlier than start of survey).
Pupping Habitat	Caves: potentially unrecorded pups due to access difficulties (defensive adults/poor sea conditions)	$(\text{No. Cave Sites With Pups} / \text{No. Cave Sites Without Pups}) \times \text{Mean No. Pups per Active Cave Site}$
	Rocky Shore: potentially unrecorded pups due to access difficulties (deep gullies) or cryptic habitats	$(\text{Total No. Pups Missed by Walkover at Rocky Shore Sites} / \text{Total No. Pups Observed at Rocky Shore Sites}) \times \text{Total No. Pups Observed at Rocky Shore Sites During Season}$
Site Access	Potentially unrecorded pups due to access issues (weather/sea state/defensive females)	Mean historic pup production used for sites where previous breeding activity recorded

### 4.3.7 Age Class V Pups

As a result of being unable to sample all sites at regular enough intervals in this survey, due to weather and tidal constraints, it could not be assumed that age class V pups had been previously recorded. It was, therefore, deemed necessary to include these counts in the pup production estimates. It is acknowledged that incorporating age class V counts into the overall pup production estimate is likely to introduce error (inflate the pup production estimate) because some pups in moult or that have fully moulted lack distinctive features (patterned or sprayed lanugo) and their more mobile nature mean that these individuals are more likely to have been previously counted.

On occasions, a resighting was confidently recorded where strong evidence showed that a previously recorded pup corresponded with an age class V pup present at the same site. If there was no corresponding pup present in earlier surveys at the site, no match to a previously identified pup was made and the age class V pup was considered an unmatched new record. Only unmatched pups of age classes I to IV were confidently identified as a new pup.

Where age class V pups could not be matched with strong evidence to previous sightings (see Section 0), it was assumed that these pups were born at the site at which they were observed but were simply missed through the irregularity of sampling. It should be considered, however, that these pups may have arrived at a site from elsewhere, artificially inflating estimates of pup production for a particular site and survey area. While this is considered unlikely, a lower estimate of pup production has therefore been calculated for each survey area by subtracting the count of age class V pups from the total observed count on the assumption that all moulted age class V pups had already been counted.

### 4.3.8 Duration of Pupping Season

The start of the survey period was delayed due to adverse weather and as a result some pups may have been weaned and left their pupping sites before survey work began in September 2017. The first estimated birth date of a pup from pups we observed was 31st August 2017. This was in the South Lley survey area, which we assume to be where the earliest pupping began. Data from this survey area was used to estimate a theoretical earliest birth date for the wider North Wales region. This was done by fitting a fourth-order polynomial curve fitted to data from this survey area (Figure 2), giving an earliest potential birth date of a pup as the 25th August 2017, the date at which the fitted curve crosses with a pup count of one (as indicated by the yellow line in Figure 2). This allowed for a prediction of pup production within this survey area on dates prior to the commencement of survey work in September 2017, using the average frequency of pup births on the South Lley across the entire season. Based on an average of one pup born every 2.6 days (total of 24 pups recorded in the South Lley survey area over a 62 day observed pupping period), it was estimated that a maximum of two additional unrecorded pups could have been born in this survey area between the 25th August and the 31st August 2017.

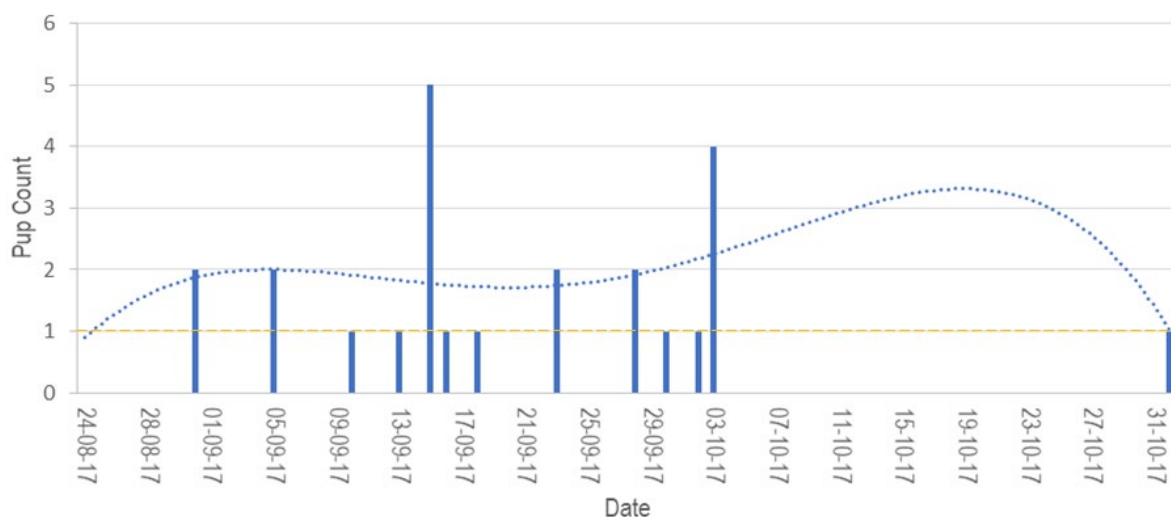


Figure 2: Fourth-order polynomial curve (dotted line) fitted to pup count data collected on the South Lley peninsula in September 2017 to estimate earliest potential date of birth and start of the pupping season, as the point at which the curve intersects a pup.

### 4.3.9 Pupping Habitat

Some pupping habitats/sites posed difficulties when accessing and collecting data on pup production, particularly cave sites and rocky shores. Difficulties due to inaccessibility and aggressive adult seals in these habitats means that counts obtained at such sites may be low.

### 4.3.10 Caves

A number of caves could not be accessed throughout the duration of the breeding season as a result of poor sea conditions. It was possible that pups in these cave sites were missed. More commonly, the presence of highly defensive adult female seals prevented site access, especially to enclosed caves; these sites probably contained pups.

An estimator was used to account for sites (and therefore pups) that were not surveyed. To estimate the number of pups in each of the sites that were not surveyed, an average of the number of pups from surveyed sites was applied:

Estimate for each site not surveyed = (Total No. Caves Surveyed with Pups / Total No. Caves Surveyed) x Average No. Pups Per Active Cave Site

The presence and suitability of caves differs in each survey area. Carmel Head, Holy Island and the South Lleyne are the only areas associated with pup production in cave habitat in this survey. The above estimator, which accounts for missed sites, was determined for each of the principal survey areas separately.

### 4.3.11 Rocky Shores

Rocky shores also present difficulties regarding access and the detection of pups in what can be highly cryptic habitats. The trial use of a UAV allowed for an assessment of sampling error at a selection of cryptic sites, to determine whether aerial surveys detect pups missed by traditional ground-based methods.

A UAV trial was conducted on 27<sup>th</sup> October 2017 at The Skerries (Ocean Ecology, 2018a) and data were compared to those collected on foot. Two pups were identified in the aerial imagery that had been missed by the ground-based survey, due to numerous deep gullies that prevented foot access to the whole site. The proportion of pups missed by traditional survey methods was then used as a multiplier for all other rocky shore sites. Given that two out of five pups were missed at The Skerries using traditional methods, a multiplier of 1.4 ( $1+(2/5)$ ) was used as a pup estimator for rocky shore sites:

Estimate = No. Pups Observed + (No. Pups Observed x Proportion of Pups Missed on Rocky Shores)

It is noted that the data used to quantify sampling error associated with rocky shores are derived from a single UAV flight carried out at a single site and assumes that the reported sampling error on rocky shores is consistent across all sites of this habitat



type. While we consider that the methods used are suitable for the Skerries rocky shore areas, caution should be taken when interpreting pup production estimates at other rocky shore sites based on this assumption.

### **4.3.12 Access Method**

There were several sites across North Wales that were inaccessible during the entire survey period and were not captured by the other estimators / multipliers described above. This was most often due to adverse weather conditions, unfavourable tides, or highly defensive and/or aggressive adult females. Sites were therefore classified as 'accessible' or 'inaccessible' in the early stages of the survey period. Where pups had historically been recorded at a site that was inaccessible and not sampled in 2017, an estimate of pup production was taken as the mean number of pups produced at the site across previous surveys, where available. While this method masks any temporal changes in pup production that may occur at an individual site, it enables an estimate of pup production to be included for previously surveyed pupping sites that probably contained pups but were not surveyed in 2017.

## 5. Results

### 5.1 Survey Effort

Following a period of adverse weather and high winds at the beginning of the month, surveys began on the 10<sup>th</sup> September 2017 and continued until the 15<sup>th</sup> November, except at Bardsey Island where surveys undertaken by Jo Porter of the RSPB continued until 31<sup>st</sup> December 2017. A total of 31 days of survey were completed during this period by the OEL team and 14 independent days undertaken at Bardsey Island by Jo Porter. Survey intervals of 7 – 10 days were not possible for every site due to weather constraints and sites where pups were recorded were therefore prioritised for survey effort.

Different areas of the North Wales coastline were surveyed at varying intensities throughout the season due to weather constraints and previously recorded pupping activity. Survey effort was highest at the North Lley, South Lley, Bardsey Island, Carmel Head, Anglesey East and The Ormes (Figure 3) All sites, including those surveyed at low intensity, were accessed at least once. Despite the access difficulties for OEL staff, survey effort at Bardsey Island was high due to Jo Porter's surveys whilst being resident at this site.

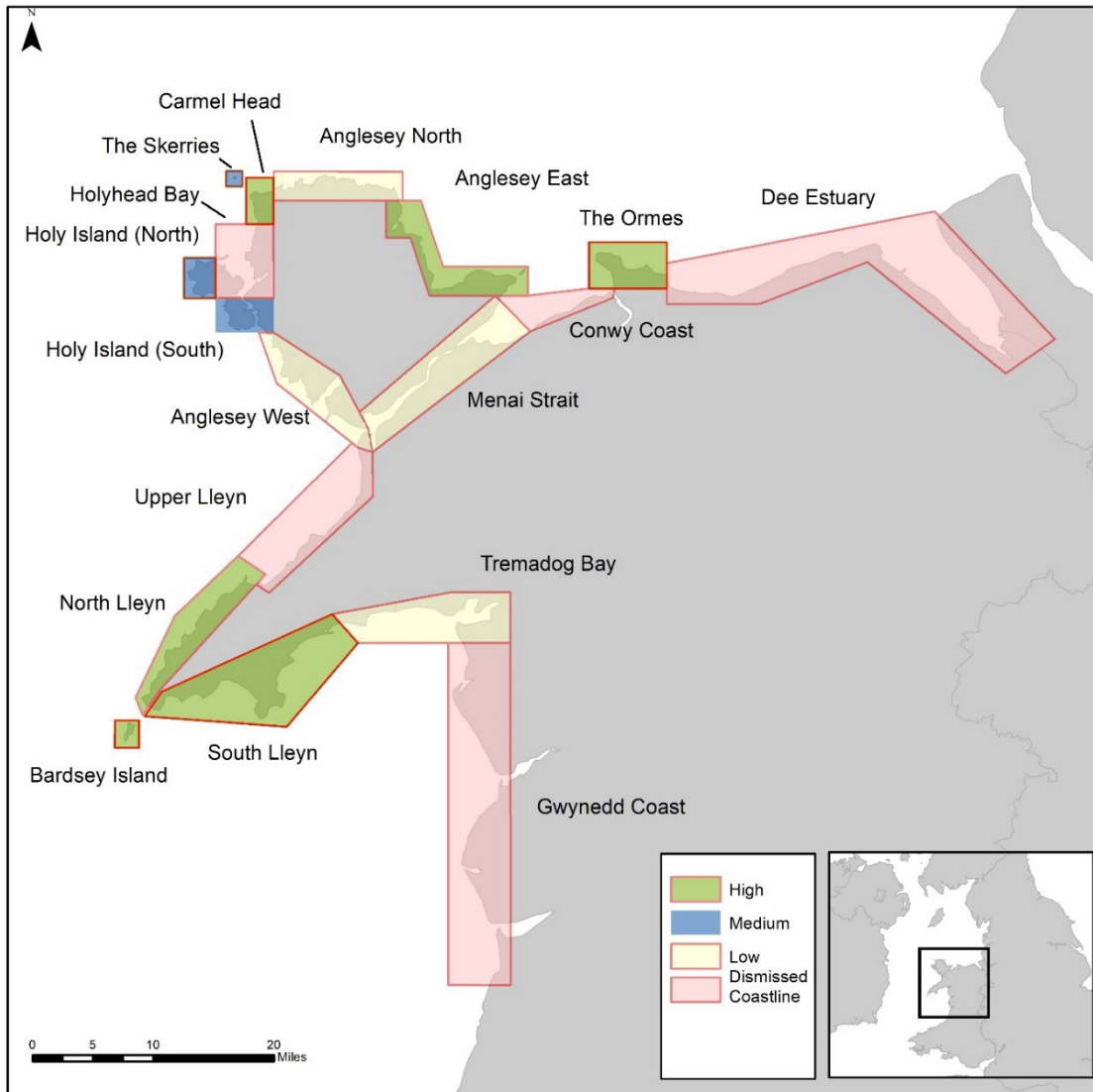


Figure 3: Survey effort per survey area during the 2017 North Wales grey seal census. Effort represents the mean number of days between each survey. High effort = <10 days, Medium = 10-25 days & Low = >25 days.

Three hundred and thirty-two active and potential pupping sites were observed and recorded by surveyors in 2017. Of these, 86.44% (n=287) were successfully observed at least once from a clear vantage point from the land, a kayak or a moving vessel, while for 13.55% (n=45), a clear view was not possible due to either restricted vantage points or poor sea conditions limiting further access.

In order to maximise coverage during short weather windows, some sites were accessed for longer periods throughout the tidal cycle and not restricted to three hours before and after low water, as per previous surveys undertaken in 2001 (Westcott, 2002), 2002 (Westcott & Stringell, 2003) and 2004 (Stringell et al 2014). Sites accessed by RHIB such as The Skerries and Bardsey Island needed to be accessed when tides allowed safe passage through the tidal races and safe access and egress to the landings. A survey timeline presenting the dates at which each survey area was surveyed is provided in Appendix 5.

Of the 332 sites surveyed, 17% (n = 56) were observed from a RHIB, 17% (n = 56) of sites were observed using a kayak, 54% (n = 181) of sites were observed on foot from the land and 12% (n = 38) of these sites were accessed using a combination of these means. Figure 4 illustrates the number of sites accessed by each method in each survey region.

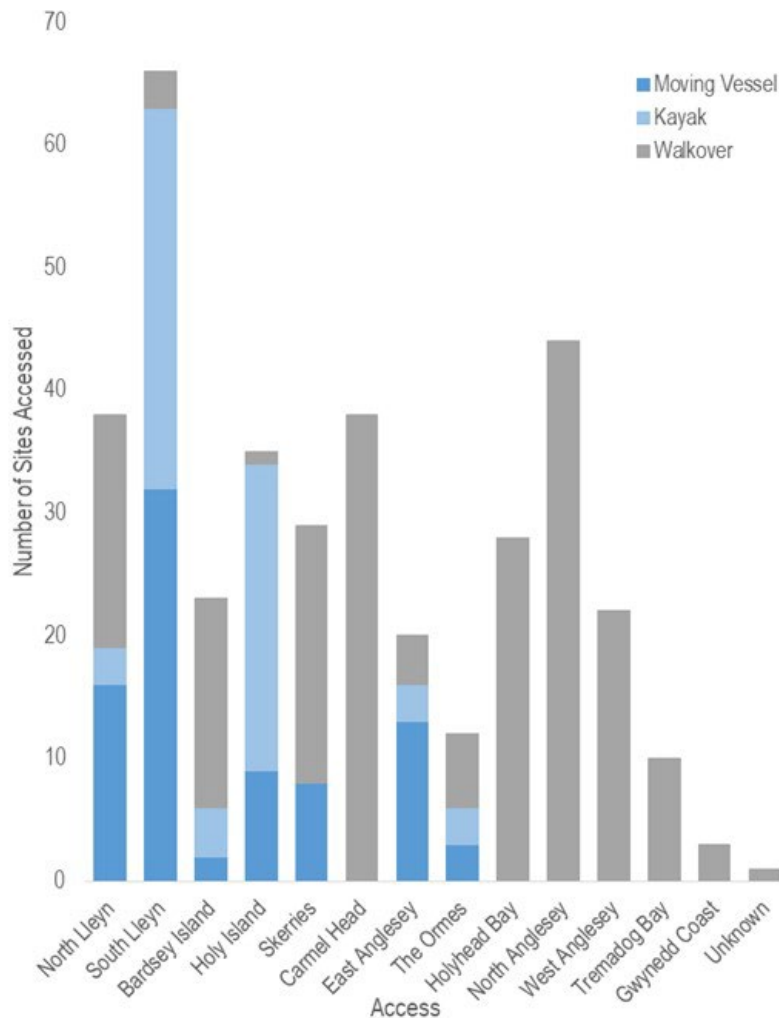


Figure 4: Stacked bar chart illustrating the number of sites across the listed survey areas accessed by moving vessel, kayak or walkover throughout the 2017 pupping season, North Wales.

## 5.2 Total Pup Production and Breeding Season Duration

Data collected from the entire North Wales region throughout the 2017 pupping season shows that a total of 279 individual grey seal pups (age class I – V) were counted that were likely to have been born in the region. The majority (207 or 74%) of these individuals were confirmed age class I – IV (i.e.  $\leq 20$  days old) pups, representing the minimum pup count for the region, while 72 (25% of the total) were unmatched age class V pups ( $> 20$  days old). Nine dead pups were observed during the season, which were excluded from the analysis, given that they do not contribute to overall pup production across the region.

The birth date of the first observed pup during the survey of the North Wales region was estimated as the 31<sup>st</sup> August 2017. Given that the start of the pupping season was not surveyed, the estimated start of the season was 25<sup>th</sup> August 2017. The season continued for 76 days before the final observation of an age class I-IV pup was recorded on Bardsey Island on 9<sup>th</sup> November 2017. Repeat sightings of age class I-IV pups continued beyond this date at Bardsey Island and Carmel Head until the 24<sup>th</sup> November, while age class V pups continued to be observed at Bardsey Island until a final sighting on 31<sup>st</sup> December. This final observation was of an unmatched pup estimated to have been born on 8<sup>th</sup> December. Beyond this date no pups were observed, suggesting all pups had weaned by this point and left their pupping sites.

## 5.3 Breeding Distribution and Habitat Preferences

### 5.3.1 Regional Distribution of Pup Production

Of the 332 potential sites surveyed, 79 were observed to contain pups (active pupping sites) during the 2017 season across the North Wales region (Figure 5a), representing an increase of 145% in the number of pupping sites in the 2004 census. The majority (55%) of pupping sites were recorded across Anglesey and The Skerries, followed by the Pen Llyn a'r Sarnau SAC (41%) and the mainland of North Wales (4%). The main areas of pup production were identified as Bardsey Island, the South Lleyrn Peninsula, Holy Island North, The Skerries, Carmel Head and The Ormes (Figure 5b). Pup production was markedly higher at Bardsey Island than other survey areas, with 45% of all pups produced in 2017 originating from this area. The Skerries and Carmel Head produced 17% and 13% of all pups produced respectively, followed by Holy Island and the South Lleyrn peninsula, which both produced 10% of all pups in 2017. The North Lleyrn, The Ormes, Gwynedd Coast, Holyhead Bay and North Anglesey all produced < 10 individual pups throughout the breeding season (Figure 6). description of pup production at each of these main areas is presented in Section 5.3.2, while detailed maps with bubble plots showing pupping activity across each area are provided in Appendix 6.

The numbers of pups of age class I-IV and class V pups recorded within each survey area across all survey months during the 2017 breeding season are presented in Figure 7. Peaks in the number of pups observed within each area appear to be in September and October, before dropping markedly from November onwards. The disparity in the numbers of pups observed between survey areas is clear, with the use of Bardsey Island and The Skerries evidently higher than other areas.

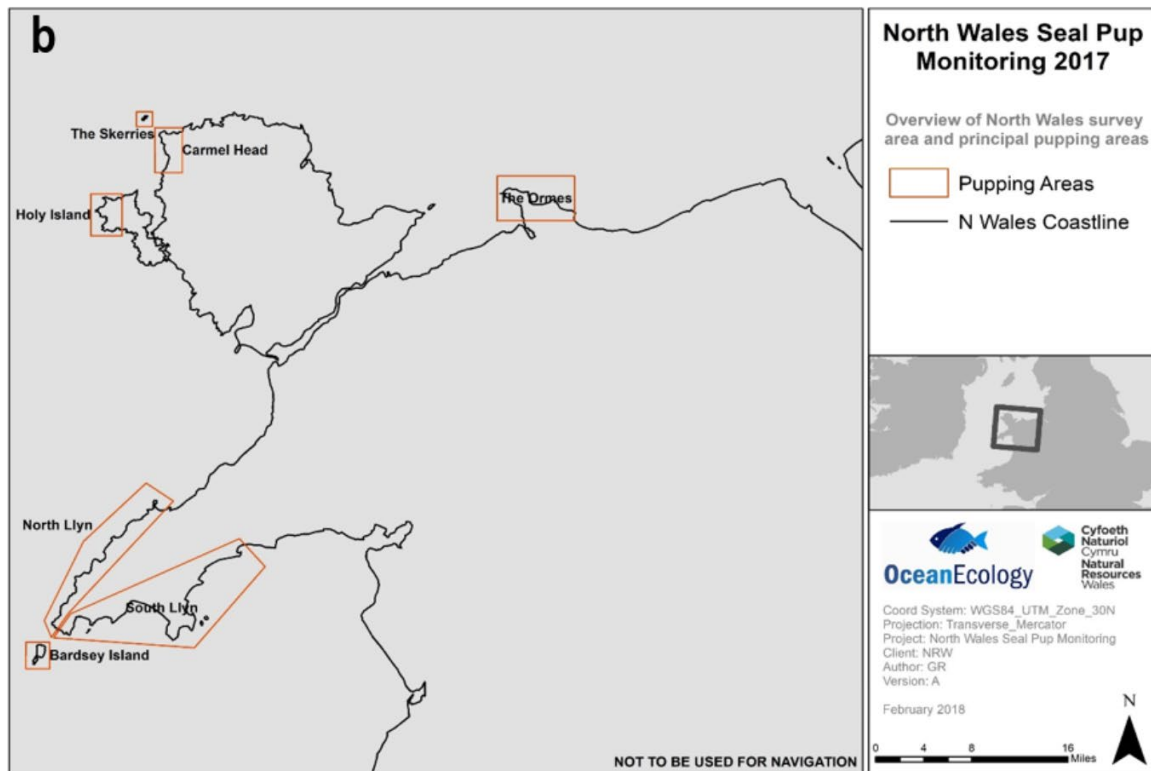
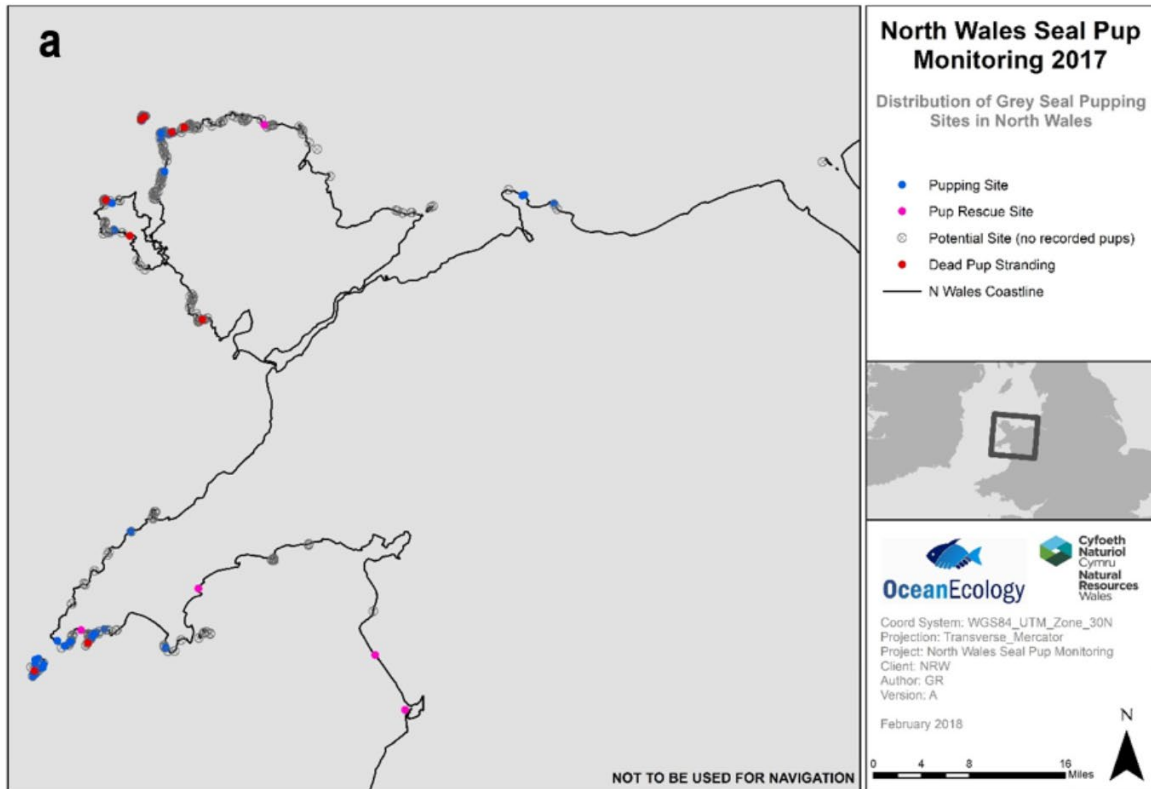
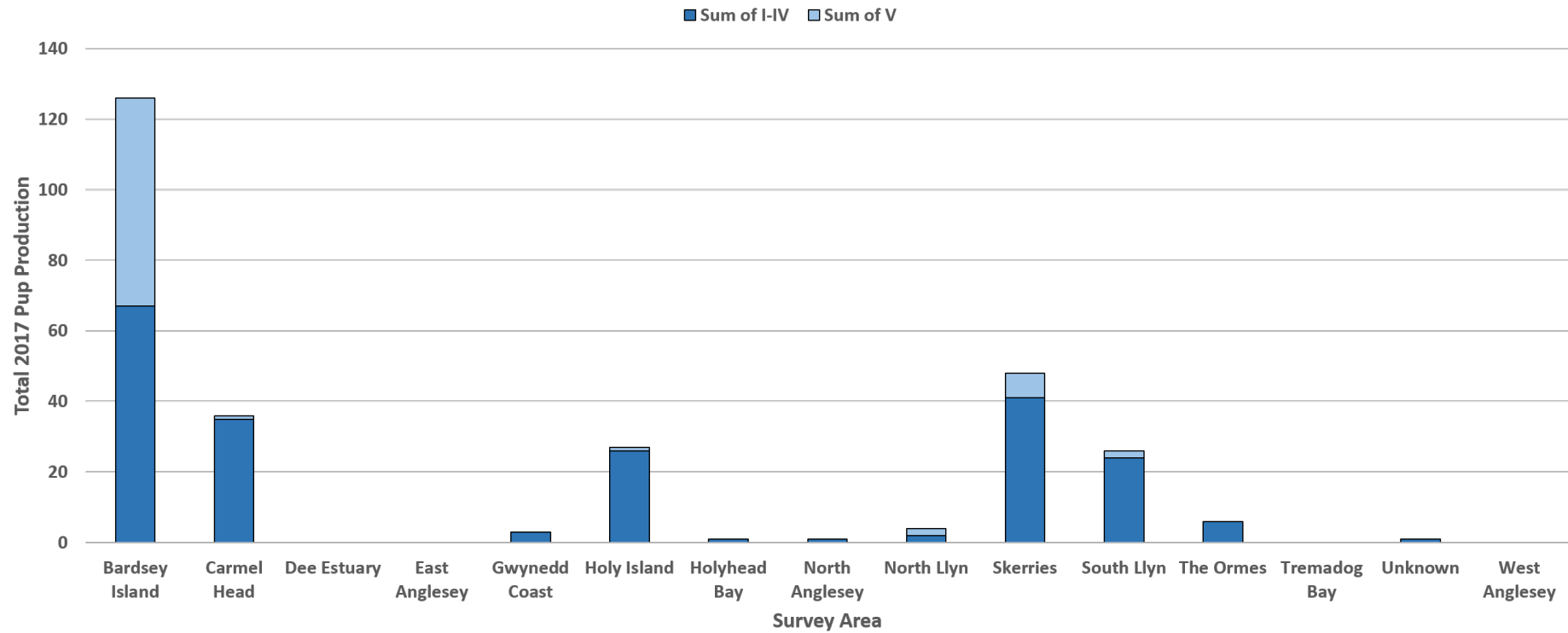


Figure 5: a) Spatial distribution of pupping sites across the North Wales region during the 2017 breeding season and b) the main areas of pup production identified.



*Figure 6:* Total pup production at each survey area across the 2017 breeding season, indicating the number of age class I-IV (dark blue) and age class V (light blue) pups recorded.

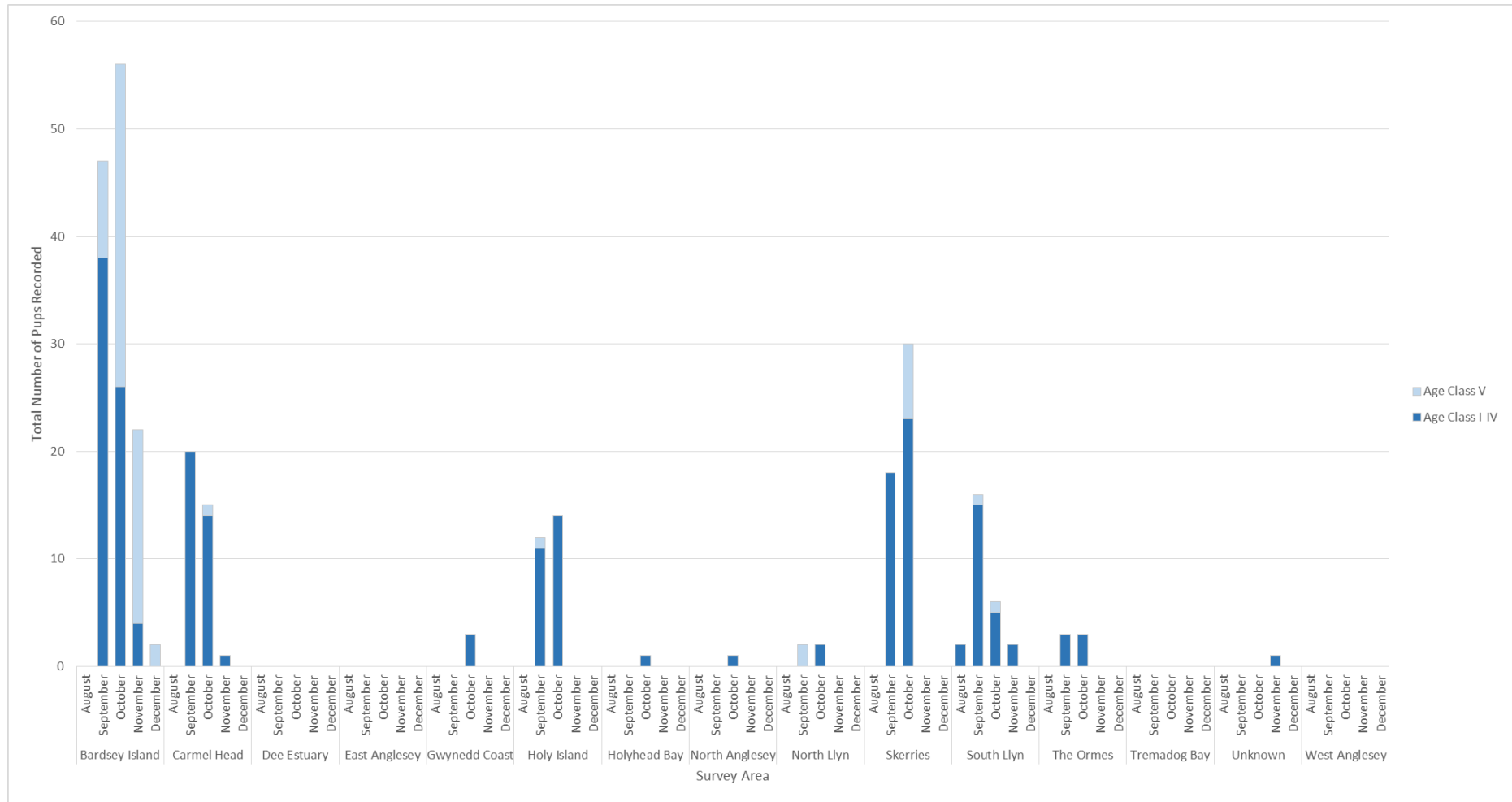


Figure 7: Total number of pups of age classes I-IV (dark blue) and age class V (light blue) observed in each survey area in each month of the North Wales 2017 breeding season.



## 5.3.2 Pup Production by Area

A description of pupping activity at each survey area is provided in this section, including the age class of pups observed and estimates of the length of the pupping season across each area. Detailed maps of pupping activity across each area including an indication of pupping density at each individual site surveyed are presented in Appendix 6.

### Bardsey Island

A total of 127 grey seal pups were recorded at Bardsey Island in 2017 by Jo Porter, of which 59 (46%) individuals were unmatched age class V pups. Two pups were recorded by OEL surveyors using kayaks at sites inaccessible to Jo Porter during walkover surveys. The pupping season on Bardsey Island lasted 94 days, running from the 10<sup>th</sup> September 2017 when three pups were first observed until the 9<sup>th</sup> November when the last new born pup was observed. Following this date, mixed groups of age class IV and V pups were regularly sighted throughout December before the last pup left.

Two sites (2.02 and 2.21) were observed to support > 21 individuals over the 2017 pupping season. These sites both featured the highest occurrences of unmatched age class V pups over the pupping season (19 and 35 respectively). Twelve age class V pups - the highest daily count across North Wales, were recorded at one site (2.21) on Bardsey Island on 28/10/2017. No pup movement assessment was conducted on Jo Porter's data but no distinctly featured or sprayed pups by OEL staff were observed to have moved between sites on Bardsey Island, suggesting pup movement here is likely to be minimal.

### The Skerries

A total of 48 pups were produced across 13 pupping sites at The Skerries in 2017. Seven (15%) of these pups were unmatched age class V pups recorded at six sites, three of which were sites where no other pups were observed over the breeding season.

Pupping on The Skerries is estimated to have commenced on September 12<sup>th</sup>, 2017 and continued for 50 days until October 31<sup>st</sup> when the last observed pup was estimated to have been born. Maximum pup production in the region was observed at Site 4.12, where nine pups were observed over the 2017 breeding season. More than 50% of all the pupping habitats on The Skerries were "open beach" sites. On numerous occasions, grey seal pups were observed high up on the grassy banks of these sites, particularly following storm events throughout the season. No pup movement was observed on The Skerries using spray marking or recorded distinct pup / mother features.

## Carmel Head

Thirty-five age class I-IV pups were recorded within this region with the greatest pup production occurring at a single open beach site with a narrow grassy slope at the rear. One unmatched age class V pup was recorded at Site 5.26 on November 14<sup>th</sup>, after which no other pups were observed at this site. The pupping season on Carmel Head lasted 50 days, running from the 7<sup>th</sup> September 2017 (estimated date of birth based on age class of pup at time of first observation) until the 5<sup>th</sup> November when the last observed pup was estimated to have been born. Two further walkover surveys of Carmel Head were conducted following this date and no more pups were observed.

Three pups were observed to have moved amongst five distinct pupping sites on Carmel Head between the 7<sup>th</sup> and 31<sup>st</sup> October. Most of these sites were situated within 300m of coastline to each other and the maximum distance between the sites was 80m, while one site (5.18) was located 200m south west of the main group of sites, with five nursery and potential sites situated in between. Small grassy headlands physically separated the sites at high tide. Pup movement was successfully identified using distinct spray marks on each pup and supplemented using distinct moult and markings observed in photographs. One of the three pups was identified at three of these sites on three different occasions suggesting transient behaviour during its nursery period.

## Holy Island

Twenty-seven age class I-V pups were observed at seven pupping sites across Holy Island in 2017. Sixteen (59%) of these pups were born at a single site (3.07) during the season, with a maximum of six individuals recorded as born on the 17<sup>th</sup> September 2017. No pup movement was observed at Holy Island through analysis of spray marking or distinct pup / mother features. Access to cave sites on the north and west coast of Holy Island were limited during survey days due to typically poor southwesterly conditions.

Surveys of Holy Island began on the 17<sup>th</sup> September 2017 when six age class I-II pups were recorded at a single site (3.07). The pupping season ran for 53 days until the 31<sup>st</sup> October when the final observed pup was estimated to have been born.

## South Lleyn Peninsula

Twenty-four pups were born at 14 pupping sites across the South Lleyn peninsula in 2017 and two unmatched age class V pups were recorded at two sites (1.46 and 1.71) on the 6<sup>th</sup> and 26<sup>th</sup> October 2017 respectively. No other pups were observed over the breeding season at either site.

Surveying on the South Lleyn commenced on September 18<sup>th</sup> and the site was successfully revisited five more times throughout the pupping season. The first two pups of the 2017 breeding season were observed on September 18<sup>th</sup> at two separate sites (1.65 and 1.68). Date of birth calculations estimated these individuals to have

been born on August 31<sup>st</sup>, 2017. The final pup of the season was observed on the South Lleyn on November 2<sup>nd</sup>. No pup movement was observed on the South Lleyn from data on spray marking or distinct features.

## The Ormes

Six pups were born at The Ormes site during the 2017 pupping season. These pups were all age class I-IV at the time of recording and were successfully matched across surveys. Pups were first recorded at The Ormes on the 17<sup>th</sup> September when three age class I-IV pups were recorded across two sites. These pups were estimated to have been born on the 13<sup>th</sup> September. The last pup observation recorded at the site was on the 8<sup>th</sup> November 2017, with an estimated date of birth of the 27<sup>th</sup> October, giving a pupping season of 45 days.

## North Lleyn Peninsula

Two age class I-IV pups and two unmatched age class V pups were recorded across the North Lleyn peninsula throughout the 2017 season. The first two pups were age class V pups recorded at two sites on the 8<sup>th</sup> and 20<sup>th</sup> of October 2017 respectively, with estimated dates of birth of 15<sup>th</sup> and 27<sup>th</sup> September 2017. One age class IV and one age class II pup were later recorded at the same site on the 20<sup>th</sup> October and 3<sup>rd</sup> November respectively, with estimated dates of birth of the 2<sup>nd</sup> and 26<sup>th</sup> October. No new pups were subsequently recorded on the North Lleyn, giving an estimated pupping season of 42 days across the area.

## Gwynedd Coast, Holyhead and North Anglesey

Three pups were recorded along the Gwynedd Coast during the 2017 survey, while single pups were recorded in Holyhead and on North Anglesey. These pups were all age class I-IV. Pups on the Gwynedd Coast were recorded separately at three sites on the 3<sup>rd</sup>, 8<sup>th</sup> and 24<sup>th</sup> October 2017. The pups observed at Holyhead and North Anglesey were recorded on the 8<sup>th</sup> and 10<sup>th</sup> November. The pup recorded at Holyhead was estimated to have been born on the 31<sup>st</sup> October 2017, giving a single birth at this site. Pups recorded on the Gwynedd Coast and North Anglesey were based on RSPCA rescues and therefore no date of birth estimates are available for these pups.

### 5.3.3 Breeding Habitat Preference

In order to identify any habitat preference in the pupping activity of grey seals in North Wales and any trends in pup production across these habitats, data were analysed across each type of habitat surveyed. The number of sites of each habitat type at which surveys were undertaken and the number that supported pupping activity are presented in Table 4. The percentage of the total number of pupping sites comprised by each habitat type is also presented. Data suggest a clear preference for cliff backed shingle beach as a breeding habitat for grey seals across the survey region, with sites of this habitat type comprising 43.9% of all pupping

sites, followed by open beaches (23.2% of all pupping sites), rocky shoreline (14.6%) and caves (13.4%). Two observations of pupping activity in gullies were recorded, while the habitat at one site from a pup that was reported by the public (Llanguadlnefn) could not be located and therefore remained undefined. While all major islands around the North Wales coastline were surveyed (e.g. Bardsey Island, Holy Island, Skerries) and were further broken down into different habitats, smaller 'islands' (i.e. rocky outcrops separated from the main area surveyed that can be classified as single potential pupping sites) appeared not to support pupping activity.

*Table 4:* The total number of sites of each habitat type surveyed (n=332) and number of sites where pups were recorded (n=82) during the 2017 grey seal survey in North Wales. Data are expressed as total numbers and percentage of total number of pupping sites surveyed. Note that 'islands' refers to smaller rocky outcrops separated from the main survey areas that are classified as single potential pupping sites

Pupping Habitat	No. Sites Surveyed (n=332)	No. Sites Supporting Pups (n=82)	% of Total Sites Supporting Pups (n=82)
Gully	23	2	2.4%
Islands	22	0	0.0%
Open Beach	61	19	23.2%
Cave	56	11	13.4%
Cliff Backed Shingle Beach	145	37	45.1%
Overhanging Cove	1	0	0.0%
Rocky Shore	22	12	14.6%
Sandbank	1	0	0.0%
Undefined	1	1	1.2%

A breakdown of total pup production by habitat type across the North Wales region during the 2017 season (Figure 8) shows a slightly different trend to the general distribution of pupping activity (Table 4), with the majority of the pups being born on open beaches, despite the majority of pupping sites comprising cliff backed shingle beach. A total of 108 pups (38% of all pups born) were produced from open beaches across the region, compared with 85 (30%) from cliff-backed shingle beaches and 63 (22%) pups born on rocky shores.

Figure 9 allows further investigation in the temporal patterns of pup production within each habitat type. Peaks in the number of pups of each age class recorded appear consistent across each habitat type surveyed, with peaks in September and October, comparable to the trends observed for each individual survey area ( ).

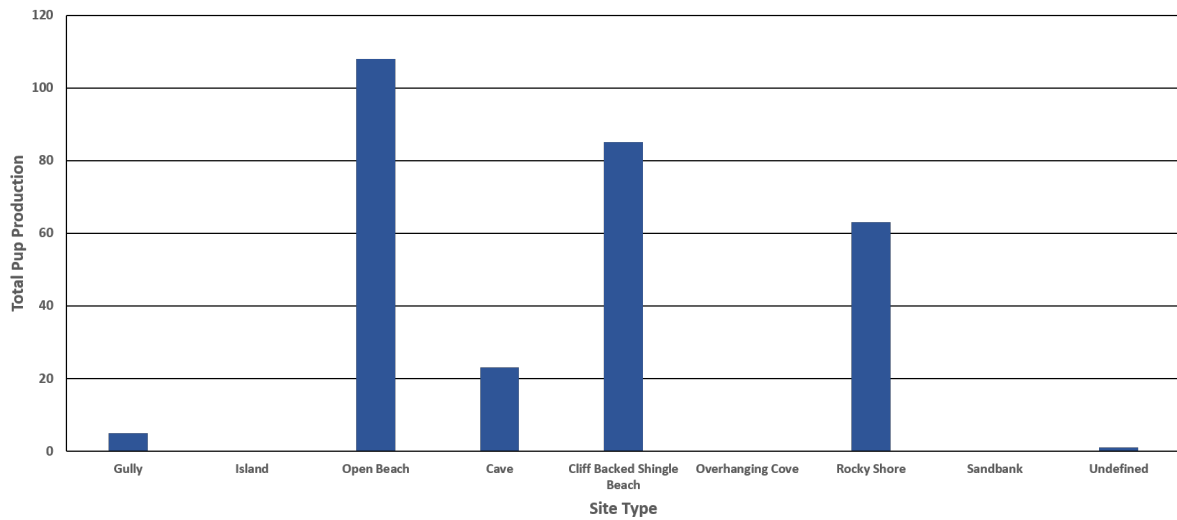


Figure 8: Total pup production per habitat type over the 2017 grey seal survey in North Wales.

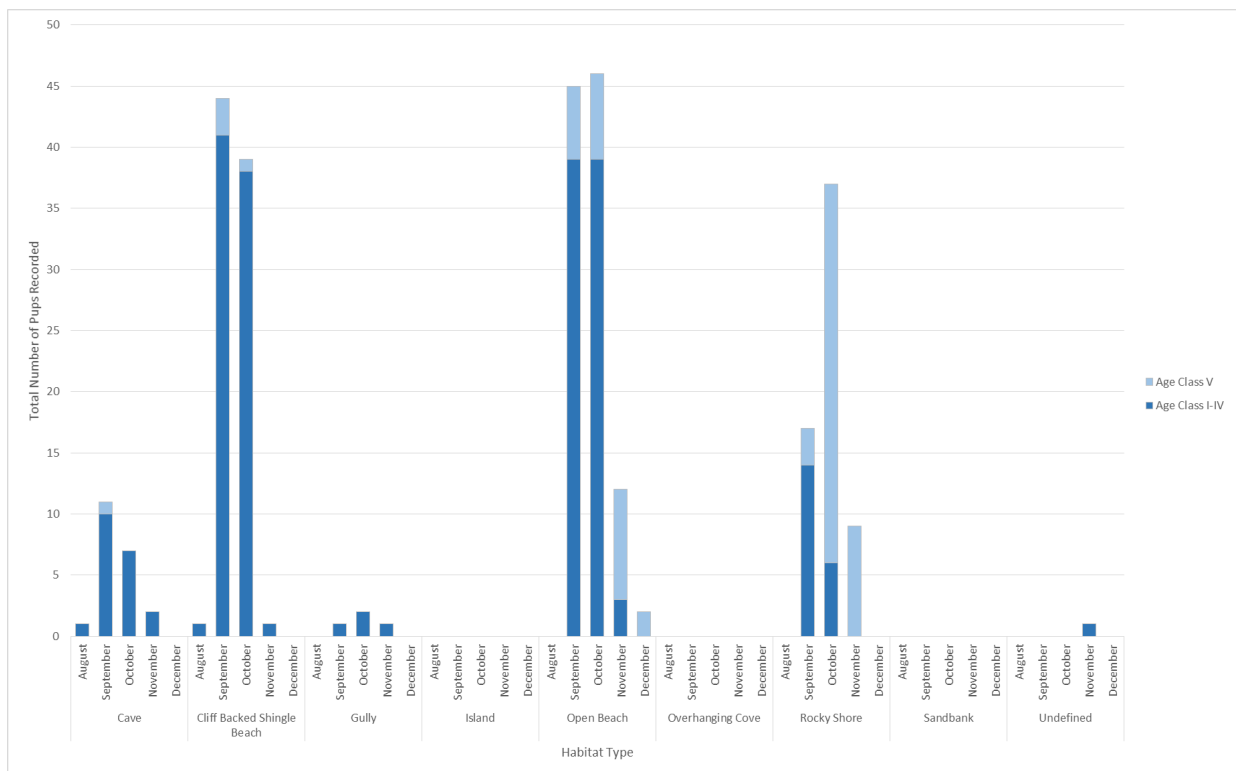


Figure 9: Total number of pups of age classes I-IV (dark blue) and age class V (light blue) observed in each habitat type in each month of the North Wales 2017 breeding season.

### 5.3.4 Comparison with Historical Data

A comparison of the 2017 data with data from past surveys of the North Wales region (2001: Westcott 2002; 2002: Westcott & Stringell, 2003; 2004: Stringell et al., 2014) allows a crude assessment of changes in pup production over time. A comparison of pup production across the entire survey region suggests that birth rates in 2017 have increased markedly compared to those recorded in earlier surveys. A small increase in production between 2001 and 2002 was followed by a small decrease between 2002 and 2004. This was followed by a large increase between 2004 and 2017. 2017 pup production is an increase of >120% since 2002 and 180% since 2004, increasing from 102 pups to 279 pups (age class I-V) in the period 2001 - 2017.

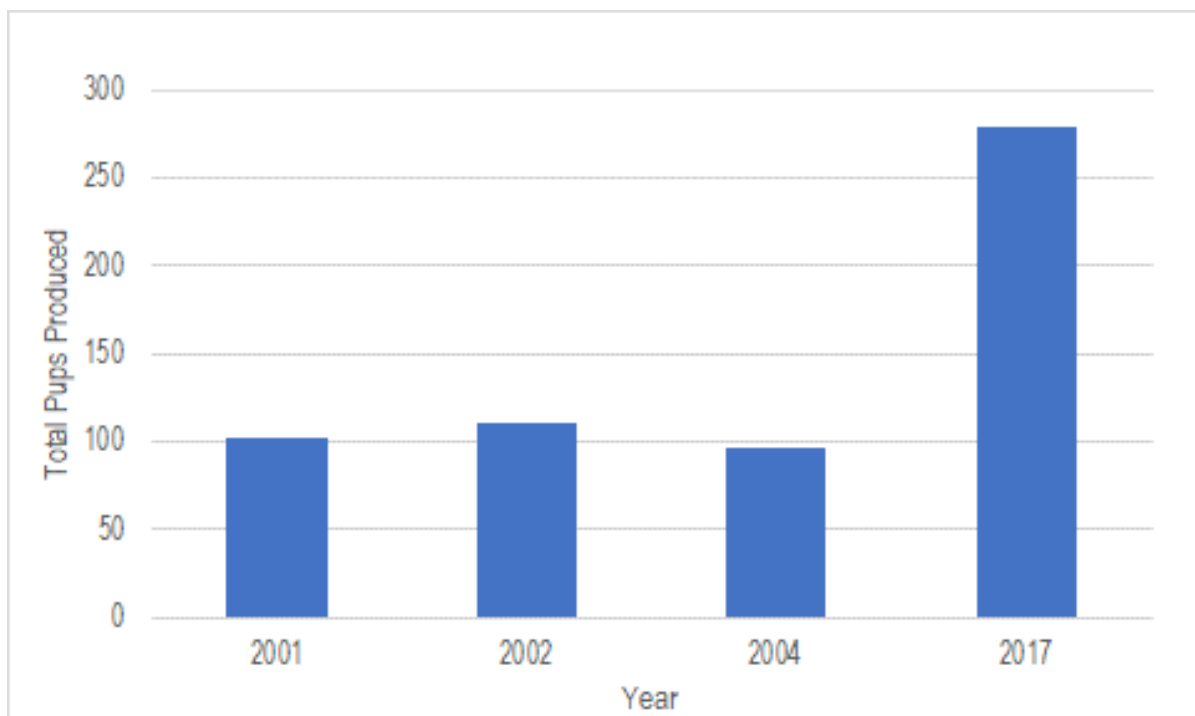


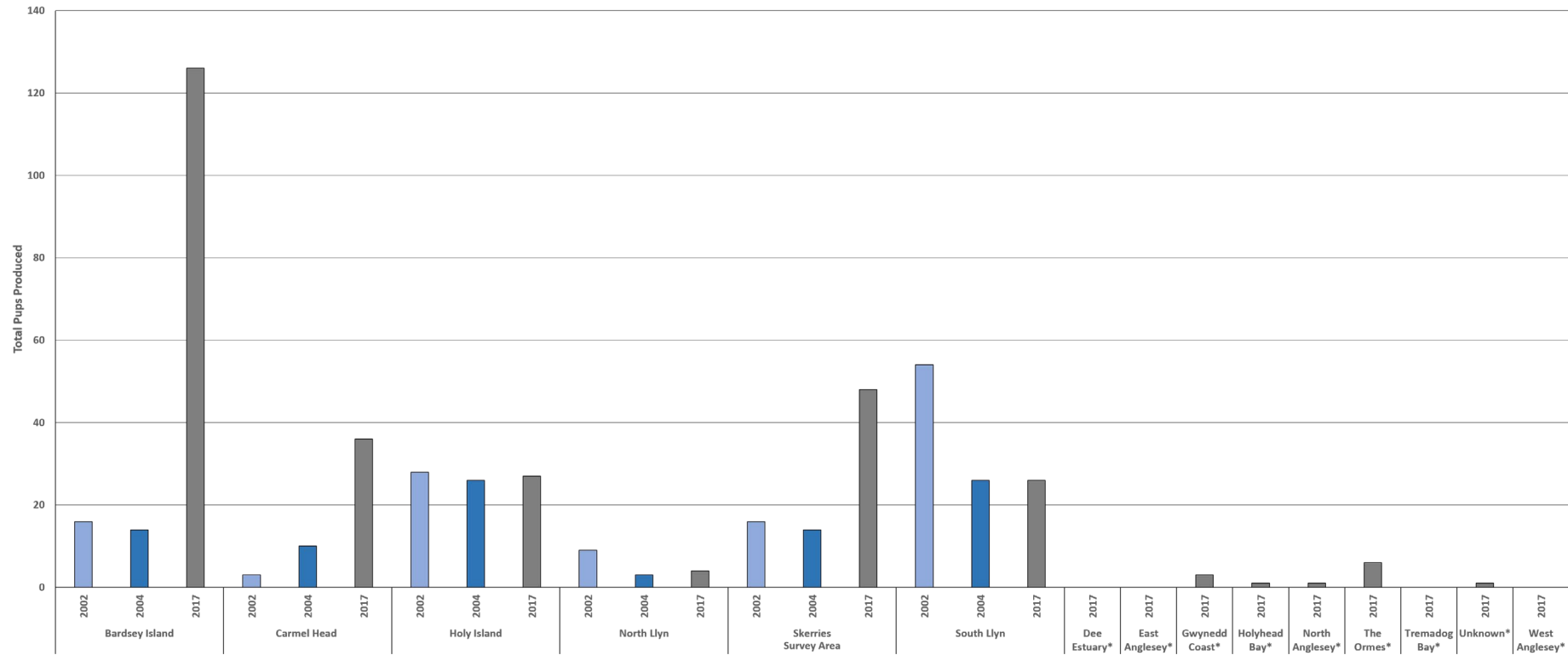
Figure 10: Total observed pup production across the North Wales region from surveys conducted in 2001 (Westcott, 2002), 2002 (Westcott & Stringell 2003), 2004 (Stringell et al 2014) and 2017 (this survey).

Breakdown of the data by individual survey area across the North Wales region allows an assessment of which sites temporal change is most evident and whether the increase observed at the regional level is consistent across all areas. Figure 11 shows that the increase in pup production between 2002 and 2017 is also evident at Bardsey Island, Carmel Head and The Skerries. This increase is most apparent at Bardsey Island, where pup production increased from just 16 pups in 2002 to 126 in 2017, nearly an order of magnitude increase over this period. Similarly, pup production has increased at Carmel Head from three pups in 2002 to 36 in 2017. Pup production has trebled at The Skerries from 16 pups in 2002 to 48 pups in 2017.

Pup production at Holy Island, however, has remained relatively constant, at around 27 pups, over years for which data are available. The number of pups born on both the North and South Lley Peninsula has approximately halved, decreasing from

nine pups in 2002 to four in 2017 on the north of the peninsula, and from 54 in 2002 to 26 in both 2004 and 2017 on the south coast of the peninsula.

Low levels of pup production (< 10 pups) were recorded in four areas in 2017 (Gwynedd Coast, Holyhead Bay, North Anglesey, The Ormes) where no grey seal pups were recorded in past surveys, suggesting an increase in the distribution of pupping in North Wales.



*Figure 11: Total pup production at each survey area within the North Wales region in 2002 (light blue bars: Westcott & Stringell 2003), 2004 (dark blue bars: Stringell et al 2014) and 2017 (grey bars: this survey). \* indicates areas that were not surveyed in previous years.*



## 5.4 Estimates of Uncertainty

### 5.4.1 Upper and Lower Estimates of Pup Production in North Wales

Following an assessment of the various potential sources of error in sampling during the 2017 season (see Section 0), maximum estimates of pup production were calculated for each survey area and for the North Wales region as a whole (Table 5).

The maximum estimate of pup production includes all potential sources of error and class V pups. Under this scenario, it is estimated that a maximum of 350 pups were produced during the 2017 breeding season in North Wales. This represents a 25.45% increase on the actual observed pup count (class I-V) during surveys undertaken in this period.

The minimum estimate of pup production is 207, which represents a total count of 207 white-coated (age class I-IV) pups born in North Wales during 2017 and assumes that all age class V pups originated from outside of the region or were previously identified age class I – IV pups. This is 74% of the count of class I-V pups in 2017 (279 pups).

*Table 5:* Observed pup production at each survey area within the North Wales survey region, including minimum estimates (i.e. all Age Class I – IV observed), counts of weaned pups (age class V), individual estimates of error per area and by source of error, and a maximum upper estimate, which combines the minimum estimate with class V pups and all sources of error. NB: The 'Estimate Observed pup count' is based on the assumption that all Age Class V pups originate from outside of the survey area boundary or were already counted. The 'Maximum Upper Estimate' is combined upper estimated in which all sources of error are added to the observed counts and weaned pups (Age Class V) included in count per area.

Survey Area	Estimate Observed pup count: Whitecoat pups (Class I-IV)	Observed pup count: Weaned pups (Class V)	Pupping Season	Caves	Rocky Shore	Site Access	Maximum Upper Estimate
Bardsey Island	67	59	0	2	21.6	0	149.6 (+82.6)
Carmel Head	35	1	0	0.54	0.8	1	38.34 (+3.34)
Dee Estuary	0	0	0	0	0	0	0
East Anglesey	0	0	0	0	0	0	0
Gwynedd Coast	3	0	0	0	0	0	3
Holy Island	26	1	0	4.5	0	7	38.5 (+11.5)
Holyhead Bay	1	0	0	0	0	0	1
North Anglesey	1	0	0	0	0	0	1
North Lleyrn	2	2	0	0	0	0	4 (+2)
Skerries	41	7	0	0	2	1	51 (+10)
South Lleyrn	24	2	2	12.8	0.4	16.3	57.5 (+31.5)
The Ormes	6	0	0	0	0	0	6
Tremadog Bay	0	0	0	0	0	0	0
Unknown	1	0	0	0	0	0	1
West Anglesey	0	0	0	0	0	0	0
<b>North Wales Survey Region</b>	<b>207</b>	<b>72</b>	<b>2</b>	<b>19.84</b>	<b>24.8</b>	<b>25.3</b>	<b>350.94</b>

## 5.4.2 Pup Production in the Pen Llŷn a'r Sarnau SAC

Pup production within the Pen Llŷn a'r Sarnau SAC is of particular importance for managers who must monitor and report on site (SAC) condition. A detailed assessment of pup production within the SAC site was issued to NRW as part of this contract (see Ocean Ecology, 2018b), and it summarised the number of pups born within the site during the 2017 breeding season, along with an assessment of uncertainty and lower and upper estimates based on potential sources of error (as described above).

Data indicate a total of 159 age class I-V pups were produced in the SAC during 2017, with the majority of pups (126, 80%) originating from Bardsey Island, as is also the case for the whole survey region. The South Lleyrn survey area appears to be the second most productive area within the SAC, with 26 pups (16% of pups born within the SAC) observed during the season, whilst only four pups (two of which were unidentified Age Class V) were observed on the North Lleyrn and three on the Gwynedd Coast, both areas entirely within the SAC boundary. No pups were recorded at Tremadog Bay throughout the entire survey season, suggesting that this area does not currently support any grey seal pupping activity (as found previously). However, reduced survey effort along the Gwynedd Coast and in Tremadog Bay should be considered when interpreting results.

When considering all sources of uncertainty in the data, pup production estimates range from a minimum estimate of 96 pups (class I-IV) produced within the SAC to an upper estimate of 191 pups.

## 6. Discussion

An assessment of total pup production across the North Wales region has been carried out for the first time in over a decade. This represents a critical dataset that can inform conservation of the species across the region and within the Pen Llŷn a'r Sarnau SAC. It also assesses the spatial distribution of pupping activity across the region, investigates the temporal pattern of pup production at sites within this survey region and examines trends in pup production since previous surveys.

### 6.1 Pup Production Estimate

The results presented in this report suggest that birth rates of grey seals across North Wales have increased markedly over the last 15 years, based on the available data. Results of surveys carried out across the 2017 breeding season indicate that 279 individual pups (class I-V) were born during this period, with a minimum estimate of 207 class I-IV pups only and a maximum estimate of 351 pups (which includes all pups class I-V and adjustments for sampling errors), although the maximum and minimum estimates are considered unlikely. Based on the latest estimates (SCOS, 2017) this represents approximately 0.4% of all UK pup production and around 18% of the total pup production in Wales. Almost half of all the pup births recorded during the 2017 breeding season originated from pupping sites on Bardsey Island, which represents a key breeding site for this species in the region. The breeding season began in late August 2017 when the first pup was born and continued until December, following the birth of the last observed pup on the 8th December. Birth rates peak in September and October across all regions and habitat types, consistent with the known breeding ecology of the species (SCOS, 2017).

While unmatched age class V pups (those over 21 days old) are included as a source of potential error in the data and discussed in Section 0, it is considered that this is unlikely to be a significant factor in overestimating pup production at a particular site. Previous work has shown that grey seal pups leave their pupping sites in what is best described as a permanent emigration model (Hall et al., 2001), and while the age at which a calf leaves the site can vary, an average of 32 days at a pupping site has been reported in the UK (Coulson and Hickling, 1964).. It is therefore considered unlikely that the age class V pups recorded during the 2017 breeding season in North Wales originated from anywhere but the site at which they were observed, as once a pup has weaned and left the nursery site they will quickly leave the area of birth for a number of months with no current evidence to suggest they return to their place of birth.

### 6.2 Spatial Distribution of Pupping Activity

The main areas of pup production in North Wales are Bardsey Island, the South Lleyl Peninsula, Holy Island North, The Skerries, Carmel Head and The Ormes. Of these areas, Bardsey Island is by far the most productive within North Wales, with 45% of all pups born in the region originating from the island and producing more than double the number of pups than The Skerries, the second most productive area. Based on these results and the latest estimates available for Wales as a whole

(SCOS, 2017), pup births on Bardsey Island comprise around 8% of all pup births recorded in Wales. During the pupping season, Bardsey Island is one of the most isolated and undisturbed survey areas within the North Wales region and falls within the boundary of the Pen Llŷn a'r Sarnau SAC. The fact that this site supports such a high proportion of all pups within the region is perhaps a result of a combination of factors: relatively low levels of disturbance at the site (the island is privately owned and managed as a National Nature Reserve), a considerable length of coastline in comparison to other islands (e.g. The Skerries) in North Wales and a high proportion of this coastline comprising open beach - a favoured breeding habitat of grey seals (SCOS, 2017). It is well known that disturbance is a key factor in determining whether grey seal breeding activity occurs at a site (Abt et al., 2002), and females demonstrate strong preference for undisturbed sites. There are some notable exceptions to this, however, where grey seals have habituated to regular human presence, such as Donna Nook on the east coast of the UK where approximately 70,000 human visits each year has no apparent effect on breeding success (SCOS, 2015). An example of this can also be found in this dataset where Angel Bay on the Little Orme was found to be a successful pupping site in 2017, despite it being a popular area for dog walking and having no historical records of pupping activity.

Female grey seals show high site-fidelity, returning to the same breeding area year after year (Coulson and Hickling, 1964). Despite this, the dominance of Bardsey Island as a breeding site within the North Wales region is only evident in 2017 data and appears a relatively recent trend in the data (Figure 11), with historic pupping levels in this area more comparable to other sites within the region, and lower than some areas in the past. There is no evidence in the data to suggest that the increase of pup production at this site is as a result of females shifting from other areas within the region to Bardsey Island; the increase over time in pup production appears consistent at several other survey areas. In the absence of information on fecundity and survival rates, pup production can be a reliable index of population size (Hiby and Duck, 2003; Duck and Thompson, 2007), and the trends in the North Wales pupping data therefore suggest an increase in the wider regional population in general. The increase in North Wales is consistent with increases in grey seal populations elsewhere along the west and south-west coast of Wales (Bull et al 2017, Morgan et al 2018) and in Scotland and the wider UK over the last three decades (Duck and Thompson, 2007; SCOS, 2017).

## 6.3 Habitat Preference

Analysis of the distribution of pup production indicates a clear breeding preference in grey seals for open beaches, cliff-backed shingle beaches, rocky shores and cave habitats. Most pup births occurred on open beaches, despite a higher number of pupping sites being recorded on cliff-backed shingle beach habitat. While more active sites were observed to be cliff-backed shingle beaches, the sites on open beaches supported higher numbers of breeding females and subsequently pup births. This represents a departure from previous evidence where in 2004, the North Wales pupping census revealed the majority of pups were born in cryptic habitats (e.g. Caves) (Stringell et al 2014). Reasons for this disparity are unknown but may simply be due to the large expansion of the population over this period and that cryptic sites such as caves are physically constrained and have finite carrying

capacity. Open beaches are a favoured breeding habitat for grey seals elsewhere in the UK, possibly because these areas allow females and pups to retreat landwards to escape storm surges and overcrowding lower down on the shore (SCOS, 2017). Cliff-backed beaches and caves limit the potential to escape such threats and therefore may represent relatively unfavourable breeding habitats.

## 6.4 Data Limitations

This disparity between the number of sites of each habitat and the overall pups produced in each habitat highlights the lack of a measure of pupping density in the results, which was not possible without detailed information on the size of each individual site surveyed - a noteworthy limitation in the data. A measure of pupping density would allow further interpretation of these trends and an assessment of density-dependent processes in grey seal breeding behaviour in North Wales. Density dependence is an important consideration when considering site carrying capacities and other factors, such as pup mortality (Coulson and Hickling, 1964).

Another noteworthy limitation in the data and results presented, regards the calculation of maximum and minimum estimates of pup production. These estimates do not represent statistical confidence intervals. The calculation of such confidence intervals may not be appropriate here given the nature of the survey - a census rather than a sampling-based design. With the data available, it would be possible to calculate a standardised mean measure of pup production and associated variance, for example a mean density of pups produced per km<sup>2</sup> of a particular habitat (e.g. pups per km<sup>2</sup> of rocky shore), if not per site. However, this is beyond the remit of this survey programme regarding pup production in North Wales, and would introduce further uncertainty into the analysis. Such measures of pup density would, however, allow extrapolation of production estimates across areas where there was no survey coverage, and together with available data on the distribution of different pupping habitats could facilitate a modelling approach to pup production in the North Wales region. It is considered that future monitoring and the collection of further data on breeding site preferences and pup production levels would allow a more statistically robust analysis and, should resources be available, a detailed modelling approach to pup production throughout the region would certainly be worthwhile.

Survey effort was prioritised to maximise efficiency within the budget constraints of the project and overcome weather restrictions on site access. Sites were assigned a priority based on previous presence of seals, the suitability of habitat and the presence of human disturbance. While some sites subject to human disturbance support grey seal breeding activity (e.g. Angel Bay, Llandudno), prioritising survey effort in this way was necessary to maximise the collection of data at high priority sites. Furthermore, a total of five survey areas were excluded from field surveys due to the presence of human disturbance (see Appendix 1), and it is therefore considered highly unlikely that significant pupping activity was missed as a result of using the selection criteria outlined in Section 2.1. Survey effort is also a key consideration when interpreting the observed increases in pup production since surveys in 2002 and 2004. The 2004 census focused on 37 known breeding sites across seven areas of North Wales, while in 2017 a total of 14 survey areas across the North Wales region were surveyed, with 295 individual sites surveyed, of which 79 were found to be pupping sites. While an accurate comparison of what was

defined as a 'site' during each survey and the exact areas surveyed in each year is not possible, it appears that survey effort in 2017 was considerably greater than that of past years. This caveat should be borne in mind when interpreting the apparent increases across the region, although the survey areas in which this increase was highest were sampled in all years.

It is unlikely that all pups observed during the surveys and included in the production estimates presented in this report will successfully survive until adulthood and be recruited to the North Wales population. Past work on the survival of grey seal pups in the UK, calculated 2-month survival probabilities (i.e. the probability of an individual surviving to two months) for male and female grey seal pups of 0.74 and 0.89 respectively (Hall et al., 2001). It is understood, however, that survival rates vary dramatically between regions, with mortality estimates ranging from 0 to 40% (Coulson and Hickling, 1964; Anderson et al., 1979; Baker, 1984; Baker and Baker, 1988; Jüssi, 1999). The estimates provided by Hall et al. (2001) are based on pups of average condition, or 0.41 kg cm<sup>-1</sup> for males and 0.39 kg cm<sup>-1</sup> for females. No information on weight or pup condition was collected during this project other than qualitative notes, and while it is not possible to infer any information on pup survival, it should be considered that the pup production values presented in this report may not provide a wholly accurate estimate of the number of pups that ultimately contribute to the North Wales population. Survival to adulthood but settlement outside of the North Wales region also needs to be considered.

## 6.5 Pup Production within the Pen Llŷn a'r Sarnau SAC

The data suggest that an estimated 159 class I-V pups were produced within the Pen Llŷn a'r Sarnau SAC in 2017, while the minimum estimate is 96 class I-IV pups. This represents 57% of all pups produced within the North Wales region. Overall the grey seal population within the Pen Llŷn a'r Sarnau SAC appears to be in favourable conservation status and growing, with the number of pups produced almost doubling between 2002 and 2017 at the sites for which a temporal comparison is possible. Bardsey Island appears to be the key pupping site in North Wales and the SAC, supporting almost 80% of all pups born within the SAC boundary in 2017.

While the grey seal is not the primary reason for which the SAC was designated, the species is a qualifying feature of the site. The pup production estimates presented in this report suggest that the Pen Llŷn a'r Sarnau SAC currently contributes approximately 10% of all pup births in Wales, highlighting the importance of the SAC as a source of new recruits to the population. Given the importance of Bardsey Island for grey seals at both a regional and national level, management of the SAC should focus on maintaining the quality of Bardsey Island as a key component of SAC site condition.

## 6.6 Conclusions

Overall, the grey seal population in North Wales appears in good health, and analysis of the data collected during the 2017 breeding season demonstrates a notable increase in pup production compared to the last dedicated census undertaken in 2004. The region as a whole produces almost one-fifth of all pup births in Wales, and Bardsey Island alone produces almost 10% of pup births in Wales. The importance of undisturbed open beach sites as key grey seal breeding habitat, especially at Bardsey Island, is clearly evident in the data. Management efforts should aim to maintain the integrity and quality of these key areas to ensure successful pup production and continued recruitment to the region's grey seal population. Efforts to minimise or manage disturbance at key sites should be focused during the periods of peak pup births in September and October.



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## 8. Appendices

### Appendix 1. Site Prioritisation

Areas which were identified to possess any or a combination of the following characteristics were assigned low priority for regular survey monitoring: a) considerable foot traffic by the general public, b) no known seal presence or c) clearly uninhabitable stretches of coastline (i.e. lack of haul out / pupping areas). Based on these criteria, the following survey areas within the North Wales region were identified:

- Gwynedd Coast (Aberystwyth to Tremadog Bay);
- Upper Lleyn Peninsula;
- Menai Strait;
- Conwy Coast; and
- Dee Estuary, including the West Hoyle Sandbank (The West Hoyle Sandbank is a notable grey seal haul-out site, but it supports no recorded pupping activity).

These survey areas were therefore not targeted during monitoring surveys. While the use of such criteria introduces scope for pupping activity in these areas to be unrecorded, it is considered that any missed pupping activity in these areas would be identified through the stakeholder engagement process (see Appendix 2).

Confidence is therefore high that the application of these criteria to prioritise survey effort did not result in any significant unrecorded pupping activity in these areas. Effort was focused on those areas of greatest expected pupping importance given the time and budget constraints of the project.

## Appendix 2. Stakeholder Engagement

Stakeholder engagement was achieved through continuous communication with a number of relevant organisations within the North Wales region. These included various seal rescue groups as well as social media groups and members of the general public. Specifically, OEL ensured engagement with the following groups:

Rescue Centres:

- North Wales Seal Rescue Centre – Welsh Mountain Zoo
- Marine Animal Rescue Network – Anglesey Sea Zoo
- Royal Society for the Prevention of Cruelty to Animals (RSPCA)

Local Public

- Local Council Wardens
- Members of the public

Social Media

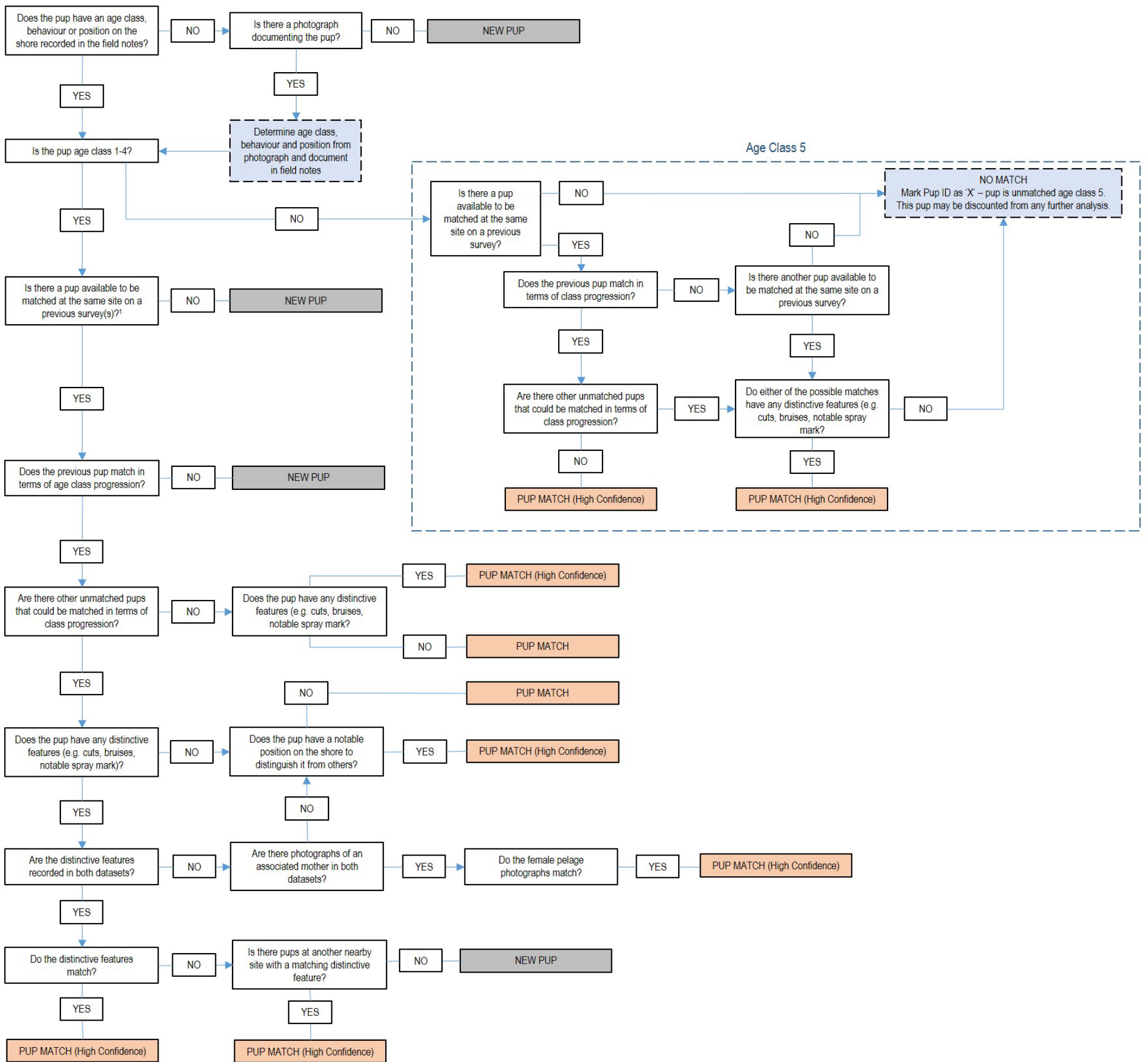
- Local Facebook Groups

Any reports of live pups across the survey region that had not been recorded by OEL were followed up by subsequent site visits to confirm the presence of pups.

## Appendix 3. Photo Catalogue

Photo catalogue provided separately to this report (see Data Archive Appendix).

# Appendix 4. Pup matching protocol to determine pup identity as either new or that of a previously recorded individual



1. Use most recent site visit. If no match found, review previous site visits within the constraints of the pups observed age class.

Figure 12: Flow chart of the process for the pup matching protocol.

## Appendix 5. Survey effort timeline by survey area

Table 6: Dates of surveys conducted in September for each survey area. Cells marked with 'X' denote the survey date.

Date	1. North Lleyn	1. South Lleyn	2. Bardsey Island	3. Holy Island (North)	3. Holy Island (South)	4. The Skerries	5. Carmel Head	6. Anglesey East	7. Dee Estuary	8. The Ormes	9. Anglesey North	10. Anglesey West	11. Holyhead Bay	12. Tremadog Bay	13. Gwynedd Coast
10-09-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
11-09-17	na	na	na	na	na	na	na	na	na	X	na	na	na	na	na
12-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
13-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
14-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
15-09-17	na	na	na	na	na	na	X	na	na	na	na	na	na	na	na
16-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
17-09-17	na	na	X	X	X	na	na	na	na	X	na	na	na	na	na
18-09-17	na	X	na	na	na	na	na	na	na	na	na	na	na	na	na
19-09-17	na	na	na	na	na	na	na	X	na	na	na	na	na	na	na
20-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
21-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
22-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
23-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
24-09-17	na	na	X	na	na	na	na	na	na	X	na	na	na	na	na
25-09-17	na	na		X	na	X	na	na	na	na	na	na	na	na	na
26-09-17	X	na	na	na	na	na	X	na	na	na	na	na	na	na	na
27-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
28-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	X	X
29-09-17	na	na	na	na	na	na	X	X	na	X	na	na	na	na	na
30-09-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Table 7: Dates of surveys conducted in October for each survey area. Cells marked with 'X' denote the survey date.

Date	1. North Lleyn	1. South Lleyn	2. Bardsey Island	3. Holy Island (North)	3. Holy Island (South)	4. The Skerries	5. Carmel Head	6. Anglesey East	7. Dee Estuary	8. The Ormes	9. Anglesey North	10. Anglesey West	11. Holyhead Bay	12. Tremadog Bay	13. Gwynedd Coast
02-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
03-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
04-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
05-10-17	na	na	na	na	na	na	na	na	na	X	na	na	na	na	na
06-10-17	X	X	na	na	na	na	na	na	na	na	na	na	na	na	na
07-10-17	na	na	X	na	na	na	X	X	na	na	na	na	na	na	na
08-10-17	na	na	na	X	na	X	na	na	na	na	na	na	na	na	na
09-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
10-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
11-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
12-10-17	na	na	na	na	na	na	na	na	na	X	na	na	na	na	na
13-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
14-10-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
15-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
16-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
17-10-17	na	na	na	na	30days	na	na	na	na	na	na	na	na	na	na
18-10-17	X	na	na	X	X	na	X	na	na	na	na	na	na	na	na
19-10-17	na	na	na	na	na	na	na	X	na	X	na	na	na	na	na
20-10-17	na	X	na	na	na	na	na	na	na	na	na	na	na	na	na
21-10-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
22-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
23-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
24-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
25-10-17	X	na	na	na	na	na	X	X	na	X	na	na	na	na	na
26-10-17	na	X	na	na	na	18 days	na	na	na	na	na	na	na	na	na
27-10-17	na	na	na	X	X	X	na	na	na	na	na	na	na	na	na
28-10-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
29-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
30-10-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
31-10-17	na	na	na	na	na	na	X	na	na	na	na	na	na	na	na



Table 8: Dates of surveys conducted in November for each survey area. Cells marked with 'X' denote the survey date.

Date	1. North Lleyn	1. South Lleyn	2. Bardsey Island	3. Holy Island (North)	3. Holy Island (South)	4. The Skerries	5. Carmel Head	6. Anglesey East	7. Dee Estuary	8. The Ormes	9. Anglesey North	10. Anglesey West	11. Holyhead Bay	12. Tremadog Bay	13. Gwynedd Coast
01-11-17	X		na	na	na	na	na	na	na	X	na	na	na	na	na
02-11-17	na	X	na	na	na	na	na	na	na	na	na	na	na	na	na
03-11-17	na	na	na	X	X	X	na	na	na	na	na	na	na	na	na
04-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
05-11-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
06-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
07-11-17	X	na	na	na	na	na	na	na	na	na	na	na	na	na	na
08-11-17	na	na	na	na	na	na	X	X	na	X	na	na	na	X	na
09-11-17	na	na	na	na	na	na	na	na	na	na	na	X	X	na	na
10-11-17	na	na	na	na	na	na	na	na	na	na	X	na	na	na	na
11-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
12-11-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
13-11-17	X	na	na	na	na	na	na	na	na	na	na	na	na	na	na
14-11-17	na	na	na	na	na	na	X	na	na	na	na	na	na	na	na
15-11-17	na	na	na	na	na	na	na	na	na	X	na	na	na	na	na
16-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
17-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
18-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
19-11-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
20-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
21-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
22-11-17	X	na	na	na	na	na	na	na	na	na	na	na	na	na	na
23-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
24-11-17	X	na	na	na	na	na	X	na	na	na	na	na	na	na	na
25-11-17	na	na	na	na	na	na	na	na	na	X	na	na	na	na	na
26-11-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
27-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
28-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
29-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
30-11-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Table 9: Dates of surveys conducted in December for each survey area. Cells marked with 'X' denote the survey date.

Date	1. North Lleyn	1. South Lleyn	2. Bardsey Island	3. Holy Island (North)	3. Holy Island (South)	4. The Skerries	5. Carmel Head	6. Anglesey East	7. Dee Estuary	8. The Ormes	9. Anglesey North	10. Anglesey West	11. Holyhead Bay	12. Tremadog Bay	13. Gwynedd Coast
01-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
02-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
03-12-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
04-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
05-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
06-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
07-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
08-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
09-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
10-12-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
11-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
12-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
13-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
14-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
15-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
16-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
17-12-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na
18-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
19-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
20-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
21-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
22-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
23-12-17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
24-12-17	na	na	X	na	na	na	na	na	na	na	na	na	na	na	na

## Appendix 6. Bubble plots by area to show pupping activity at all sites

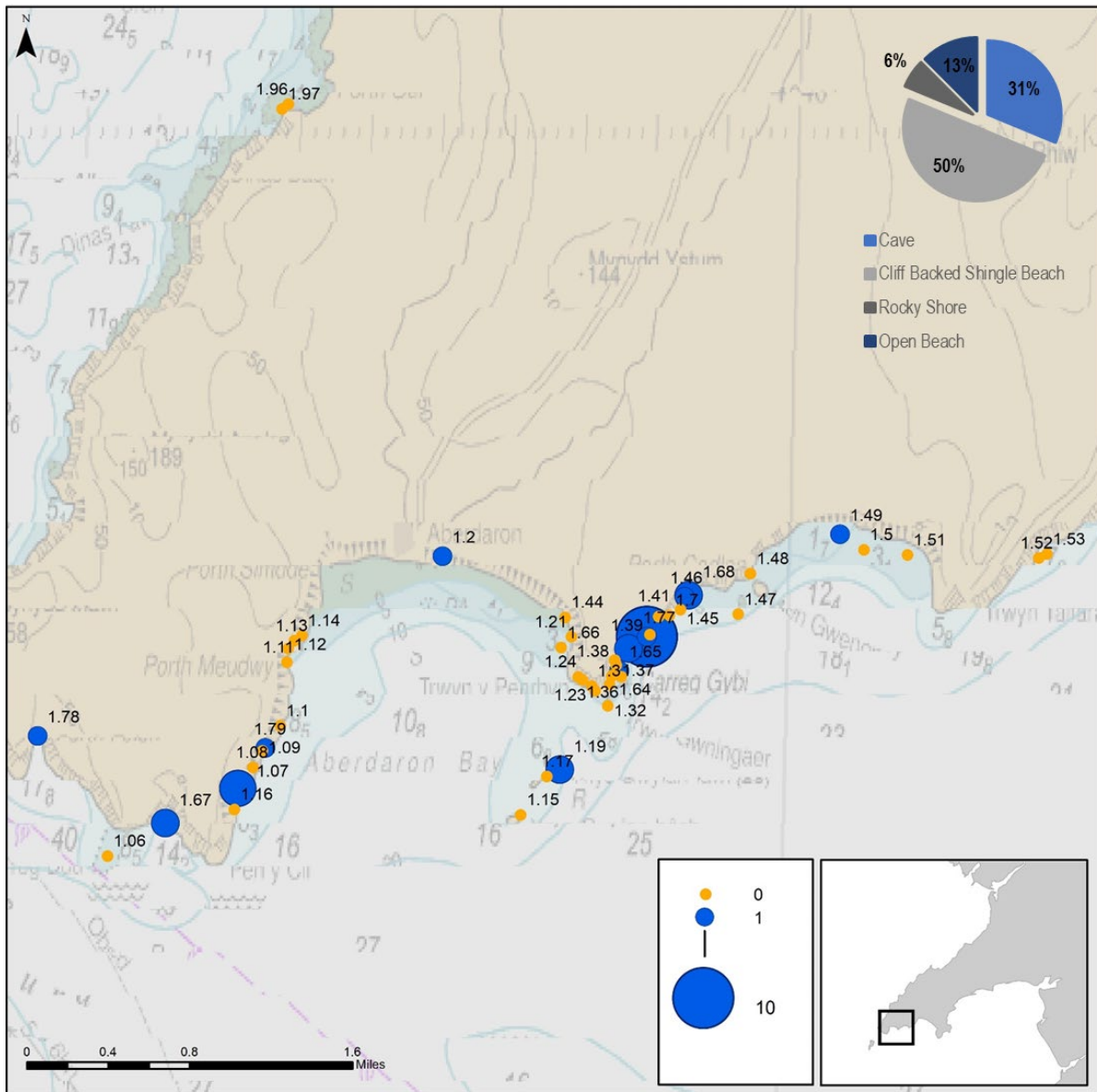


Figure 13: Map to show total observed pups along the westernmost section of the South Llyn in 2017 and all recorded potential sites. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded within the South Llyn.

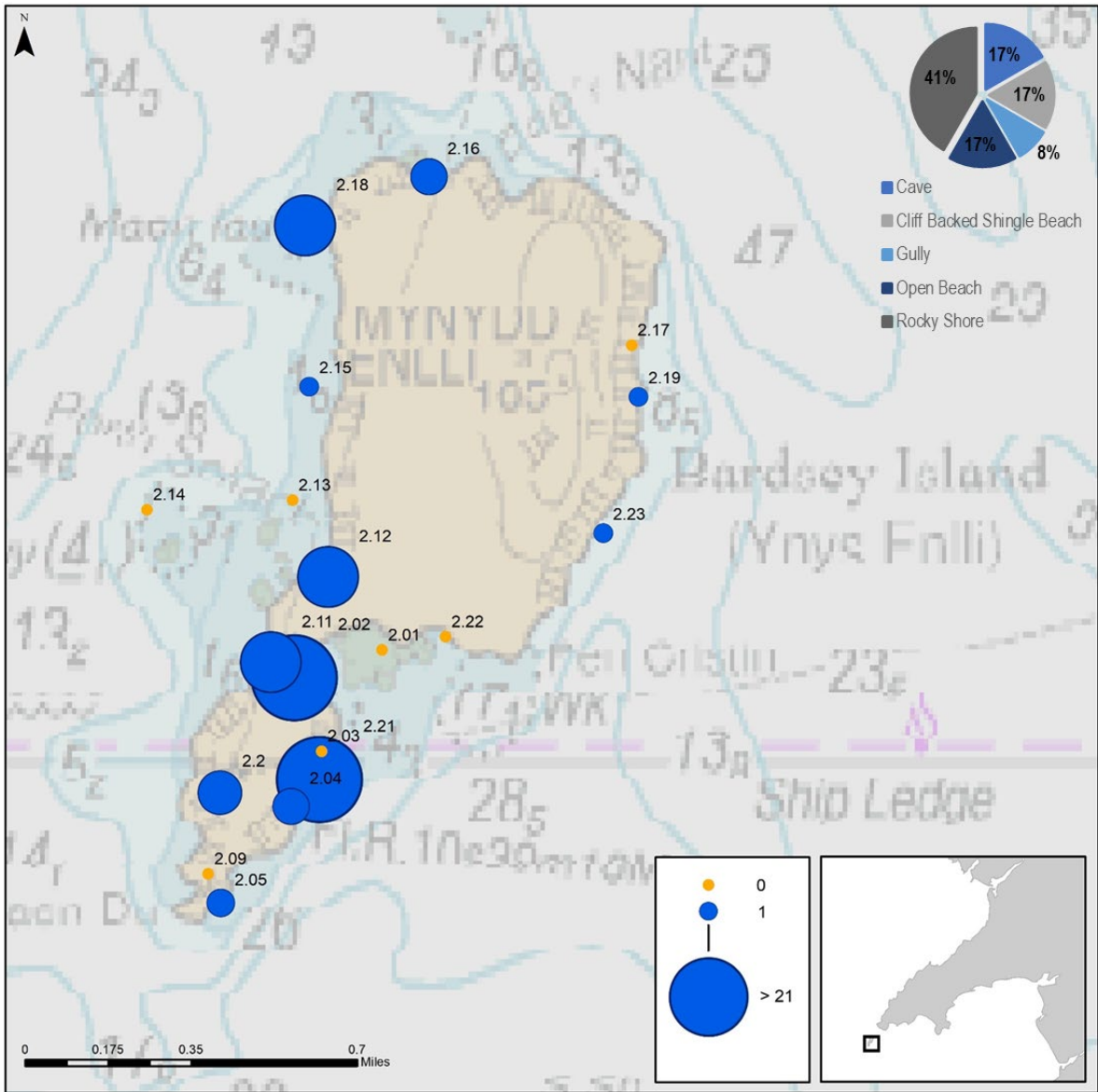


Figure 14: Map to show total observed pups on Bardsey Island in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded on Bardsey Island.

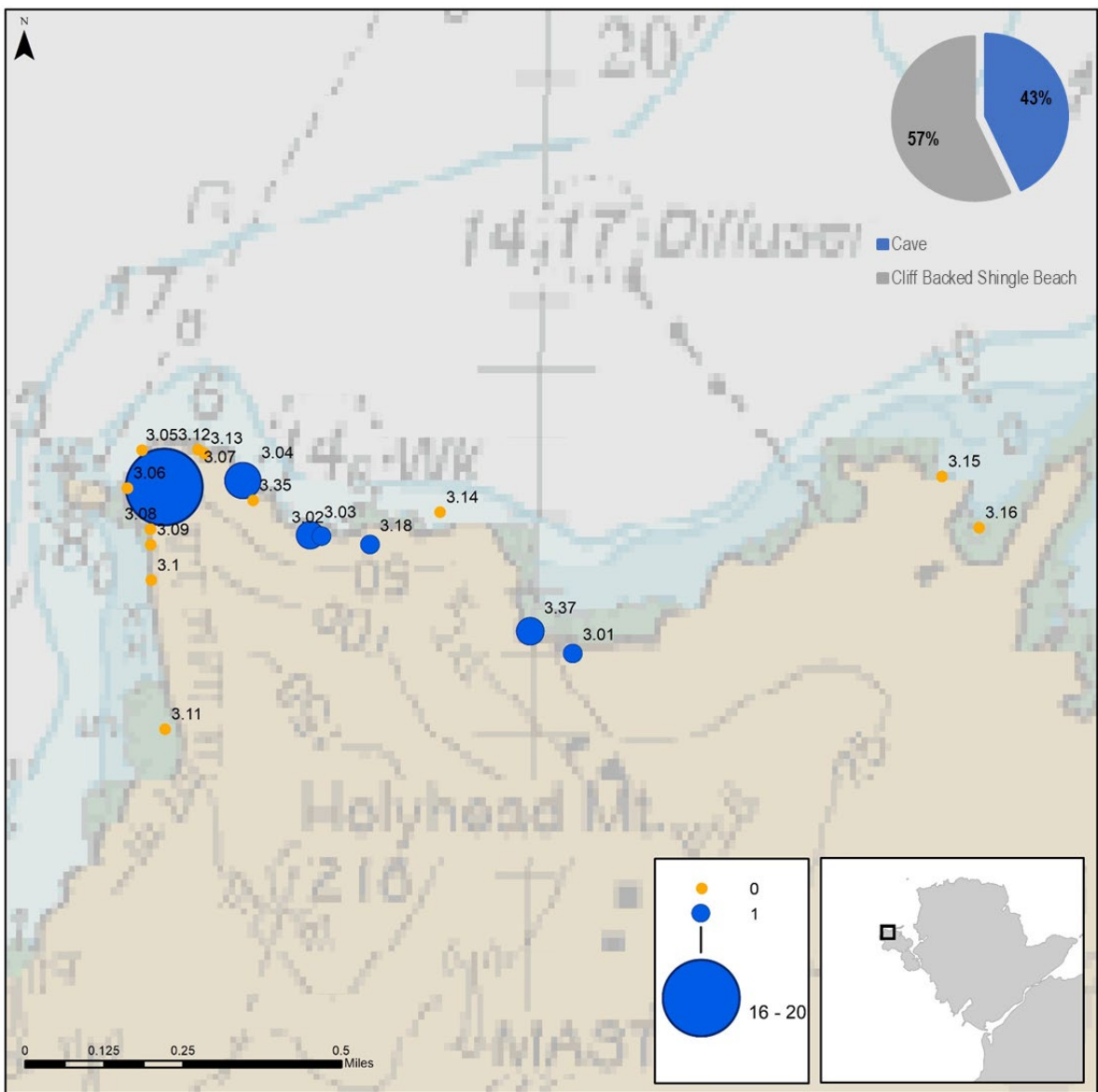


Figure 15: Map to show total observed pups at Holy Island (North) in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded within Holy Island (North).

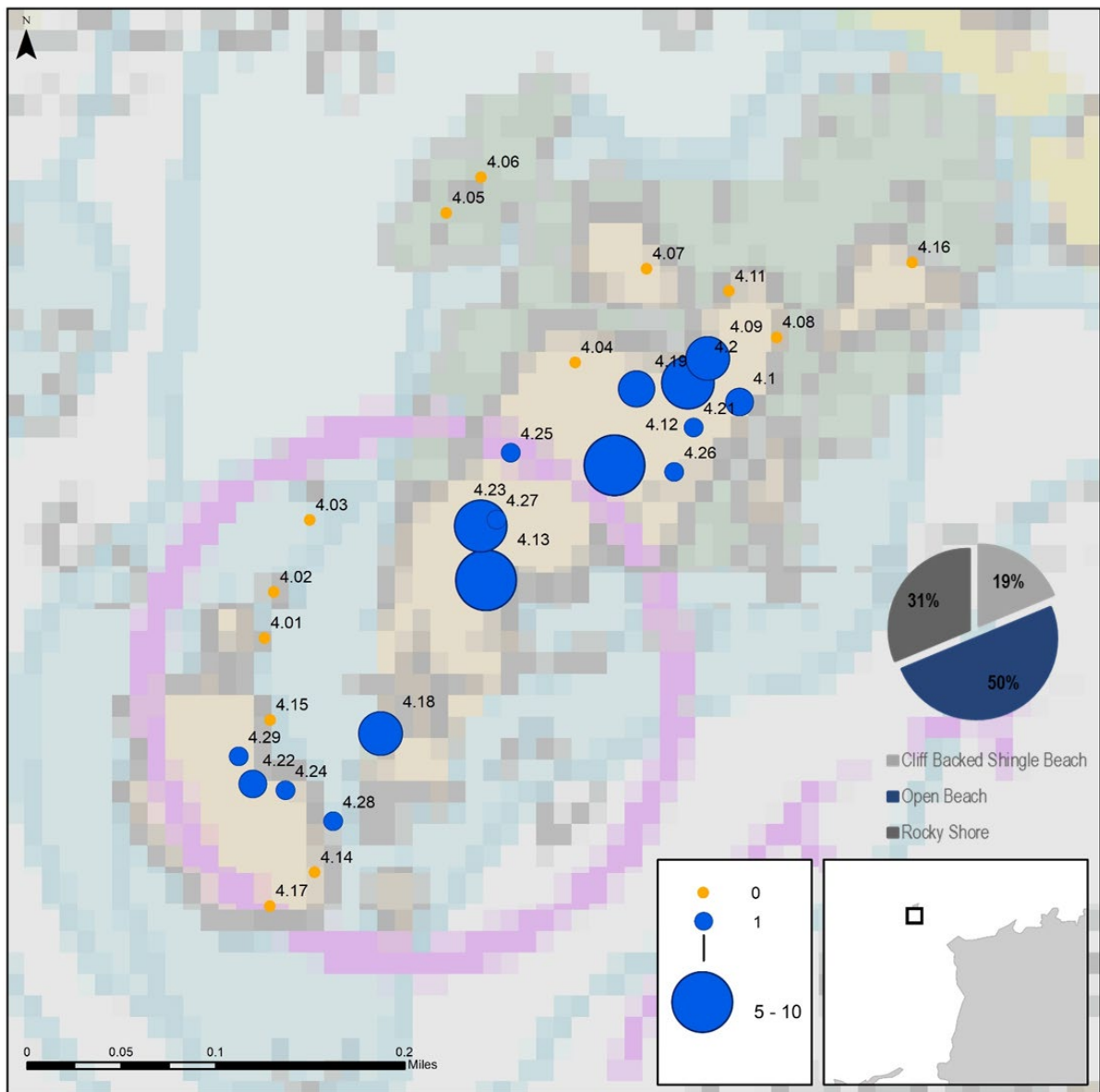


Figure 16: Map to show total observed pups on The Skerries in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded on The Skerries.

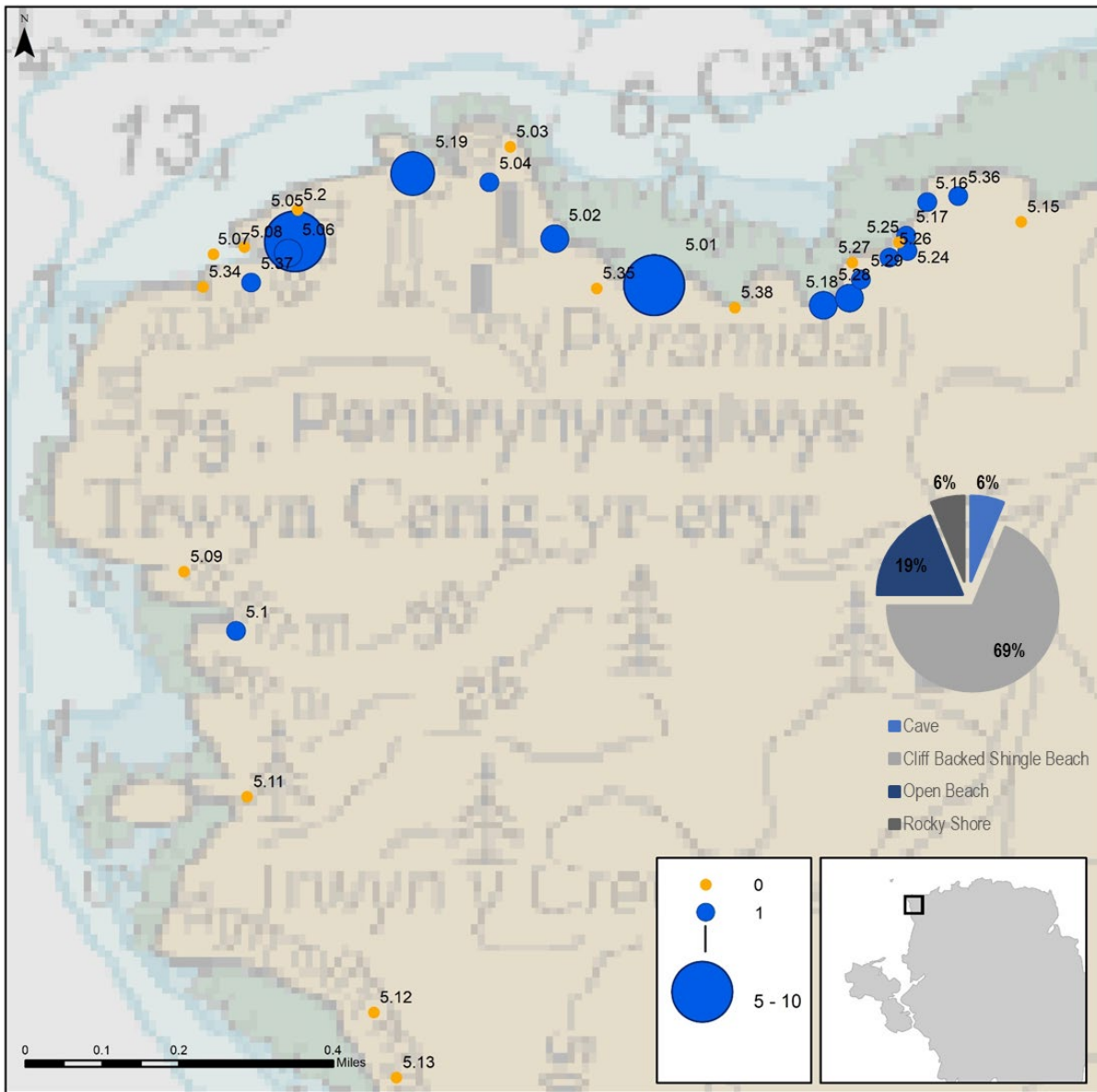


Figure 17: Map to show total observed pups at Carmel Head in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded along Carmel Head.

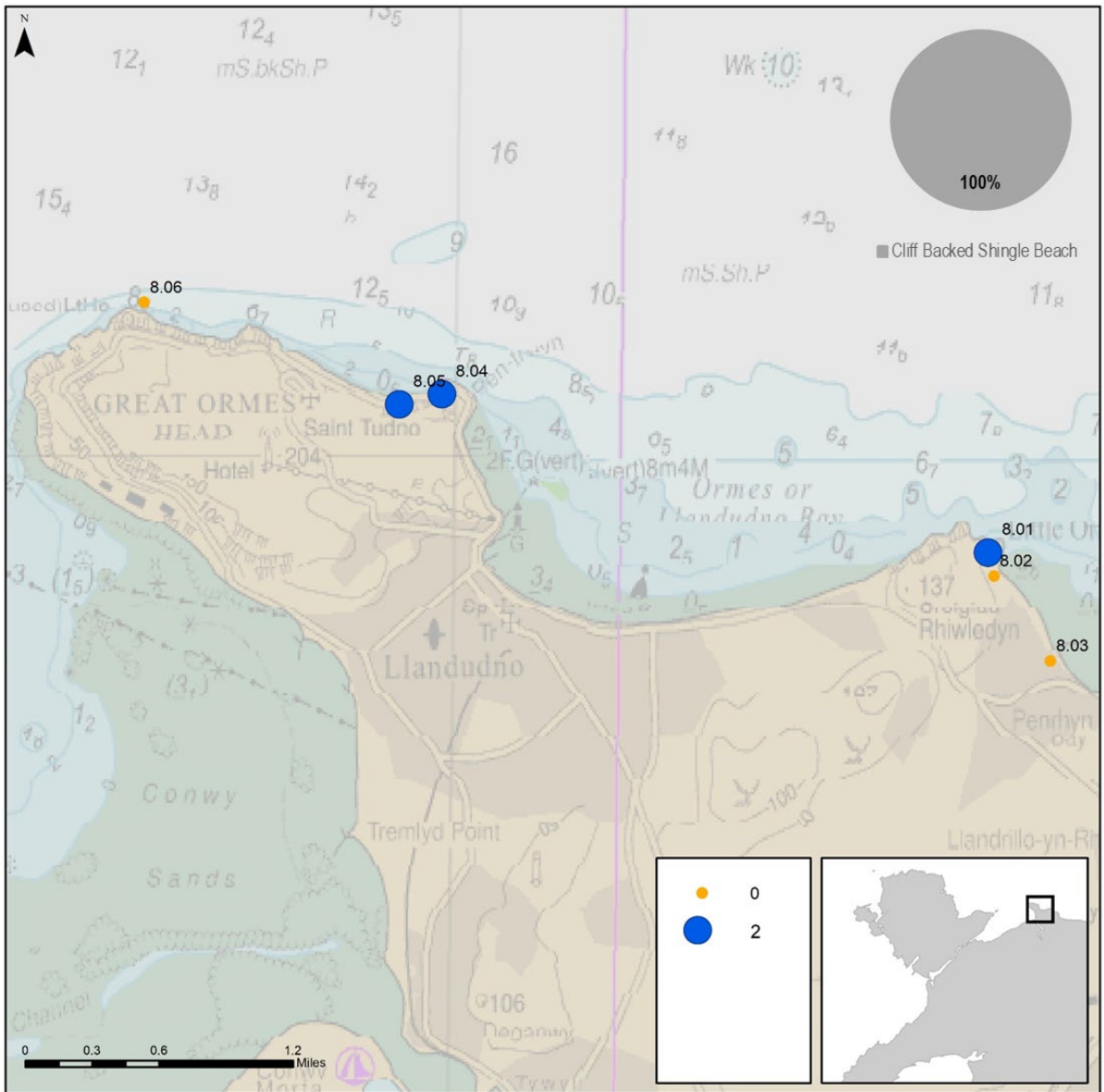


Figure 18: Map to show total observed pups at The Ormes in 2017. Pie chart to show the proportion of pupping habitats including nursery, pup rescue, dead pup and unmatched age class 5 sites recorded at The Ormes.



# Data Archive Appendix

Data outputs associated with this project are archived on server-based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] A full set of maps produced in JPEG format.

[C] A series of GIS layers on which the maps in the report are based

[D] A full set of photographic images of pups, photoID images of female grey seals for EIRPHOT, and site/survey information. Photos are in JPEG format organised by region and site.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue <https://libcat.naturalresources.wales> (English Version) and <https://catllyfr.cyfoethnaturiol.cymru> (Welsh Version) by searching 'Dataset Titles'. The metadata is held as record No. 124871



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Published by:  
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Maes y Ffynnon  
Ffordd Penrhos  
Bangor, Gwynedd  
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