A review of Northern Ireland seal count data 1992-2017: Investigating population trends and recommendations for future monitoring

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Executive Summary

Background

The Department of Agriculture, Environment and Rural Affairs (DAERA) coordinate the Northern Ireland seal counts and have requested a review of these data (from 1992 – 2017) to determine whether the methods employed have produced sufficient data to inform trends in seal populations over time. In addition, DAERA wanted to determine whether the methods employed are fit for future monitoring and if the count programme can be rationalised to better fit currently available resources.

Methods

The database was first summarised by columns to review available data. Maximum counts for each year and for each month were extracted from the database for: 1) harbour seal adults and juveniles combined, 2) harbour seal pups, 3) grey seal adults and juveniles combined, 4) grey seal pups, using counts from hauled out seals only. These were compared to proxies of effort (including: number of unique Seal Count IDs, number of surveys and number of Area IDs surveyed). A regression analysis was undertaken to assess what the percentage of annual change was, for each of the four species/age class datasets. This was done for Northern Ireland as a whole and for two individual areas separately; Strangford Lough and Murlough, both of which are ASSIs and SACs with harbour seals listed as a qualifying feature.

Results

Large numbers of missing values for environmental and observational data meant that these could not be included in the analysis, which resulted in a limited dataset to work from. Highest counts of adult harbour seals were in August and September, corresponding with the moult. The highest counts of harbour seal pups were in July, corresponding to the breeding season. For grey seals, the highest counts for adults were in August and September, with higher counts for pups in October; which corresponds to the breeding season. Comparing maximum counts with proxies for survey effort suggested that the harbour seal breeding season and moult were targeted, rather than the grey seal breeding season.

It is highly likely that varying effort across years and areas has played an influential role in the trends identified. In general, there has been lower effort in the earlier and the most recent years. If these data are omitted (using data from 1995 – 2014, inclusive), then, for the whole of Northern Ireland, there was a 0.1% and 0.88% annual increase in adult harbour seals and pups, respectively; and for grey seals, there was a 1.24% and a 4.91% annual increase in adults and pups, respectively.

Using the same approach in Strangford Lough, there was a 2.01% and a 1.31% annual decrease in harbour seal adults and pups, respectively; and for grey seals there was a 2.8% and a 5.21% annual increase in adults and pups, respectively. For Murlough, there was a 2.05% and a 4.41% annual increase in harbour seal adults and pups, respectively. Grey seals occurred in lower numbers at Murlough and were not assessed quantitatively, but it did appear that counts in recent years were yielding higher numbers. With respect to conservation objectives for the respective ASSIs and SACs, it appears that Murlough is successfully meeting the objective relating to maintaining a minimum population size of 84 harbour seals. However, for Strangford Lough, this may not be the case, as the population should be at least 200 adults, with at least 25% of the population being pups. The most recent

year that had any notable survey effort was 2014, where the maximum count was 87 adults and 34 pups, which equates to pups making up approximately 28% of the population. Applying a correction factor to account for seals at sea during the count would provide a maximum population estimate of 145 adults.

The variability in results based on the subsets of data analysed does demonstrate the issues associated with variable survey effort over time and space. As such, it is strongly recommended that these results are interpreted with caution. For example, it was not possible to identify, with confidence, whether low maximum counts were attributable to incomplete surveys of areas or were a true representation of a decreasing population.

Recommendations

- The errors in the database identified in this report should be cross-referenced with the datasheets from the field in an effort to maximise the volume of data for future analysis.
- Every effort should be made to ensure that the database is up-to-date and the analyses presented herein should be replicated with the complete counts in order to re-assess population trends.
- A minimum of two counts for each targeted species/demographic should be maintained. Specifically, these are: 1) harbour seal adults during the moult, 2) harbour seal pups during the breeding season and 3) grey seal adults and pups during the breeding season.
- Surveys should be undertaken in the best possible environmental conditions to allow for the maximum seal count. The most important factors in this respect are to ensure that surveys are undertaken +/- 2 hours from low tide and avoid periods of medium to heavy or prolonged rain.
- Restructuring the database to make it more streamlined and easier to manage would be extremely advantageous for future analysis and would likely result in fewer errors being entered into the database. Specific examples are provided in more detail within the report.
- It is strongly recommended that Northern Ireland provides representation at the Special Committee on Seals (SCOS), where scientific advice to government on matters relating to seal populations are discussed.

1. Introduction and Background

Seal monitoring in Northern Ireland began on Strangford Lough in 1976 with counts of the resident grey (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) populations at haul out points. Initial surveys were focused on the pupping season but became monthly from July 1992 and monitoring expanded in 1993 and 1996 to include populations at Dundrum and Tyrella, and Carlingford Lough respectively.

Since 1993, it has been the aim of the monitoring programme to conduct counts at each site on a monthly basis, which included double counts in July and August to cover harbour seal pupping and moulting periods (14 counts/site/year), but effort was variable based on availability of staff.

Monthly monitoring at each location remained the aim of the programme until 2015. Since then staffing pressures have resulted in a reduction in monitoring effort to a target of six counts per year at sites deemed the highest priority. Of these that are harbour seal sites, effort was focused on undertaking a double count in July for pups and a double moult count in August/September. At priority grey seal sites in this time, only double pup counts were undertaken in September/October.

The Department of Agriculture, Environment and Rural Affairs (DAERA) coordinate the Northern Ireland seal counts which are primarily undertaken by staff from Northern Ireland Environment Agency (NIEA), Marine and Fisheries Division (M&FD) and the National Trust (NT). DAERA now want to review the data collected and determine whether the methods employed have produced sufficient data to inform trends in seal populations (if any) over time. In addition, DAERA now want to determine whether the methods employed are fit for future monitoring and if the count programme can be rationalised to better fit currently available resources.

2. Aims

I. Review data collected and undertake a time-series analysis of grey and harbour seal populations for NI as a whole;

II. Review methodologies implemented historically in NI to monitor seal populations and determine whether current protocols are fit for detecting future change in seal populations in NI;

III. Using the results from ii) provide recommendations for a number of monitoring programme options based on the ability of any proposed schemes to detect agreed population changes and quantify the associated varying levels of effort required.

3. Database

The database was provided as three excel spreadsheets extracted from an Access database. These spreadsheets provided details on the 1) seal counts 2) environmental data and 3) geographical data (Figure 1). Each of these were examined before the relevant data from each spreadsheet was merged into one datasheet. All data organisation, manipulation, presentation and analyses were carried out in R (R Core Team, 2017) or Microsoft Excel (2016).

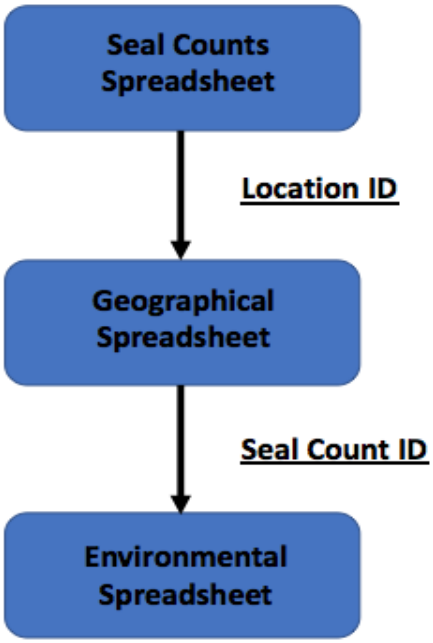

Figure 1: A flow diagram depicting the order in which each of the three spreadsheets were investigated and then merged with the following spreadsheet (indicated by the arrows). The underlined text to the right of the arrows is the name of the data column that the spreadsheets were merged on. See Sections 3.1, 3.2, 3.3 and 3.4 for more details.

3.1. Seal count spreadsheet

This spreadsheet houses the individual counts of seals. These are provided at the smallest spatial scale, referred to as 'LocationID' within the database (see Section 3.2). Therefore, there are counts taken at many known location IDs during a survey of one area (for example, Strangford Lough has a total number of 384 recorded location IDs within the database). Each line of count data has the number of seals counted for each of the species and age categories (Table 1) and whether the seal was hauled out or at sea.

Table 1: Summary of the codes used for species, age classes and locations of seals recorded in the field, the codes used in the database are in parentheses. For example, CAO is a hauled out adult common seal.

Species	Age	Location
Common/harbour Seal (C)	Adult (A)	Hauled out (O)
Grey Seal (G)	Juvenile (J)	At sea (S)
Unknown (U)	Pup (P)	

The seal count spreadsheet consisted of 70,379 rows of count data which amounted to a total of 85,558 seals counted (Table 2). Of the 70,379 lines of data, 60,873 (86.5%) were zero counts.

Table 2: Summaries of the seal counts by species, age class and location (Hauled out or at sea). The total number of harbour seals, grey seals and unknown species was 68,315, 16,892 and 351, respectively.

	Harbour seal			Grey seal			Unknown species			
Location	Adult	Juv.	Pup	Adult	Juv.	Pup	Adult	Juv.	Pup	Total
Hauled out	62,765	77	3,141	14,328	20	1,046	334	0	7	81,718
At Sea	2,227	4	101	1,472	4	22	10	0	0	3,840
Total	64,992	81	3,242	15,800	24	1,068	344	0	7	85,558

3.2. Geographical spreadsheet

The geographical spreadsheet holds the information on each 'LocationID'. These are the smallest spatial components surveyed. It consists of 715 unique locations and has 11 variables; some of these variables have no data associated and/or are uninformative (Table 3). The coordinates have 196 blank lines, which indicates missing data; however, 44 of these rows are named 'no seals observed' in 'LocationDescription'. Therefore, there are LocationIDs that have nothing to do with a location and there are also examples of LocationIDs that do relate to geographic data but are relatively uninformative (e.g. haul out unknown, ca. n = 50).

Table 3: Summary of data/variable names within the geographical spreadsheet; the number of missing values and percentage of data missing, along with some additional notes where relevant, are provided. The percentage is calculated based on the size of the spreadsheet (n = 715).

Data/variable	No. missing values	% data missing	Notes
LocationID	0	0%	-
AreaID	0	0%	-
SectionID	18	3%	-
ParentLocationID	77	11%	-
LocationDescription	NA	NA	Text description
XCoordinate	196	27%	Irish Grid Reference (OSI)
YCoordinate	196	27%	Irish Grid Reference (OSI)
IGR	0	0%	Unique alpha-numeric
HyperlinkJPEG	715	100%	No data
HyperlinkDoc	715	100%	No data
Historical	NA	NA	All are "FALSE"

The order of the geographic data (from smallest to largest) are: Location ID > Parent Location ID > Area ID (see Figure 2, for an example of Strangford Lough). The latter two appear to be relatively stable, i.e. these are well-defined geographic areas (at least this is the case for Strangford Lough; see Figure 2). The location IDs are far more variable and do appear to change regularly, which suggests that location IDs were not consistently surveyed within years and, based on the nomenclature, may be specific to an individual doing the survey and/or were created on the day based on the location of the seals within the wider Parent Location ID. However, with respect to the spatial resolution, the seal count ID is, for the vast majority of the data, only associated with one Parent Location ID on a survey day. Therefore, there is no need to consider individual location IDs, these are deemed redundant for the purposes of investigating population trends. However, the location ID is the only data column that links the seal count spreadsheet with the geographical spreadsheet; for this reason, it was used to merge the two spreadsheets.

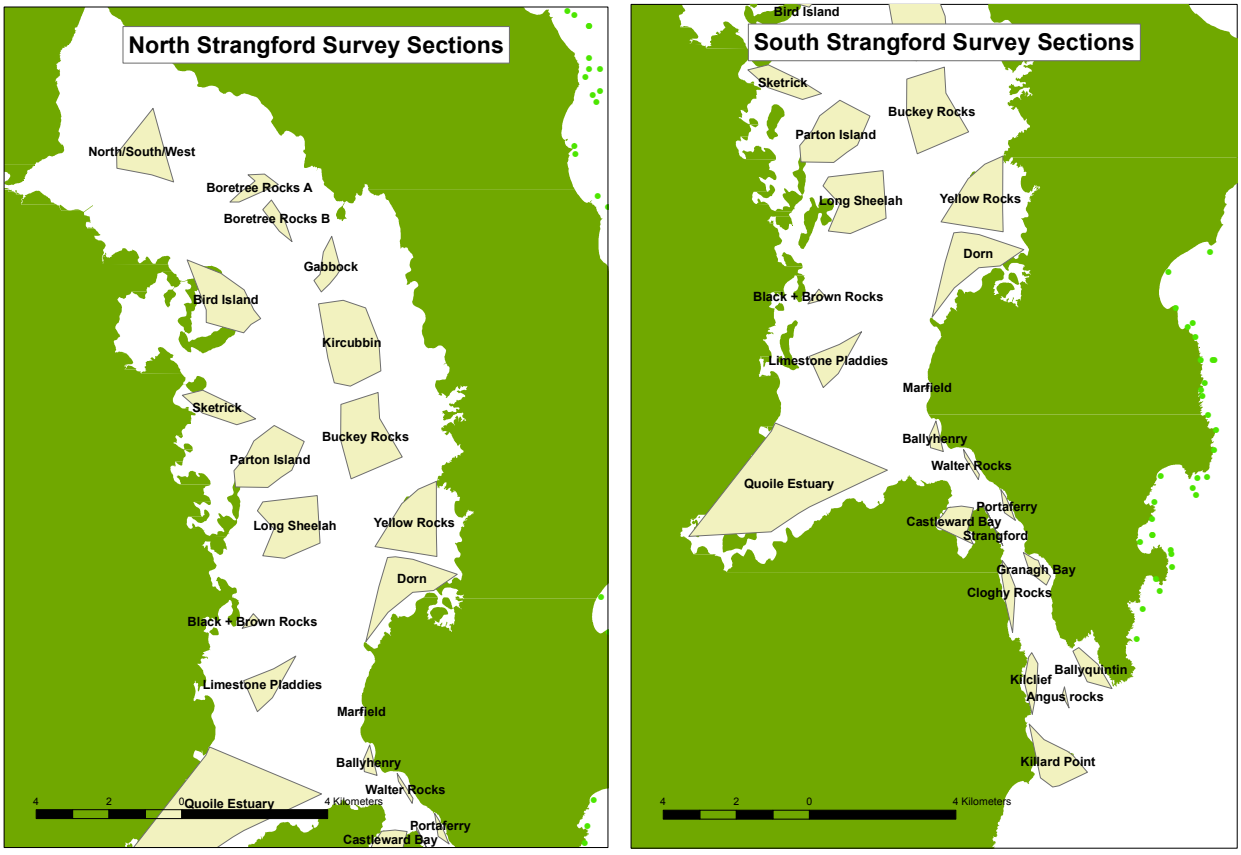

Figure 2: Strangford Lough (Area ID), separated into north and south sections, showing the 25 Parent Location IDs, as polygons with their given name associated. Location IDs would be within these polygons, and the number of these, for each Parent Location ID was variable across years. Note that Parent Location IDs do cover variable surface areas, with those in the narrows tending to be smaller. These GIS plots were provided by David Tosh (CEDaR) (Map created using ArcGIS 10.5.1).

3.3. Environmental spreadsheet

The environmental spreadsheet consisted of 25 variables over 8,956 rows of information. It contained the temporal, environmental, methodological and some geographical information for each 'SealCountID' from the seal count spreadsheet.

These 25 variables were investigated for missing values, the results of which are outlined below, with the name of the data/variable, the number of missing values and the percentage that this equates to across the 8,956 rows split across Tables 4, 5 and 6.

The temporal data has no missing start or end dates but has a relatively large percentage of missing start and end times and, as a result, a relatively large percentage of missing durations of the count (Table 4). The data for environmental variables do tend to have a large number of missing values (Table 5). For seal counts on haul outs, the important data to collect or generate is the tidal state, as this is the most influential environmental variable when quantifying number of seals hauled out (Thompson et al., 1989). Although missing data for variables pertaining to tide have the lowest percentage of data missing, these are still values approaching one fifth of the dataset.

Table 4: The data/variable names, number of missing values and percentage of data missing. The percentage is calculated based on the size of the of the spreadsheet (n = 8,956).

Variable	No. missing values	% data missing
Start date	0	0%
End date	0	0%
Start time	655	7.3%
End time	1,065	11.9%
Duration of the count	971	10.8%

Table 5: Environmental variable names, number of missing values and percentage of data missing. The percentage is calculated based on the size of the of the spreadsheet (n = 8,956).

Variable	No. missing values	% data missing
Low tide time	1,586	17.7%
Low tide height	3,947	44.1%
Air temperature	4,211	47.0%
Sea temperature	5,605	62.6%
Visibility	1,451	16.2%
Wind direction	2,030	22.7%
Wind force	1,724	19.2%
Sea state	6,483	72.4%
Cloud cover	6,076	67.8%
Degree of precipitation	6,735	75.2%

Table 6: Methodological and Geographical variables, number of missing values and proportion of data missing. The percentage is calculated based on the size of the of the spreadsheet (n = 8,956).

Variable	No. missing values	% data missing
Recorder ID	533	6.0%
Survey type	3	0.03%
Methodology	3	0.03%
Comments	3,284	36.7%
Survey document	8,956	100%
Incomplete Survey (true/false)	2,842	31.7%
Added By	8,570	95.7%
Added Date	8,570	95.7%
Area	126	1.4%
Section	640	7.1%

The methodological and geographical variables also have high percentages of missing values (Table 6). Some of this information is non-essential but the variable 'Incomplete survey' is a True/False variable that may hold valuable information on the survey effort (particularly at sites were effort is split between teams covering different geographic areas).

3.4. Bringing the spreadsheets together

In merging the seal count spreadsheet with the geographical spreadsheet (using the Location ID; the only variable/information that linked the two spreadsheets), the unique location IDs were reduced from 715 to 623. This means that 92 unique Location IDs had no seal count IDs associated with them. This was not investigated further, but it is assumed these are either zero counts or were Location IDs with no location information associated (see Section 3.2). The Seal Count ID was used for multiple Location IDs; therefore, it was not a unique value (i.e. the same Seal Count ID reoccurred over multiple rows). The Seal Count ID was the only variable/information that linked the seal count spreadsheet with the environmental spreadsheet; therefore, it was used to merge the seal count/geographical spreadsheet with the environmental spreadsheet. In doing this, 63 duplicated Seal Count ID rows were identified. These duplicates contained all the same information except the values in the 'Section' column; which is a text descriptor of the area. This information is not relevant to the analysis; therefore, the duplicates were removed.

3.5. Defining the dataset

The process of merging the three spreadsheets (seal count, geographical and environmental) created a dataset of 9,119 rows. Given the large number of missing values in the environmental data, which would restrict quantitative analysis (i.e. all rows with missing data would have to be removed); all of the columns listed in Tables 5 and 6 were removed from the dataset.

In R, the start and end time associated with each Seal Count ID was used to calculate the duration for that Seal Count ID. This approach identified values ranging from ca. -1000 minutes to ca. 800 minutes, with a median of ca. 0 minutes (Figure 3). As the plot suggested,

the majority of data were 00:00:00; further investigation found that some start (n = 655) and end (n = 1,065) time data had defaulted to 00:00:00 or was not entered (Table 4). There were likely examples of data entered using a 12-hour format, where Access uses a 24-hour format (for example, the data read 1:30:00am, where it is most likely the user intended to enter 13:30:00); however, these errors appear to occur less frequently (estimated to be n <50). These were not removed or edited; however, given the errors for these data, duration and times were not used in the analysis.

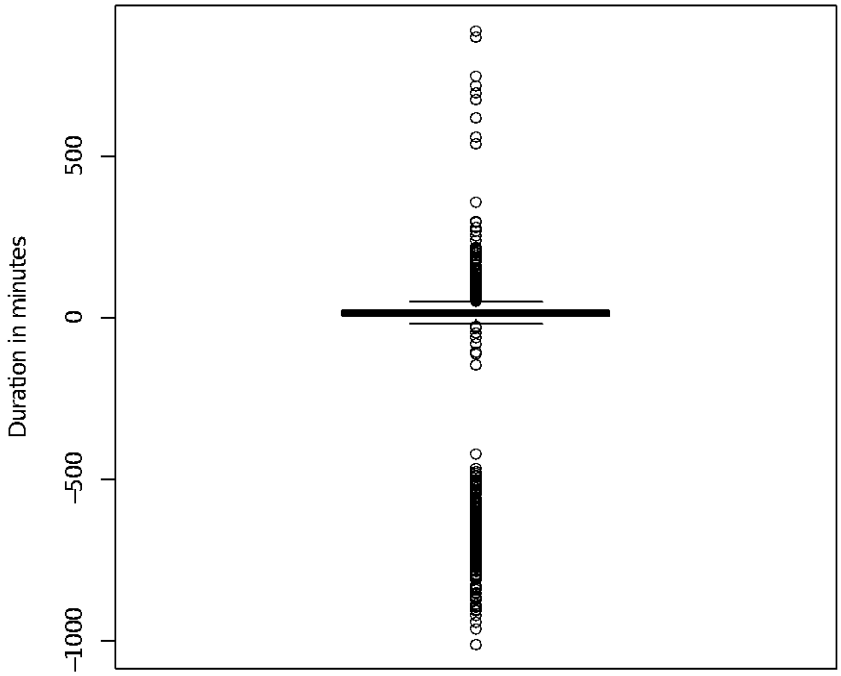

Figure 3: The duration of time in minutes for each of the Seal Count IDs. The centre of the boxplot shows the median (50% percentile), the bottom and top of the box (which are not visible in this plot due to the spread of the outliers and the majority of data centred at 00:00:00) indicate the 25% and 75% percentiles; the whiskers illustrate the quartile range + 1.5 x the Inter Quartile Range (IQR); the data points shown are out-with that range.

The seals recorded as an unknown species (n = 351) were removed from the analyses as these cannot be assumed to be either species and therefore cannot be used in any assessment of population trends of either species. It is difficult to accurately count seals in the water and this can lead to multiple counts of the same individuals, as such it is recommend that the counts are targeted on seals that are hauled out, only. Therefore, seals in the water have been removed from the analysis and instead, a minimum population estimate is presented. In addition, population trends were investigated for adults (incorporating the juveniles) and pups, separately. Pups are not reproductively active, and mortality prior to reaching a reproductive active age is high (e.g. estimated survival probabilities of 0.39 by 6 months for female harbour seal pups in Scotland; Hanson et al., 2013; annual survival rates of 0.617 and 0.193 for female and male grey seals of the east coast of Scotland; Hall et al., 2001). Therefore,

inclusion in population estimates would only serve to (incorrectly) over-estimate the population size.

The remaining columns used to generate plots of the count data were:

- Area ID – to allow for splitting the dataset by Areas (see Table 7)
- YY, MM, DD – these three columns broke the date into year (YY), month (MM) and day (DD)
- Seal Count ID – the unique identifier for seal counts

The seal counts for each species (harbour seal and grey seal) and age class, for hauled out counts, only, were retained within this dataset.

Table 7: A summary of the number of Seal Count IDs, number of survey days and the years in which data were collected at each of the areas. Area ID 819 had location IDs that mostly appeared to be associated with Belfast Lough, but this was not investigated further.

Area ID code	Area	No. of seal count IDs	No survey days	Years of data
10	Test haul outs	2	1	1 (2014)
11	N/A	1	1	1 (2014)
12	The Maidens	12	5	4 (2000, 2002, 2006, 2007)
13	Strangford Lough	6,522	361	25 (1992 – 2014, 2015, 2017)
14	North Antrim & Skerries	63	62	9 (2002, 2006 – 2012, 2016)
15	Carlingford Lough	130	129	17 (1996 – 2012)
310	Rathlin Islands	47	39	6 (1999, 2002, 2011 – 2014)
311	Lough Foyle	103	68	7 (2008 – 2014)
312	Outer Ards	972	174	19 (1993-2000, 2005-2014, 2016)
313	Murlough SAC	382	251	22 (1993-2014)
314	Larne Lough	66	64	5 (2009-2014)
819	N/A	42	41	3 (2009-2012)
852	South Belfast Lough	92	92	12 (1995-2003, 2009, 2013, 2014)
853	North Belfast Lough	129	127	15 (1996-2009, 2015)
854	Copelands	81	35	12 (1995-2004, 2007, 2008)
855	Dundrum	475	239	19 (1993-2012)

4. Approach used

For the purpose of managing seal populations, obtaining a maximum count to give a minimum population estimate is the aim. Therefore, maximum counts were extracted from the database for the relevant spatial and temporal periods of interest. However, as effort has varied within and across years (and in particular, in recent years during July and August to target the harbour seal breeding season and moult) (see Section 1), three proxies for effort and the completeness of surveys are considered in the analyses:

1. The total number of Area IDs surveyed in a year/month

2. The total number of surveys in a year/month

3. The total number of unique Seal Count IDs in a year/month

The first proxy provides information on the coverage across Northern Ireland as a whole. This is important because, if few Area IDs were surveyed and this corresponded to a low maximum count, this could be indicative of low survey effort, rather than a decrease in the population, for example. The second proxy provides information on the number of surveys conducted (where a survey is defined by day; i.e. an Area ID with one or more Seal Count IDs on a given day, would be defined as a survey). Similar to Area ID, this is important because, if few surveys were undertaken and this corresponded to a low maximum count, this could be indicative of low survey effort, rather than a decrease in the population, for example. Furthermore, given the changes to the survey protocols over the recent years (Section 1), it is likely that the number of surveys in more recent years will have decreased; therefore, it is important to consider this in the analysis.

The third of these proxies aims to address one of the principal concerns with the data, which is that surveys of Area IDs may be incomplete. It is not straightforward to discern if this was the case or not, as the 'incomplete survey' column had a lot of missing data (Table 6); even if this information were entered, the degree to which the survey was incomplete could not be derived from this column. For some areas, like Strangford Lough (which has considerably more data than any other Area IDs; Table 7), one unique Seal Count ID is almost always associated with only one Parent Location ID (Figure 2); therefore, it can give an indication of how complete a survey was. Collectively, if surveys in all Area IDs followed this approach, then this would give a proxy for completeness of surveys across Northern Ireland. However, for other Area IDs, the manner in which Seal Count ID corresponds to Parent Location ID is variable over time. Nonetheless, this proxy was considered to be informative with respect to effort, as the same logic as to the other two proxies still stands; if low maximum counts correspond to a low total number of unique Seal Count IDs, these data should be interpreted with caution.

For each year, the highest count from a survey for each Area ID was extracted from the database; this is referred to as the annual maximum count. The annual maximum count for each Area ID was then summed to give a total annual maximum count for that year for Northern Ireland. Note that the annual maximum counts for Area IDs will unlikely to be from the same day, and it is possible that they may not even be from the same month. Nonetheless, this was deemed to be the best approach for obtain maximum counts and, from the results

presented in the report, it is extremely likely that the maximum counts were obtained from either the months July, August or September, depending on the species and age class.

For each month, the highest count from a survey for each Area ID was extracted from the database; this is referred to as the monthly maximum count; these could originate from any survey year. The monthly maximum count for each Area ID was then summed to give a total monthly maximum count for that month for Northern Ireland. These data are to highlight seasonal trends only and are not as informative from the perspective of a population estimate, as the monthly counts are populated by data from multiple years. Note that the annual and monthly maximum counts included only hauled out seals where there was a positive species ID and these data were split into two age classes: adults (which included juveniles) and pups. These were considered to be the minimum annual population estimates.

To assess population trends, the maximum counts by year were used. Using these data, a regression line was applied to the time series and (using the log10 of the annual counts) the percentage annual change in the population was calculated. This was done for Northern Ireland as a whole, and for Strangford Lough and Murlough, separately. Given variations in survey effort, particularly in the earliest and the most recent years, regression lines and the percentage of annual change was calculated for the complete data set (1992 – 2017) where possible, and for subsets of the data, where low effort was presumed to have resulted in reduced numbers in the maximum counts.

5. Results

5.1. Collective Northern Ireland counts

The maximum count for each year for Northern Ireland were compared with the total number of unique Seal Count IDs undertaken and the total number of Area IDs (excluding Area IDs 10 and 11; Table 7) with at least one Seal Count ID associated in that year. The use of Area ID gave an indication of completeness of survey across Northern Ireland (i.e. more Area IDs surveyed indicate greater coverage). A Spearman's rank correlation coefficient was used to test this relationship, which found a strong, significant correlation between the maximum seal counts and both proxies for survey completeness, for both species, for both age classes (Table 8; Figures 4 – 7). In general, this relationship was much more prominent for the annual counts than for the monthly counts (Table 8; Figures 4 - 7).

In all cases for harbour seal adults and pups there was a significant positive correlation for all three proxies of effort and completeness of surveys. Therefore, the more effort (i.e. more Area IDs surveyed, more surveys undertaken, more unique Seal Count IDs recorded in the database), the greater number of harbour seals (adults and pups) counted. For year, the correlation coefficient did tend to be higher for adult harbour seals than for pups; the converse pattern was true for month (Table 8; Figures 4 – 7). The results for grey seal adults and pups is more variable, with several correlations not significant; this was particularly true for pups (Table 8; Figures 4 – 7). This may be an indication that surveys were targeted more towards harbour seals than to grey seals. For both species, the monthly comparisons are not particularly informative because there are two considerably higher numbers associated with surveys in July and August, and there are always 13 Area IDs surveyed each month (collectively across the years), with an additional Area ID that was surveyed in July and August (The Maidens; Table 7). Therefore, these plots have two outliers each (Figures 5 & 7). As

there was little variation in the number of Area IDs surveyed across months, these data were not plotted in conjunction with the maximum seal counts, as this comparison would not be informative.

Table 8: Spearman's rank correlation coefficient for harbour and grey seal maximum counts against number of: Area IDs, surveys and unique Seal Count IDs across years and months. A P value of < 0.05 is considered significant and is displayed in bold; a coefficient of 1 would indicate a perfect straight line (i.e. a perfect correlation).

			Number of Area IDs		Number of Surveys		Number of unique Seal Count IDs	
	Species	Age class	Coefficient	Significance	Coefficient	Significance	Coefficient	Significance
Years	Harbour	Adult	**0.74**	**P < 0.001**	**0.73**	**P < 0.001**	**0.40**	**P = 0.043**
		Pup	**0.44**	**P = 0.026**	**0.54**	**P < 0.005**	**0.41**	**P = 0.037**
	Grey	Adult	**0.78**	**P < 0.001**	**0.74**	**P < 0.001**	0.13	P = 0.533
		Pup	**0.64**	**P < 0.001**	**0.75**	**P < 0.001**	0.06	P = 0.785
Months	Harbour	Adult	**0.58**	**P = 0.047**	**0.66**	**P = 0.019**	**0.80**	**P = 0.002**
		Pup	**0.65**	**P = 0.023**	**0.88**	**P < 0.001**	**0.78**	**P = 0.003**
	Grey	Adult	**0.65**	**P = 0.023**	**0.65**	**P = 0.021**	**0.78**	**P = 0.003**
		Pup	-0.42	P = 0.172	-0.06	P = 0.845	-0.03	P = 0.931

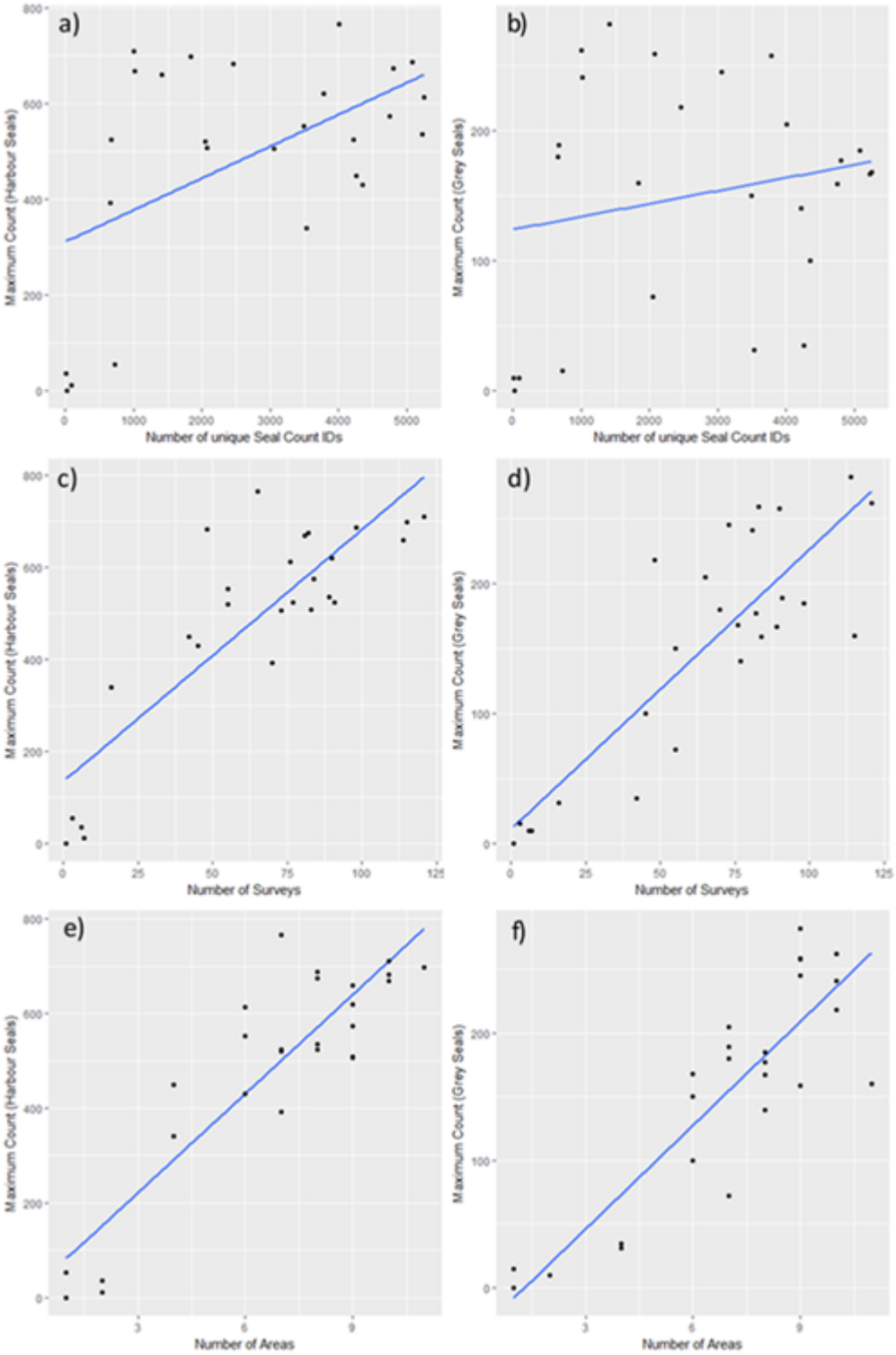

Figure 4: Maximum counts for each year, plotted: against the number of unique Seal Count IDs in that year for a) harbour seal adults and b) grey seal adults; against number of Surveys in that year for c) harbour seal adults and d) grey seal adults; and against number of Area IDs surveyed in that year for e) harbour seal adults and f) grey seal adults. The blue line is the line of best fit (see Table 8).

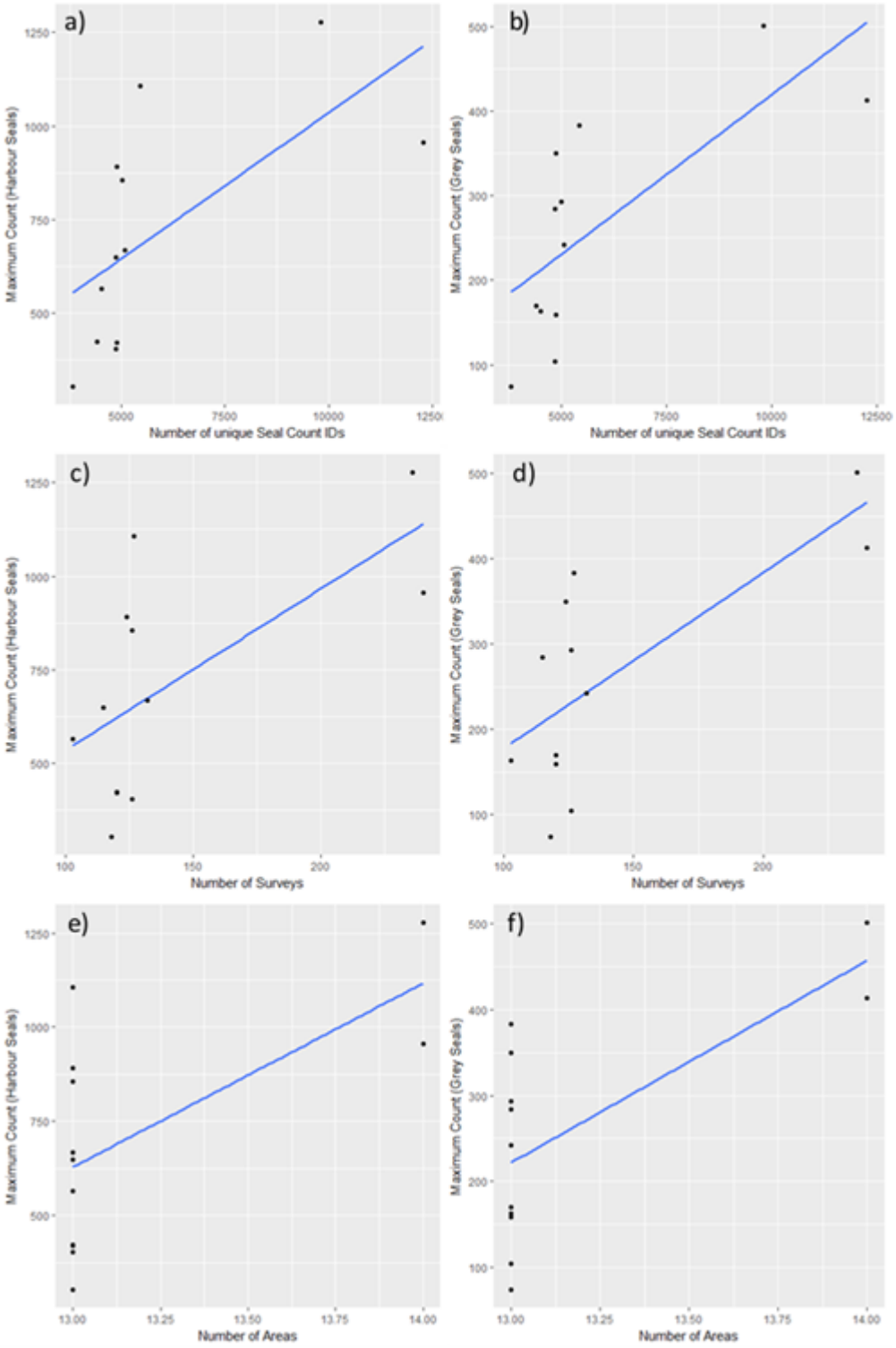

Figure 5: Maximum counts for each month, plotted: against the number of unique Seal Count IDs in that month for a) harbour seal adults and b) grey seal adults; against number of Surveys in that year for c) harbour seal adults and d) grey seal adults; and against number of Area IDs surveyed in that month for e) harbour seal adults and f) grey seal adults. The blue line is the line of best fit (see Table 8).

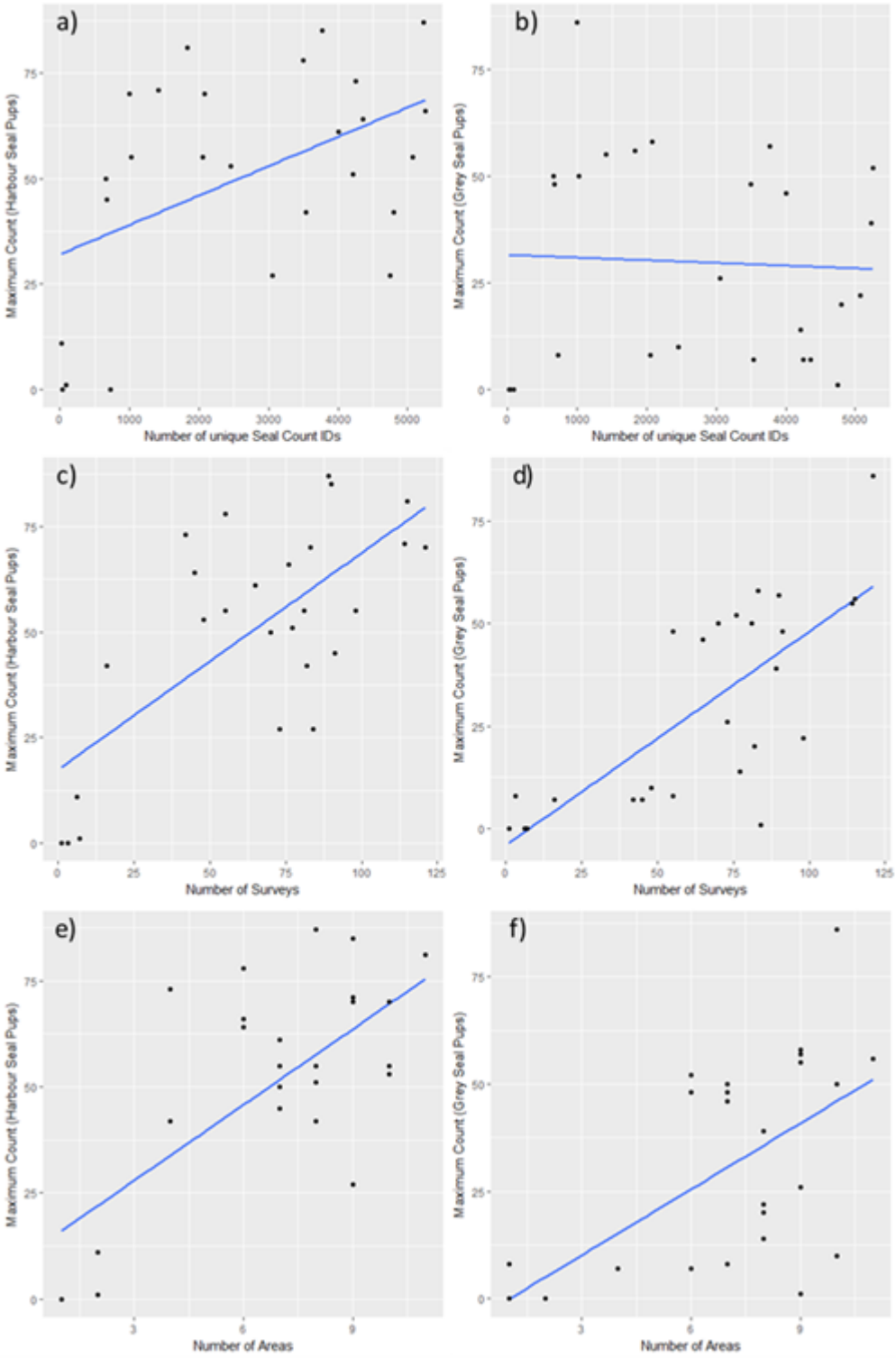

Figure 6: Maximum counts for each year, plotted: against the number of unique Seal Count IDs in that year for a) harbour seal pups and b) grey seal pups; against number of Surveys in that year for c) harbour seal pups and d) grey seal pups; and against number of Area IDs surveyed in that year for e) harbour seal pups and f) grey seal pups. The blue line is the line of best fit (see Table 8).

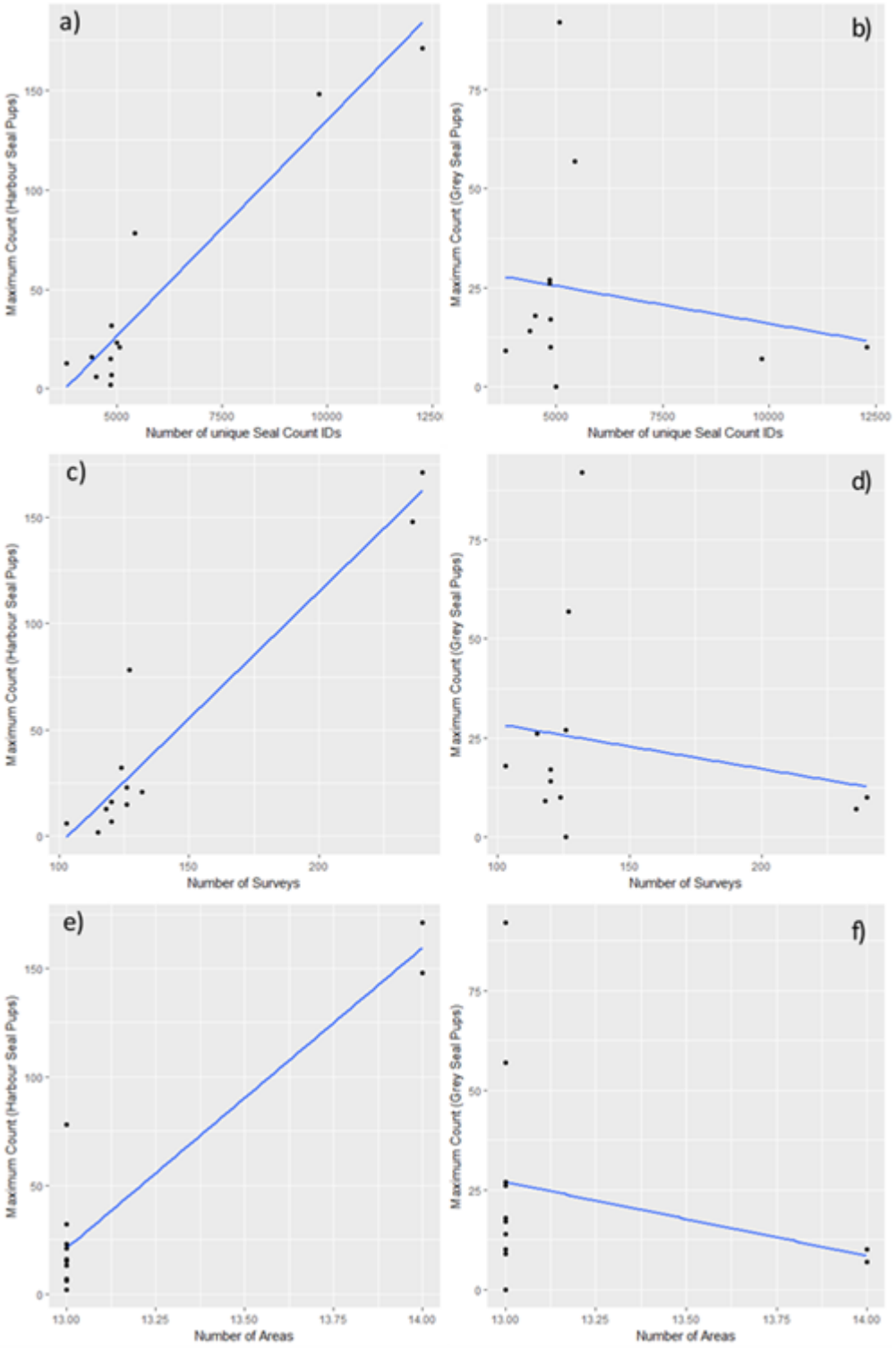

Figure 7: Maximum counts for each month, plotted: against the number of unique Seal Count IDs in that month for a) harbour seal pups and b) grey seal pups; against number of Surveys in that year for c) harbour seal pups and d) grey seal pups; and against number of Area IDs surveyed in that month for e) harbour seal pups and f) grey seal pups. The blue line is the line of best fit (see Table 8).

5.1.1. Trends in adult harbour seal counts

Using survey data from all months, the maximum seal counts for each year do tend to reflect the number of surveys undertaken (Figure 9) and the number of Area IDs surveyed (Figure 10). There is one noticeable exception to the former, with higher maximum seal counts in 2001 and 2002, when considering the comparably lower number of surveys. Similar patterns were seen in unique Seal Count IDs until 2008, where there were considerably fewer unique Seal Count IDs (Figure 8). Given that Area IDs and number of surveys have similar patterns, it does suggest that the protocol for recording a Seal Count ID has either varied in recent years (e.g. the number of unique Seal Count IDs recorded during a survey have been reduced) and/or varies between Area IDs. Therefore, the number of unique Seal Count IDs are unlikely to be a suitable proxy for effort, at least when considering all Area IDs collectively.

Using the maximum count for each year, the lowest counts occur in the earliest and most recent years, which appears to correspond with reduced numbers of surveys undertaken and the number of Area IDs surveyed (Figure 9 and 10). The majority of effort with respect to the time of the year was within July and August, and this did correspond with the higher number of counts, which occurred in August, during the moult (Figure 11 & Figure 12).

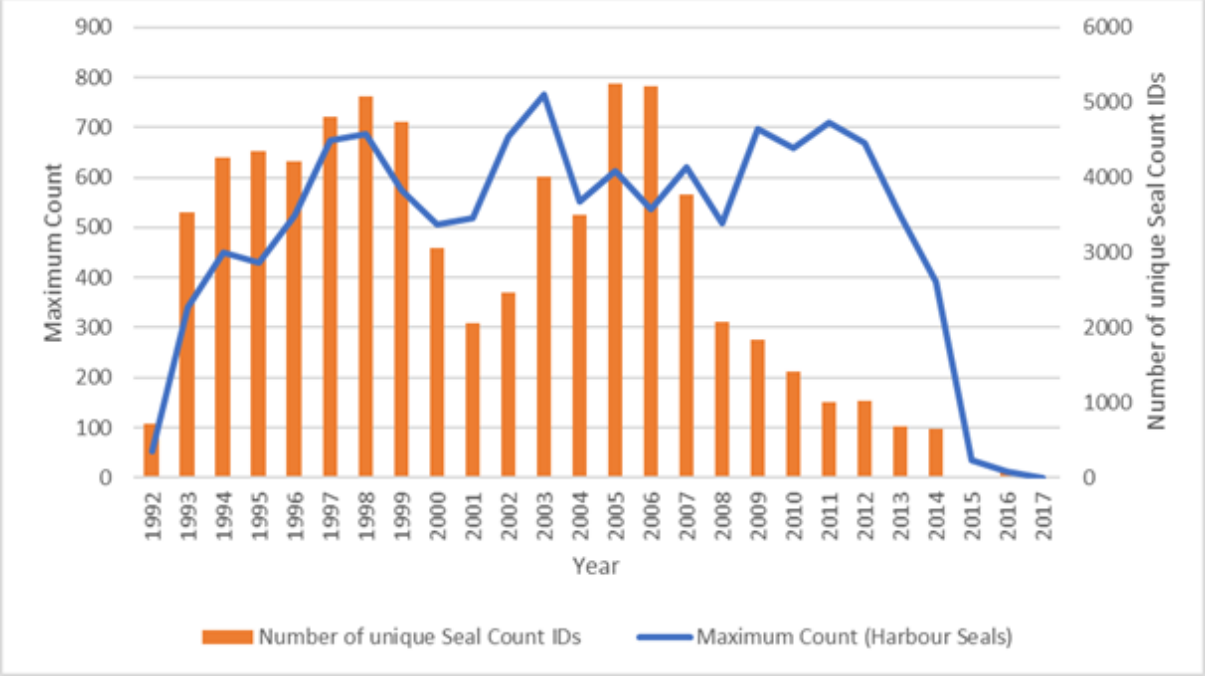

Figure 8: Maximum counts of harbour seals for all areas of Northern Ireland for each year (blue line) with the number of unique Seal Count IDs for that year plotted as orange bars.

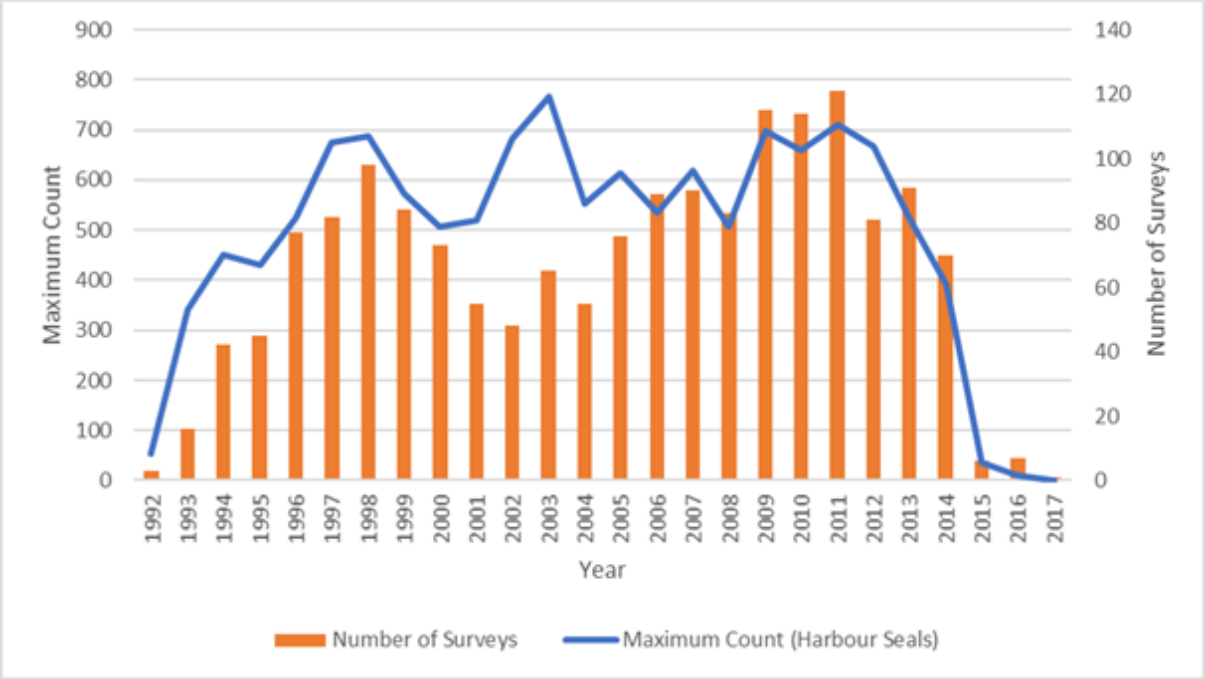

Figure 9: Maximum counts of harbour seals for all areas of Northern Ireland for each year (blue line) with the number of surveys for that year plotted as orange bars.

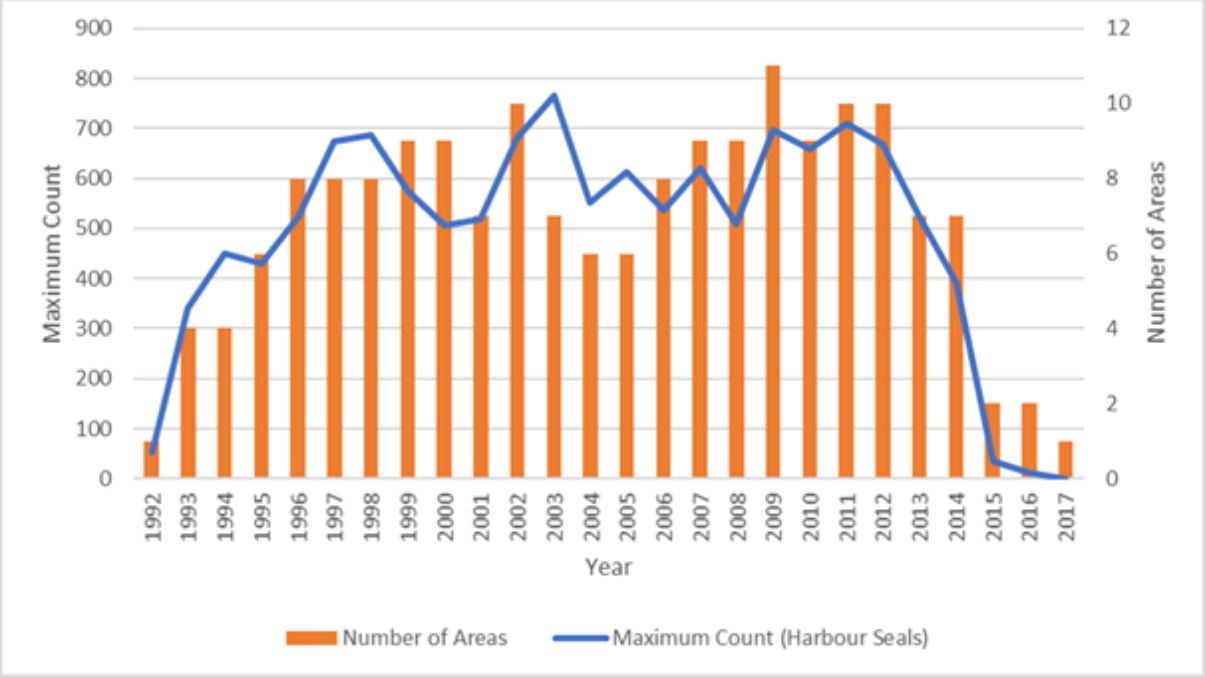

Figure 10: Maximum counts of harbour seals for all areas of Northern Ireland for each year (blue line) with the number of Area IDs surveyed that year plotted as orange bars.

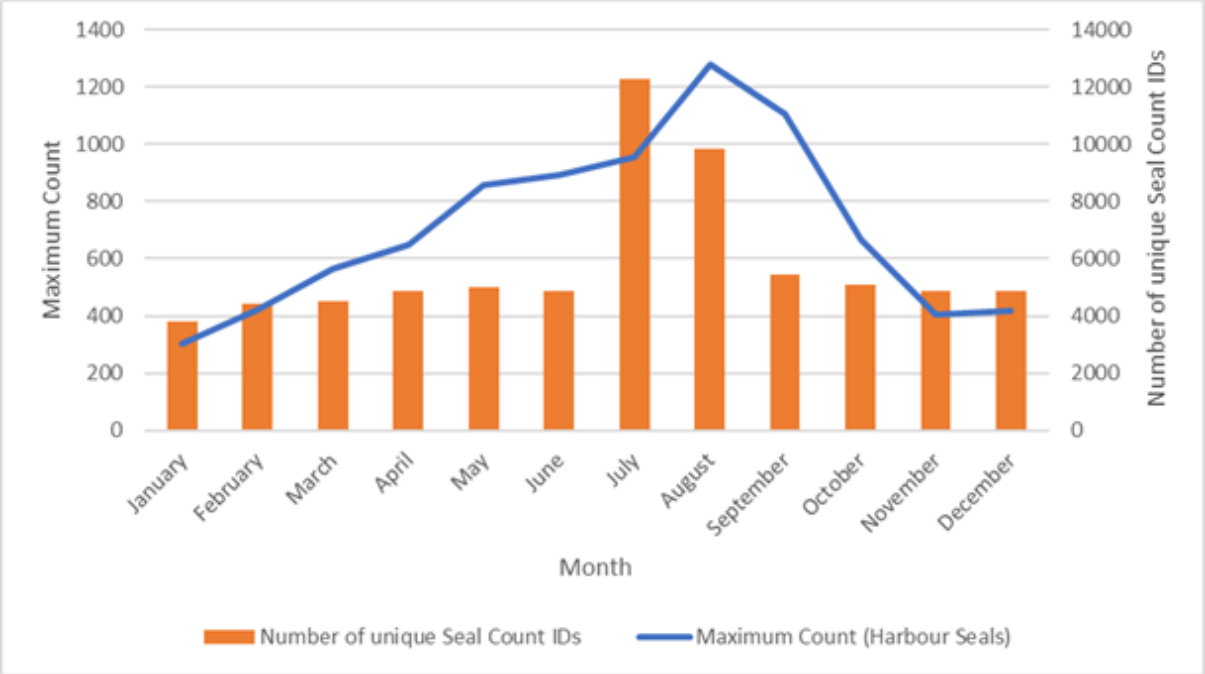

Figure 11: Maximum counts of harbour seals for all areas of Northern Ireland for each month (blue line) with the number of unique Seal Count IDs for that month plotted as orange bars.

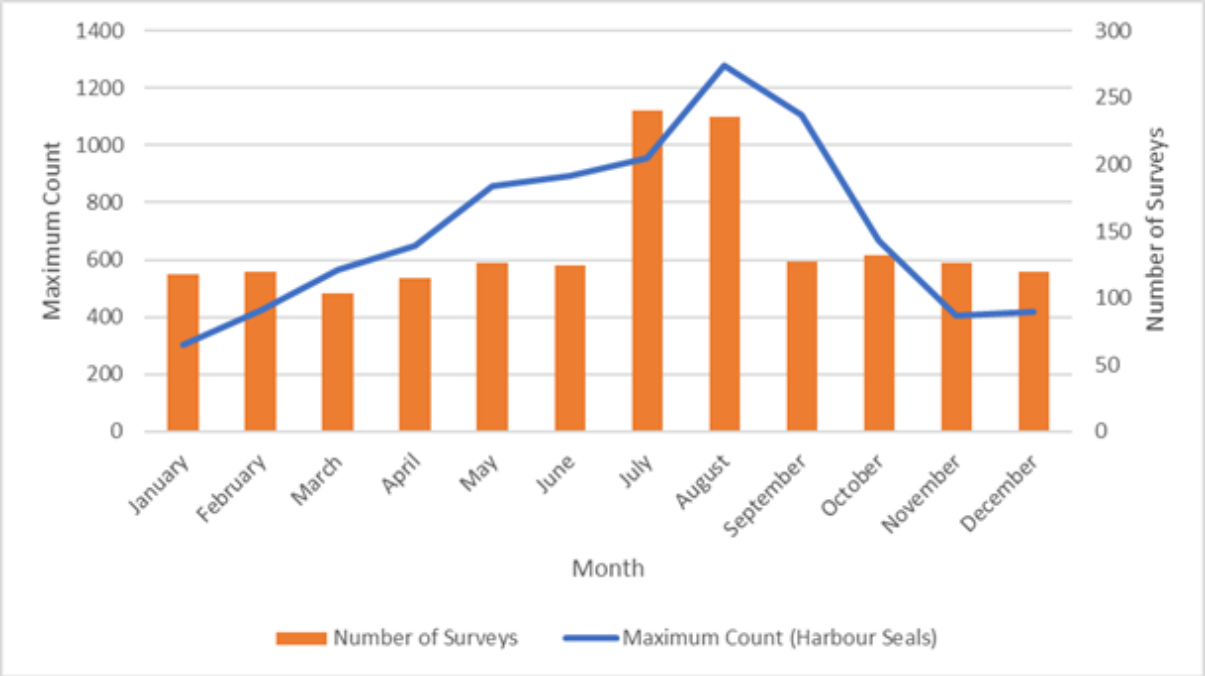

Figure 12: Maximum counts of harbour seals for all areas of Northern Ireland for each month (blue line) with the number of surveys for that month plotted as orange bars.

5.1.2. Trends in harbour seal pup counts

Using survey data from all months, the maximum seal counts for pups for each year are not as well reflected in the number of surveys undertaken (Figure 14) or the number of Area IDs surveyed (Figure 15), as compared to the adults. This is most likely a result of the discrete pupping season (ca. July/August) and the varied survey effort across the years (e.g. high effort outside the breeding season could lead to the pattern seen in the late 90's to the early 00's, whereas targeted effort during the breeding season could lead to the pattern seen in the early to mid-90's; Figure 13). The unique Seal Count IDs are greatly reduced from 2008 onwards, and these generally continue to decline annually, which does correspond to a decrease in the maximum counts for pups over the intervening years (2008 – 2017) (Figure 13). As expected, the peak in counts of harbour seal pups occurred in July and August (Figure 16 & 17).

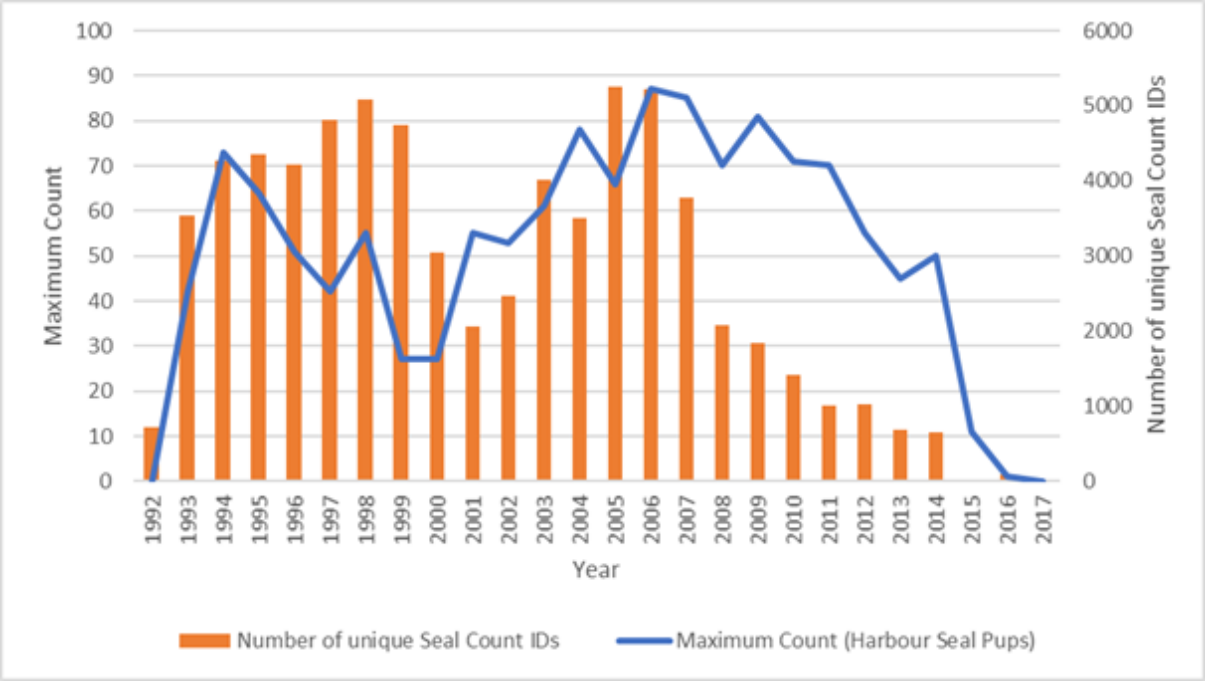

Figure 13: Maximum counts of harbour seal pups for all areas of Northern Ireland for each year (blue line) with the number of unique Seal Count IDs for that year plotted as orange bars.

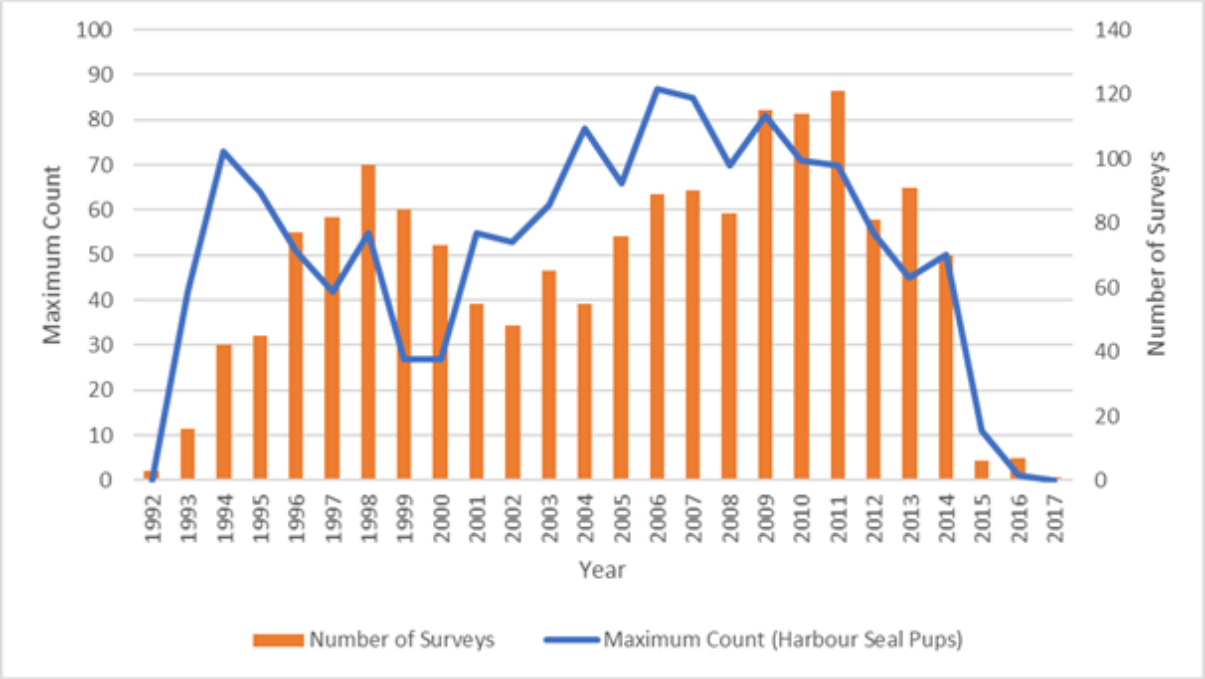

Figure 14: Maximum counts of harbour seal pups for all areas of Northern Ireland for each year (blue line) with the number of surveys for that year plotted as orange bars.

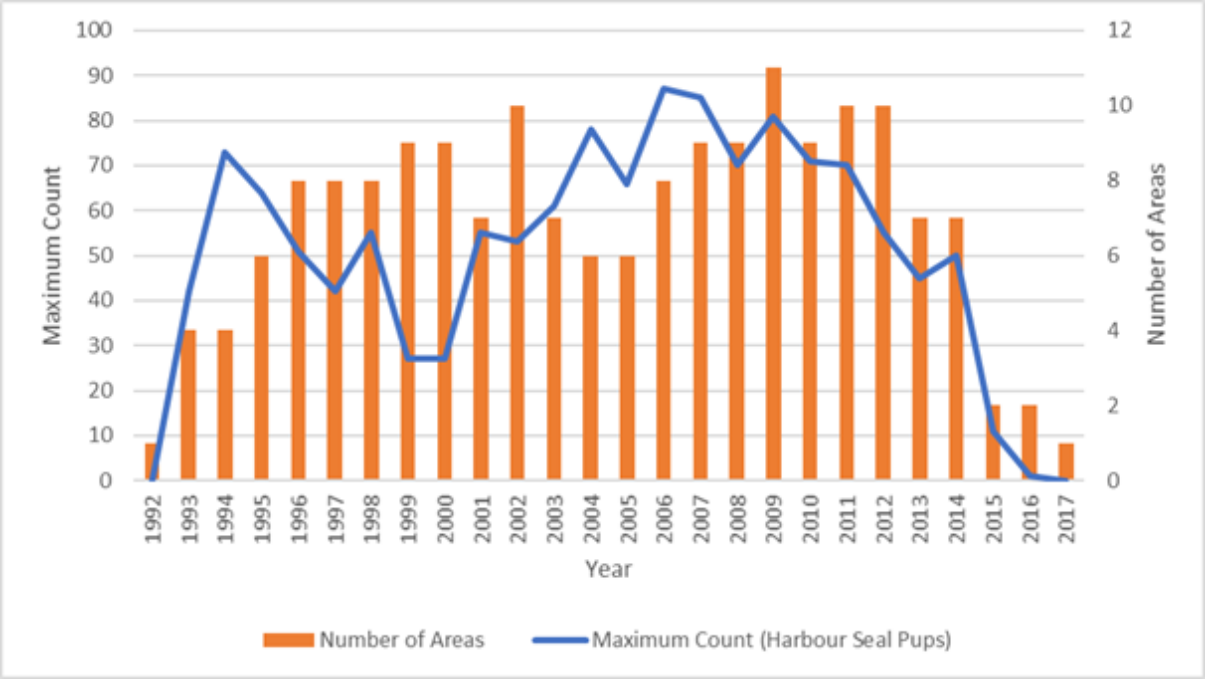

Figure 15: Maximum counts of harbour seal pups for all areas of Northern Ireland for each year (blue line) with the number of Area IDs surveyed that year plotted as orange bars

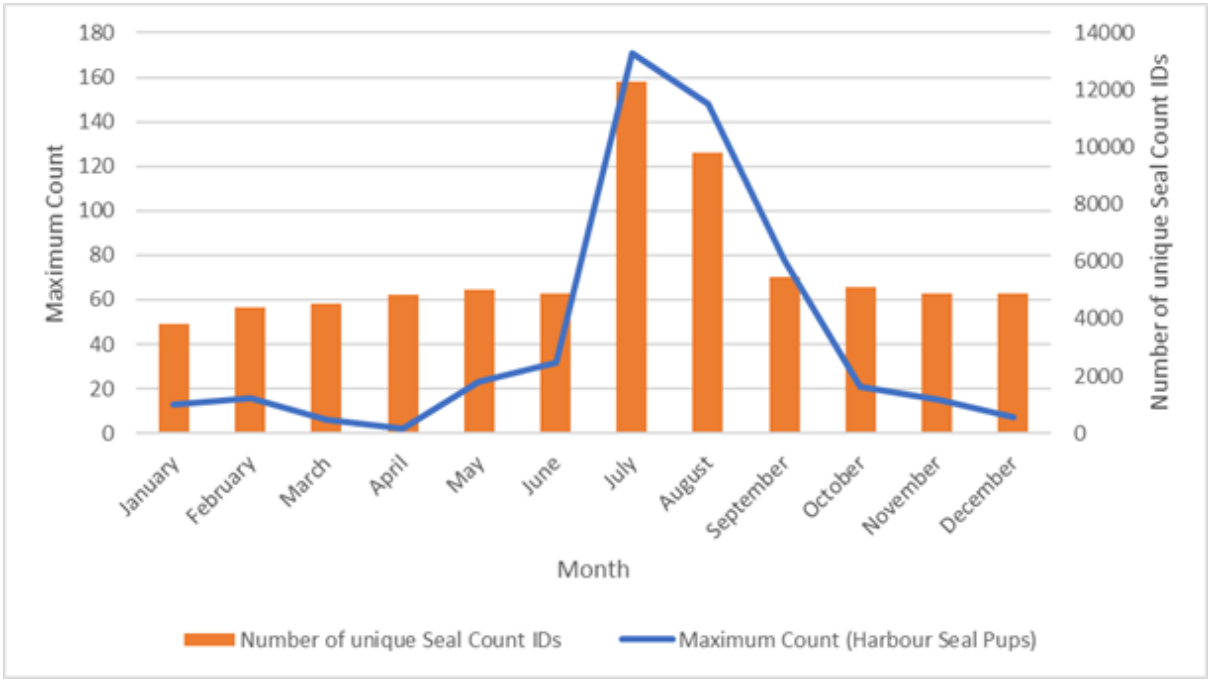

Figure 16: Maximum counts of harbour seal pups for all areas of Northern Ireland for each month (blue line) with the number of unique Seal Count IDs for that month plotted as orange bars.

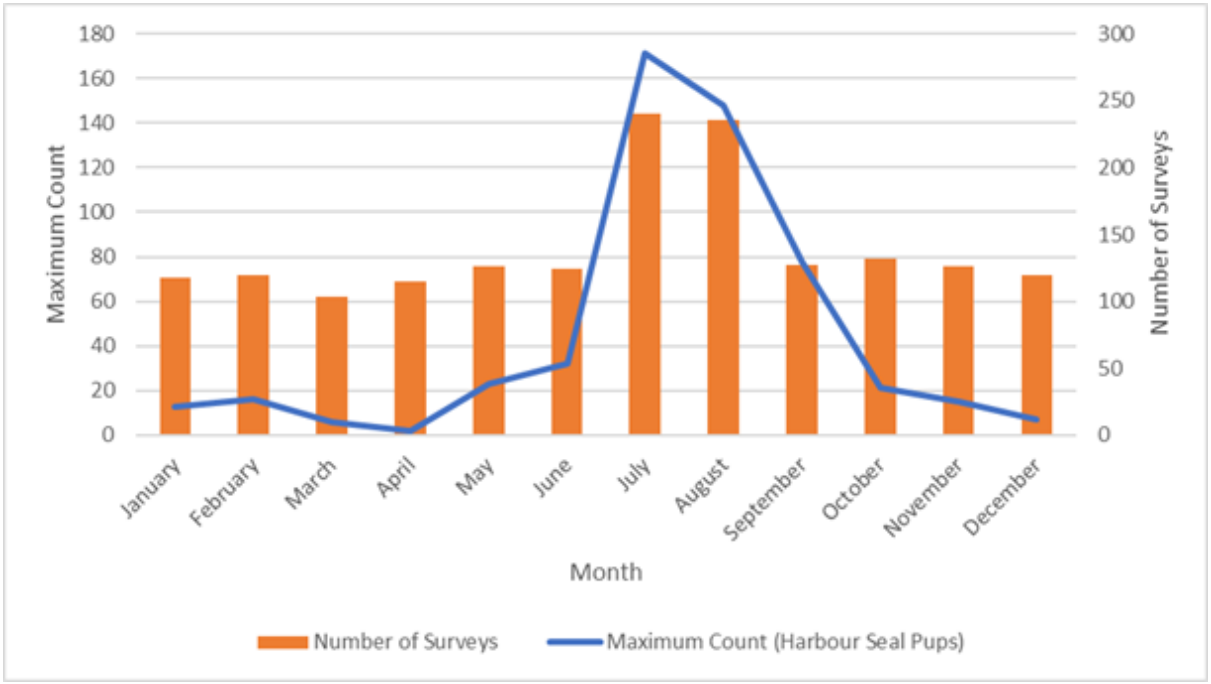

Figure 17: Maximum counts of harbour seal pups for all areas of Northern Ireland for each month (blue line) with the number of surveys for that month plotted as orange bars.

5.1.3. Harbour seal population trends

Using the maximum counts for each year for the whole of Northern Ireland, it is evident that for adult harbour seals, counts were low in the earliest and the most recent years. A similar pattern was seen in the harbour seal pup counts. In using the entire data set, the regression lines in Figures 18 & 19 show a 3.37% and 1.21% decline since 1992 for adults and pups, respectively. However, it is apparent that there was lower effort in these years, with less Area IDs surveyed (Figure 10) and fewer surveys undertaken (Figure 9) and, as the correlation statistics showed (Table 9 and Figures 18 – 19), this would likely result in reduced counts. If these data were omitted, and only 1995 – 2014 are considered, then there is a 0.1 % annual increase in adults and a 0.88% annual increase in pups. As an example of how influential these data points are, if the earlier data were retained and the more recent data were omitted, the annual increase for both adults and pups is considerably higher (see 1992 - 2014 in Table 9). Based on the analyses presented here, this is not recommended; rather, this example was presented to illustrate the importance of ensuring systematic surveys are in place, so as to avoid likely erroneous conclusions being formed as a result of survey design (see Section 7).

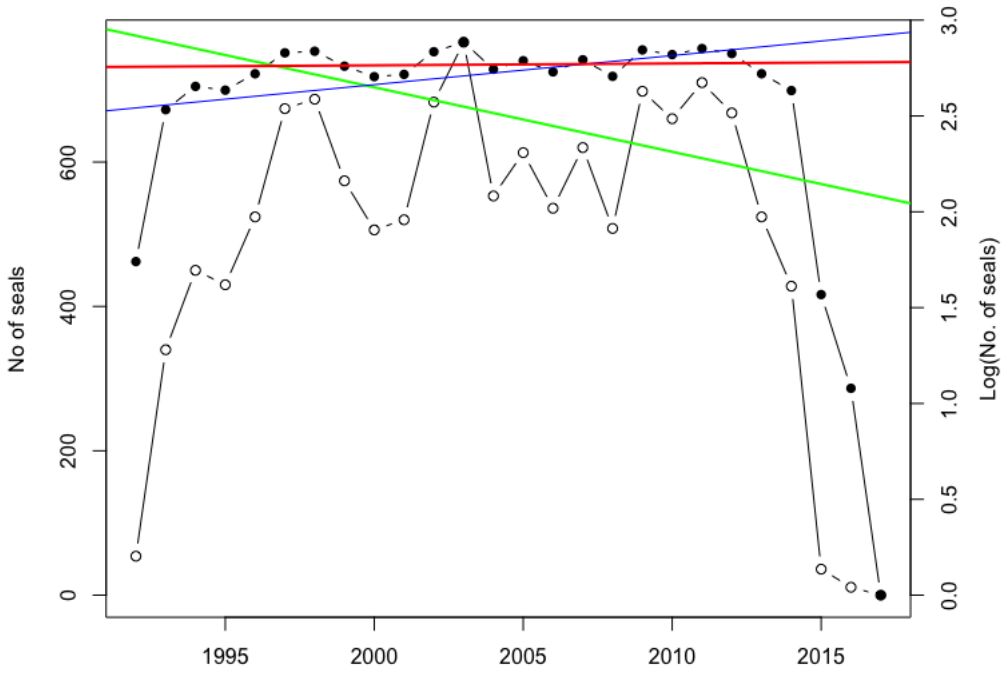

Figure 18: The maximum count of adult harbour seals (open circles) and the log10 of those counts (black circles) by year. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 9.

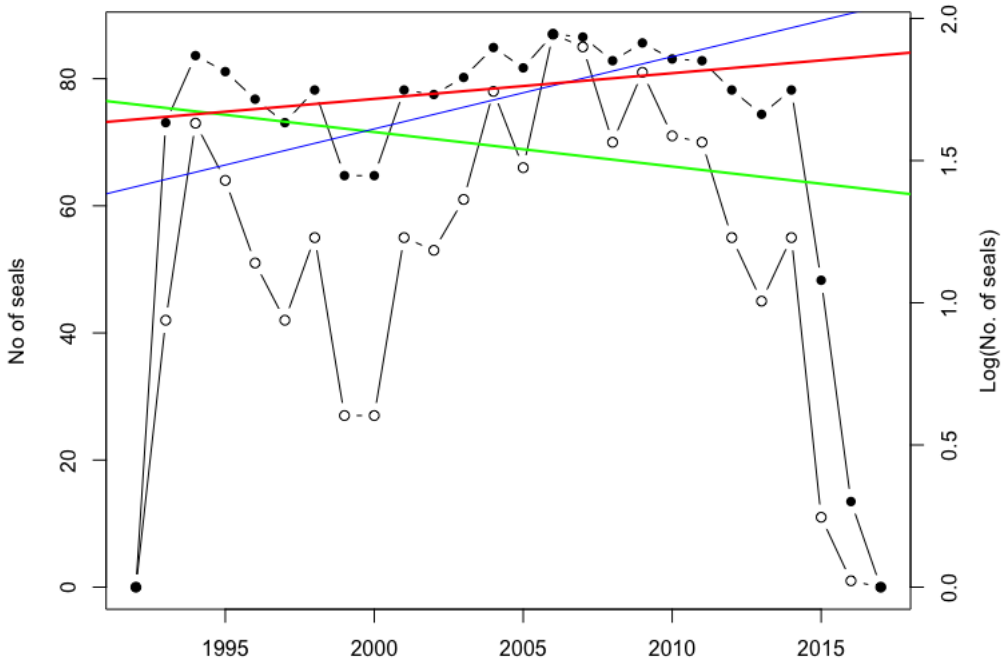

Figure 19: The maximum count of harbour seal pups (open circles) and the log10 of those counts (black circles) by year. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 9.

Table 9: The annual percentage change for each age class of harbour seal, using subsets of data based on the exploratory analysis on the completeness of surveys. The line colour column relates to the respective Figures for adults (Figure 18) and pups (Figure 19).

Age Class	Years	% annual change	Line colour
Adults	1992 – 2017	-3.37	Green
	1992 – 2014	1.52	Blue
	1995 – 2014	0.1	Red
Pups	1992 – 2017	-1.21	Green
	1992 – 2014	2.53	Blue
	1995 – 2014	0.88	Red

5.1.4. Trends in adult grey seal counts

Using survey data from all months, the maximum seal counts for each year do tend to reflect the number of surveys undertaken (Figure 21) and the number of Area IDs surveyed (Figure 22). However, it does appear that there are exceptions for the grey seal counts too; for example, 2001 and 2009 had low counts, when considering the comparably high number of surveys undertaken and Area IDs. Similar patterns were seen in unique Seal Count IDs until 2005, where there was a peak, followed by a considerable year on year decrease, from 2007 onwards (Figure 20). Given that Area IDs and number of surveys have similar patterns, it does suggest that the protocol for recording a Seal Count ID has either varied in recent years (e.g. the number of unique Seal Count IDs recorded during a survey have been reduced) and/or varies between Area IDs. Therefore, the number of unique Seal Count IDs are unlikely to be a suitable proxy for effort, at least when considering all Area IDs collectively.

Using the maximum count for each year, the lowest counts occur in the earliest and most recent years, which appears to correspond with reduced numbers of surveys undertaken and the number of Area IDs surveyed (Figure 21 & 22). The majority of effort with respect to the time of the year was within July and August, which corresponds to the harbour seal breeding season and moult. Despite the breeding season (ca. October) being the best time to obtain maximum counts of grey seals, the highest counts, across the 25 years of data, were typically in August (Figure 23).

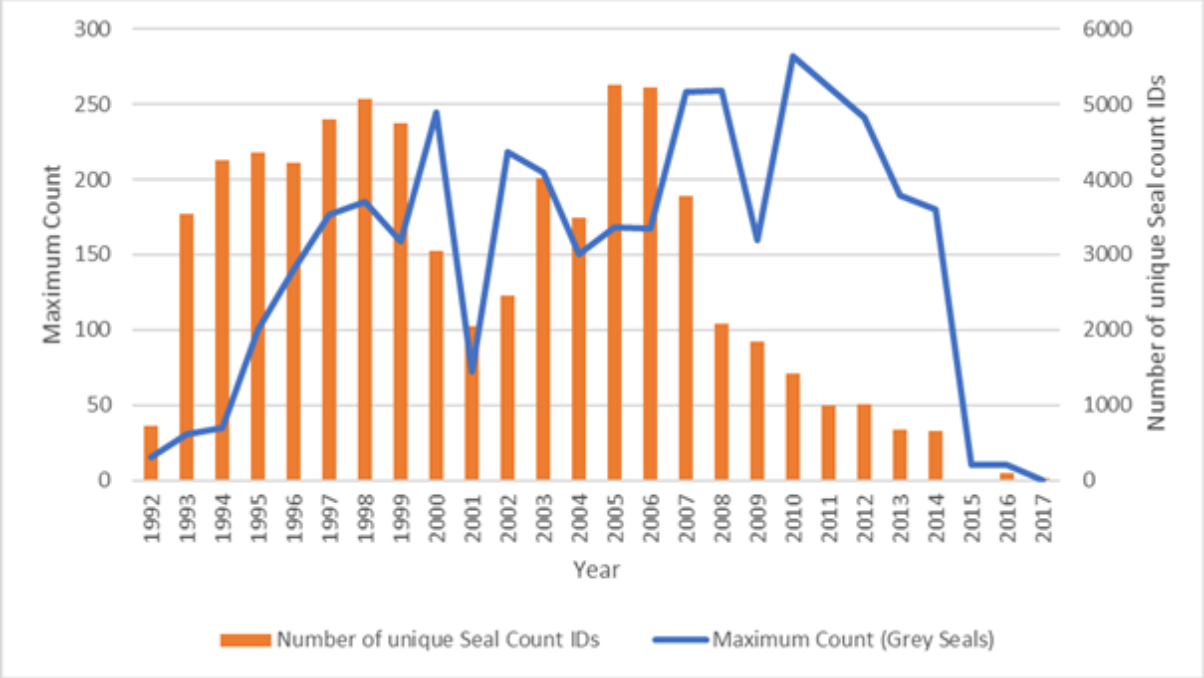

Figure 20: Maximum counts of grey seals for all areas of Northern Ireland for each year (blue line) with the number of unique count IDs for that year plotted as orange bars.

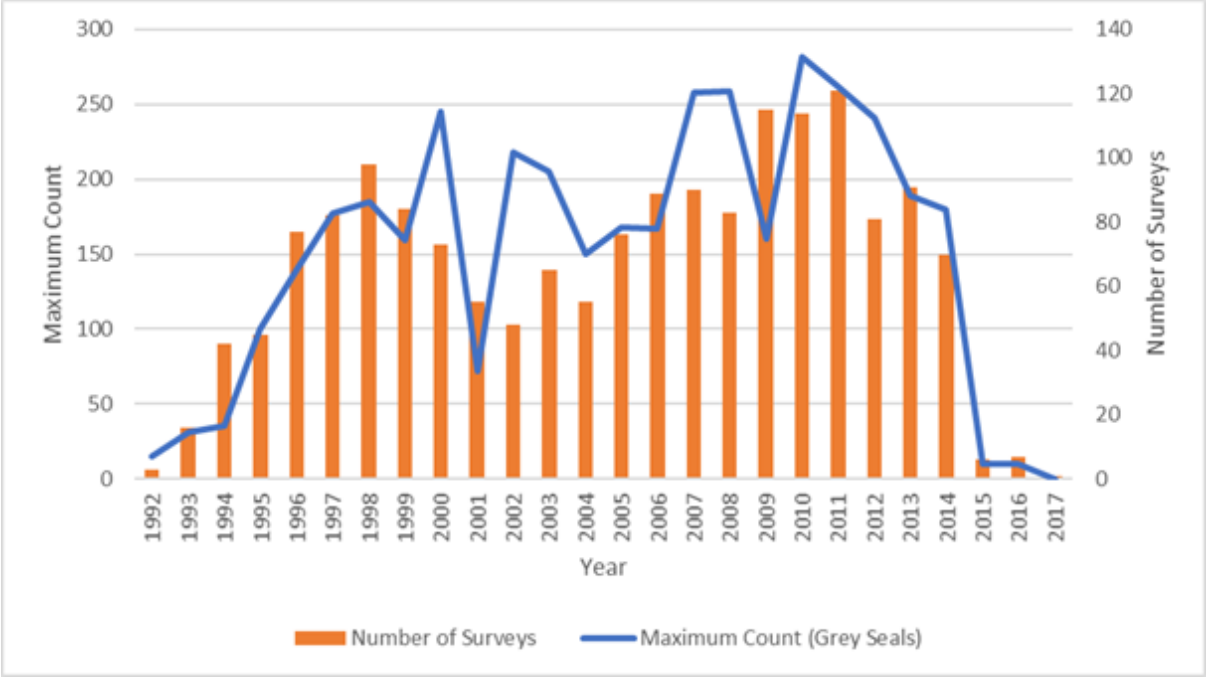

Figure 21: Maximum counts of grey seals for all areas of Northern Ireland for each year (blue line) with the number of surveys for that year plotted as orange bars.

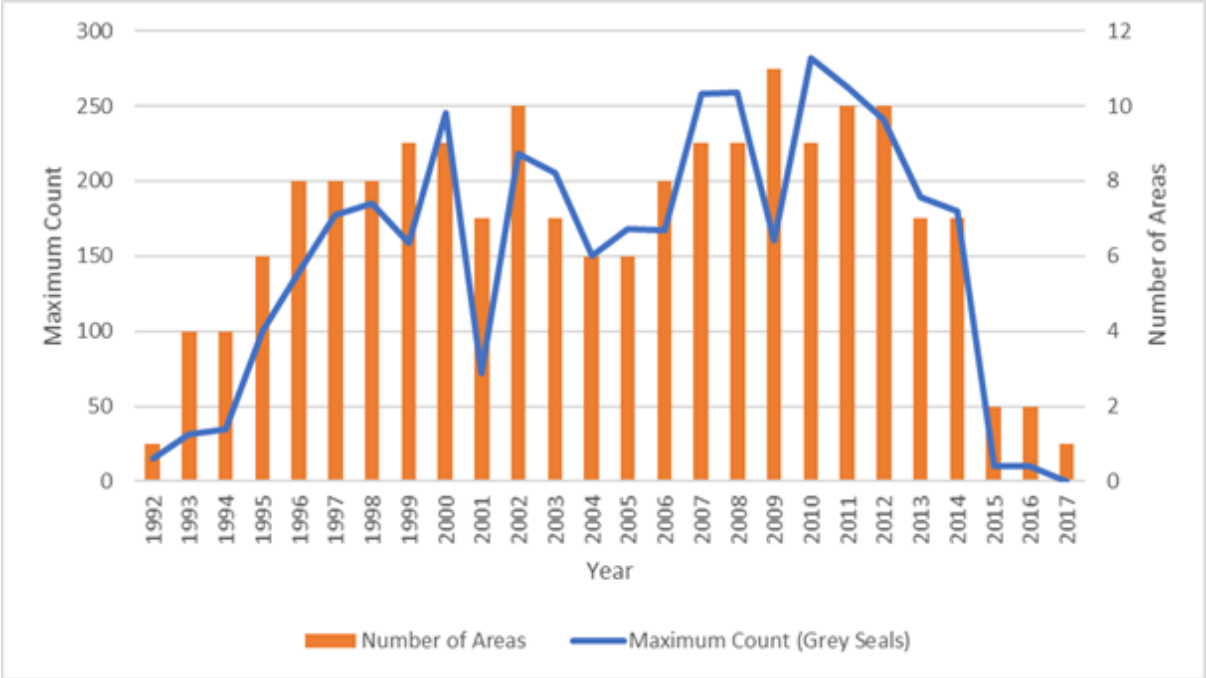

Figure 22: Maximum counts of grey seals for all areas of Northern Ireland for each year (blue line) with the number of Area IDs surveyed that year plotted as orange bars.

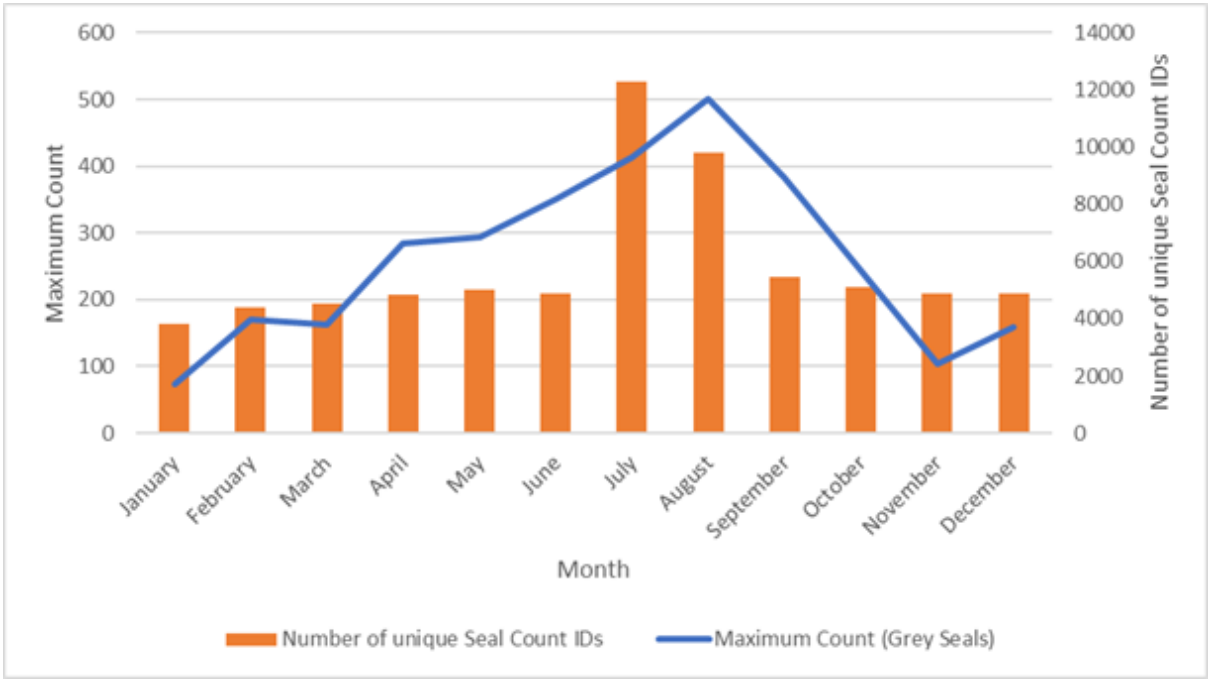

Figure 23: Maximum counts of grey seals for all areas of Northern Ireland for each month (blue line) with the number of unique count IDs for that month plotted as orange bars.

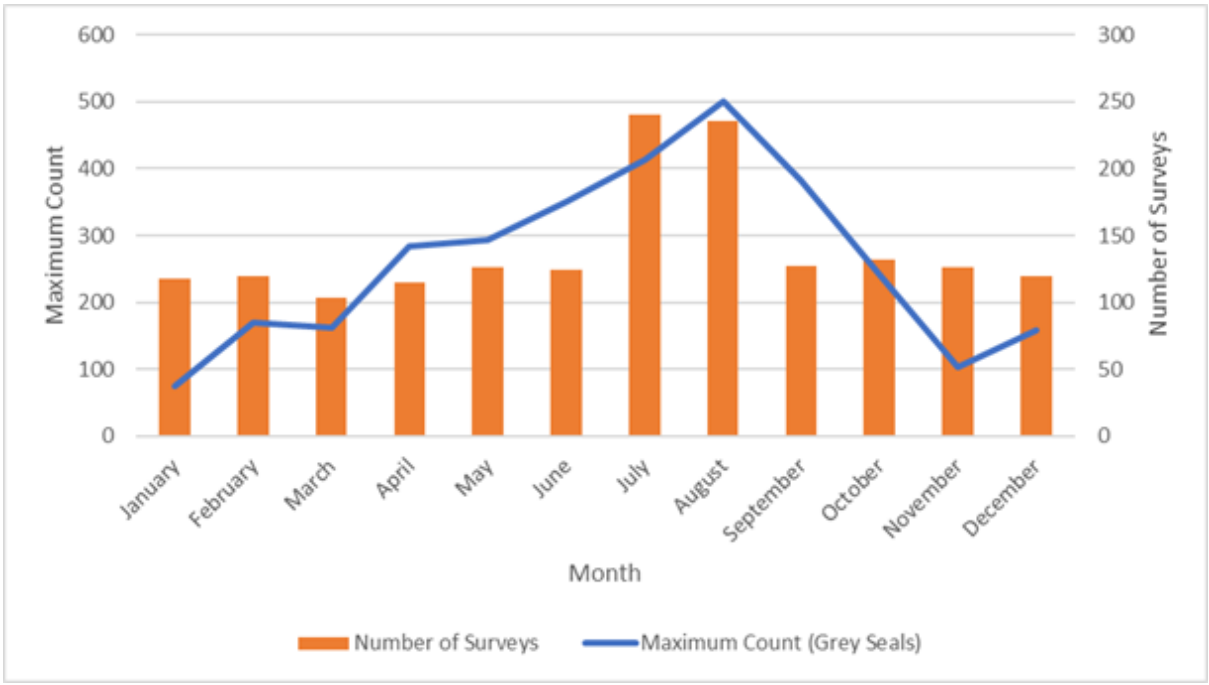

Figure 24: Maximum counts of grey seals for all areas of Northern Ireland for each month (blue line) with the number of surveys for that month plotted as orange bars.

5.1.5. Trends in grey seal pup counts

Using survey data from all months, the maximum seal counts for each year in the earlier years (ca. 1992 – 2002) do not reflect the number of unique Seal Count IDs (Figure 25), the number of surveys undertaken (Figure 26) or the number of Area IDs surveyed (Figure 27). From approximately 2003 onwards, a pattern whereby more counts results in greater numbers of pups, is more apparent. This could be a result of more focus on harbour seal counts in earlier years but may also, in part, be due to the apparent annual increase in adult grey seals in Northern Ireland (see Section 5.1.6). These suppositions are supported by Figure 29, which shows that the number of surveys undertaken are considerably higher in July and August, yet the greater counts for grey seal pups is October time, corresponding with the peak in their breeding season.

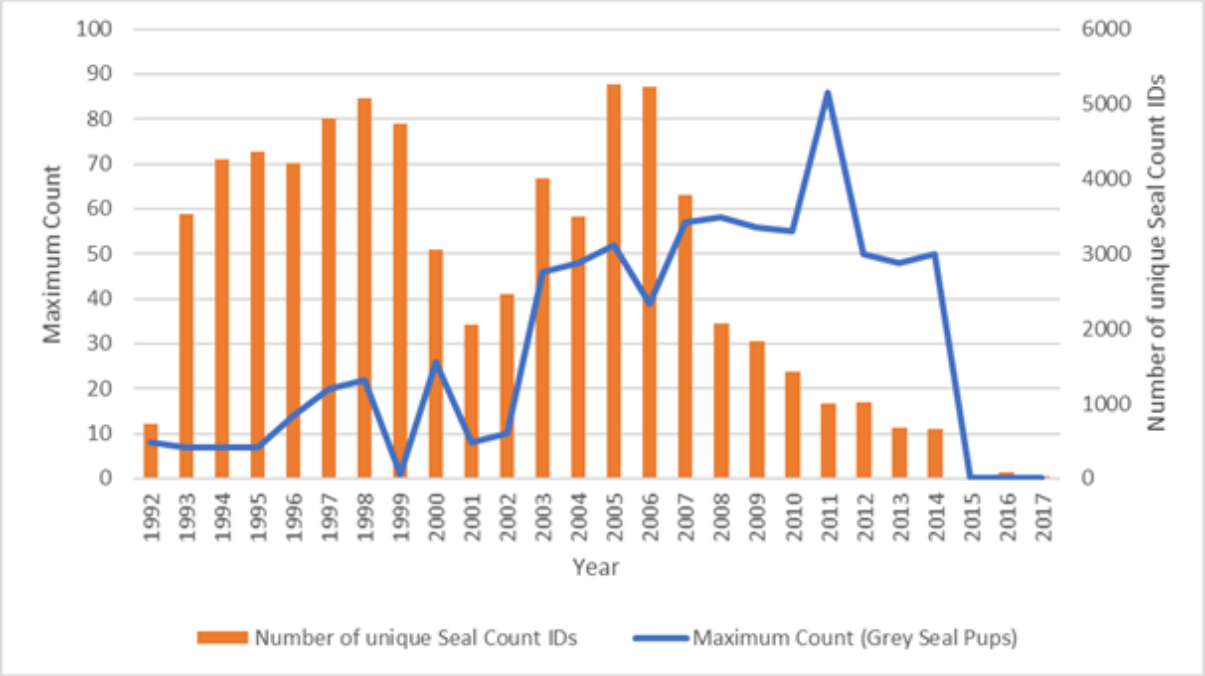

Figure 25: Maximum counts of grey seal pups for all areas of Northern Ireland for each year (blue line) with the number of unique count IDs for that year plotted as orange bars.

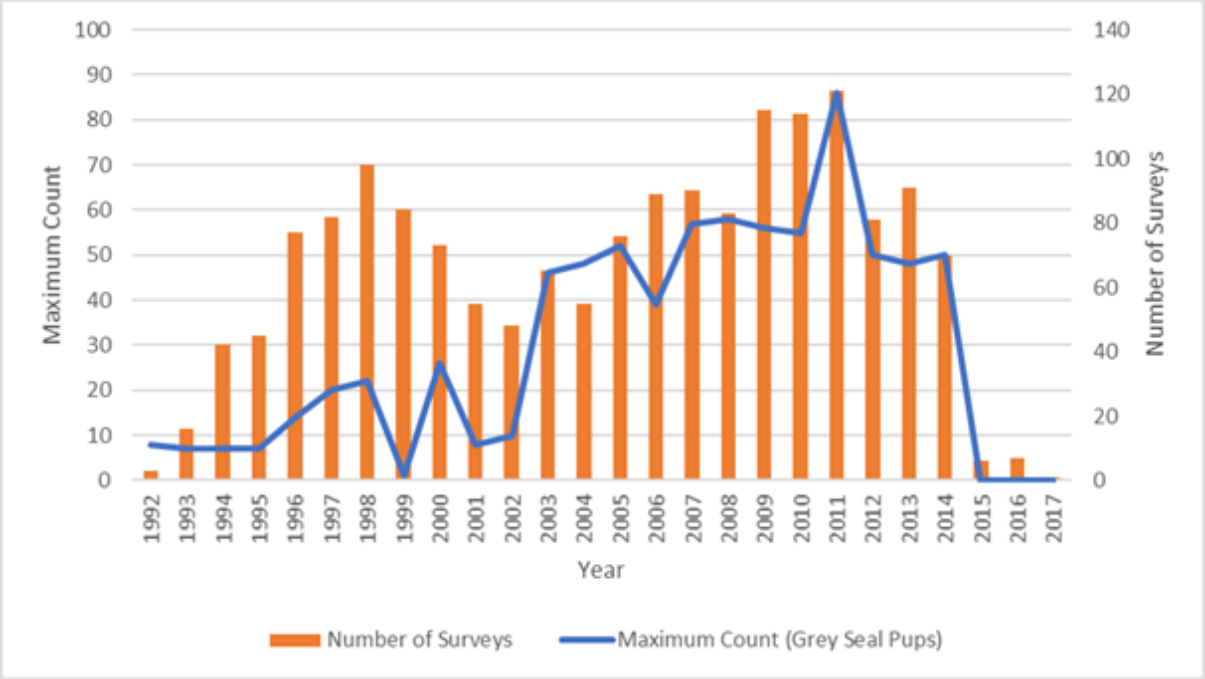

Figure 26: Maximum counts of grey seal pups for all areas of Northern Ireland for each year (blue line) with the number of surveys for that year plotted as orange bars.

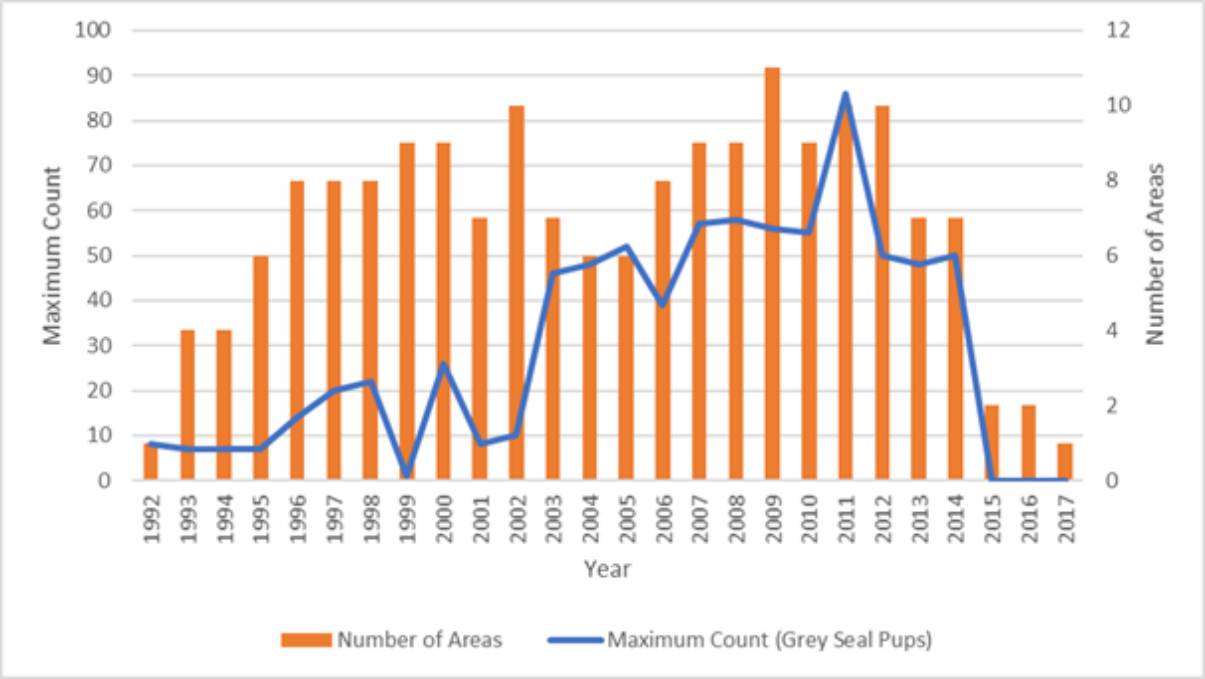

Figure 27: Maximum counts of grey seal pups for all areas of Northern Ireland for each year (blue line) with the number of Area IDs surveyed that year plotted as orange bars.

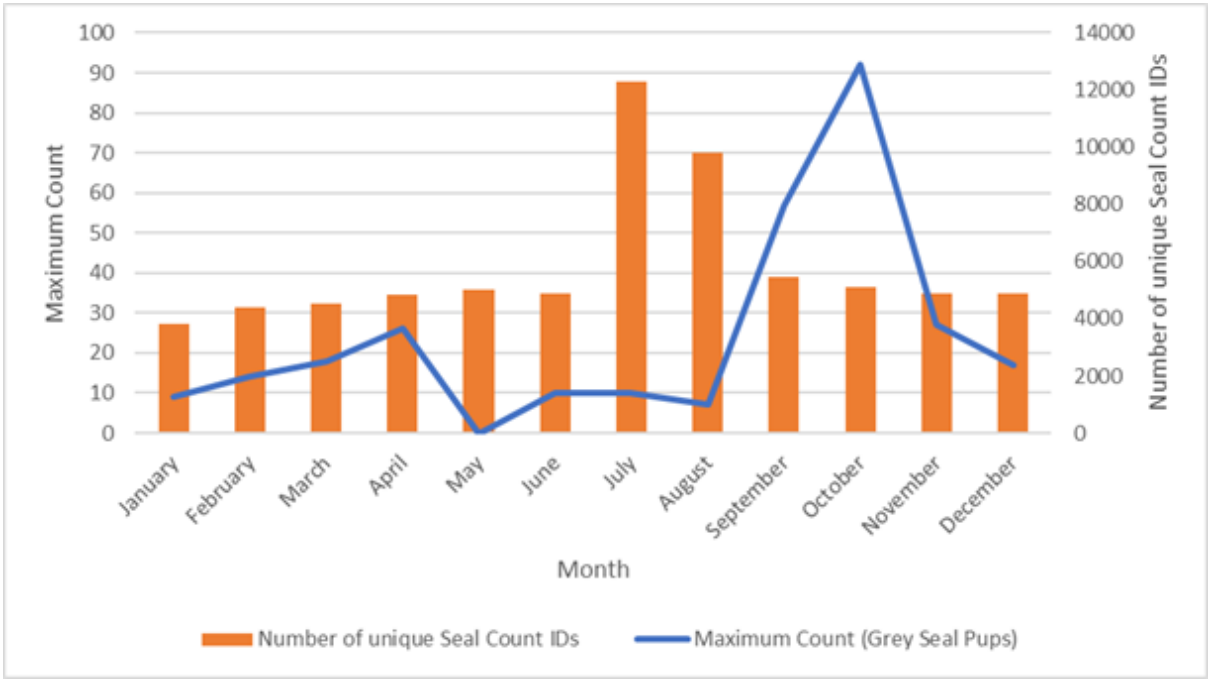

Figure 28: Maximum counts of grey seals for all areas of Northern Ireland for each month (blue line) with the number of unique count IDs for that month plotted as orange bars.

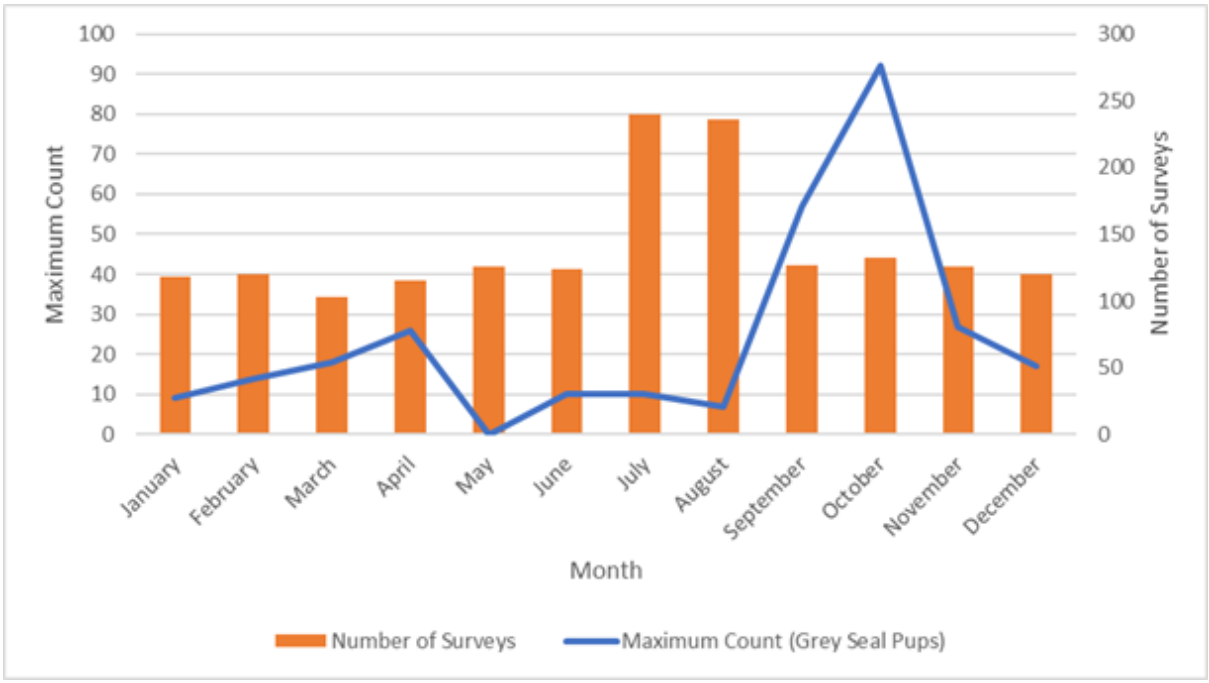

Figure 29: Maximum counts of grey seal pups for all areas of Northern Ireland for each month (blue line) with the number of surveys for that month plotted as orange bars.

5.1.6. Grey seal population trends

Using the maximum counts for each year for the whole of Northern Ireland, it is evident that for adult grey seals, counts were low in the earliest and the most recent years. A similar pattern was seen in the grey seal pup counts. Notably, the low grey pup counts were maintained until approximately 2002, which, as shown in Section 5.1.5, may not be entirely attributable to a lack of survey effort within the years. In using the entire data set, the regression lines in Figure 30 show a 1.2% decline since 1992 for adult grey seals, whilst for pups, there has been little to no annual change (0.06%) since 1992 (Figure 31). However, it is apparent that there was lower effort in the earlier and most recent years, with less Area IDs surveyed (Figure 27) and fewer surveys undertaken (Figure 26) and, as the correlation statistics showed (Table 10; Figures 30 – 31), this would likely result in reduced counts. If these data were omitted, and only 1995 – 2014 are considered, then there is a 1.24% annual increase in adults and a 4.91% annual increase in pups (Table 10; Figures 30 & 31).

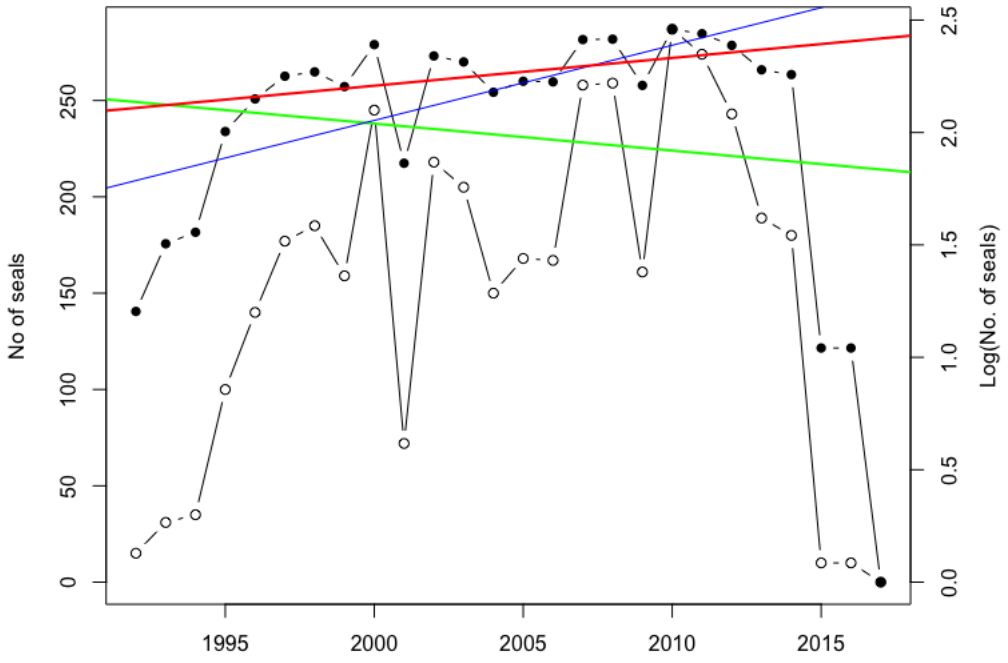

Figure 30: The maximum count of grey seal adults (open circles) and the log10 of those counts (black circles) by year. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 10.

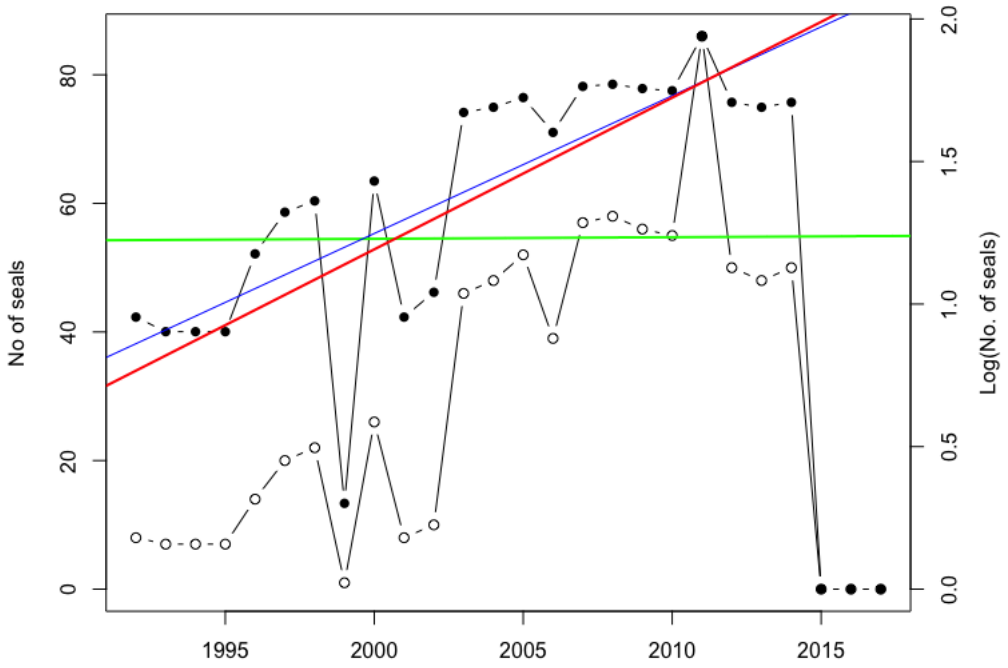

Figure 31: The maximum count of grey seal pups (open circles) and the log10 of those counts (black circles) by year. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 10.

Table 10: The annual percentage change for each age class of grey seal, using subsets of data based on the exploratory analysis on the completeness of surveys. The line colour column relates to the respective Figures for adults (Figure 30) and pups (Figure 31).

Age Class	Years	% annual change	Line colour
Adults	1992 – 2017	-1.2	Green
	1992 – 2014	3.34	Blue
	1995 – 2014	1.24	Red
Pups	1992 – 2017	0.06	Green
	1992 – 2014	4.83	Blue
	1995 – 2014	4.91	Red

5.2. Area Specific Analysis

Harbour seals are qualifying features under both the Murlough and Strangford Lough Areas of Special Scientific Interest (ASSI) and Special Areas of Conservation (SAC). Within the conservation objectives for both Murlough and Strangford Lough, it is stated that the harbour seal population is to be maintained and enhanced as appropriate, as are the physical features

used by this species within the site. For that reason, these two areas were analysed separately, following the methods used for Northern Ireland as a whole. For the other Area IDs, these data are summarised in the appendix (Section 9, Tables 16 – 26).

5.2.1 Strangford Lough

Strangford Lough has the largest number of surveys performed (n = 361) and for the most years (n = 25). However, 2015 - 2017 were removed from the regression analysis as there were considerably fewer data for these years (Figures 32-34); it was assumed that the data from the most recent years had not yet been completely entered into the database.

5.2.2. Trends in adult harbour seal counts from Strangford Lough

Using survey data from all months, the maximum seal counts for each year do tend to reflect the number of unique Seal Count IDs (Figure 32), whereas the pattern with number of surveys is more variable (Figure 33). The number of unique Seal Count IDs from 2007 onwards have been low, yet there is not a corresponding decrease in surveys. For Strangford Lough, the exploratory analysis did find that one unique Seal Count ID was associated with one Parent Location ID; therefore, if surveys of the Lough were complete, then the pattern in number of surveys and number of unique Seal Count IDs would be similar. This does suggest that since approximately 2007, the entire Lough has not been surveyed in its entirety. Therefore, although the data suggest a decline in the population, caution should be exercised as this may, at least in part, be related to effort. For month, the majority of the effort was in July and August, although the highest counts (although comparable to August), were in September (Figure 34).

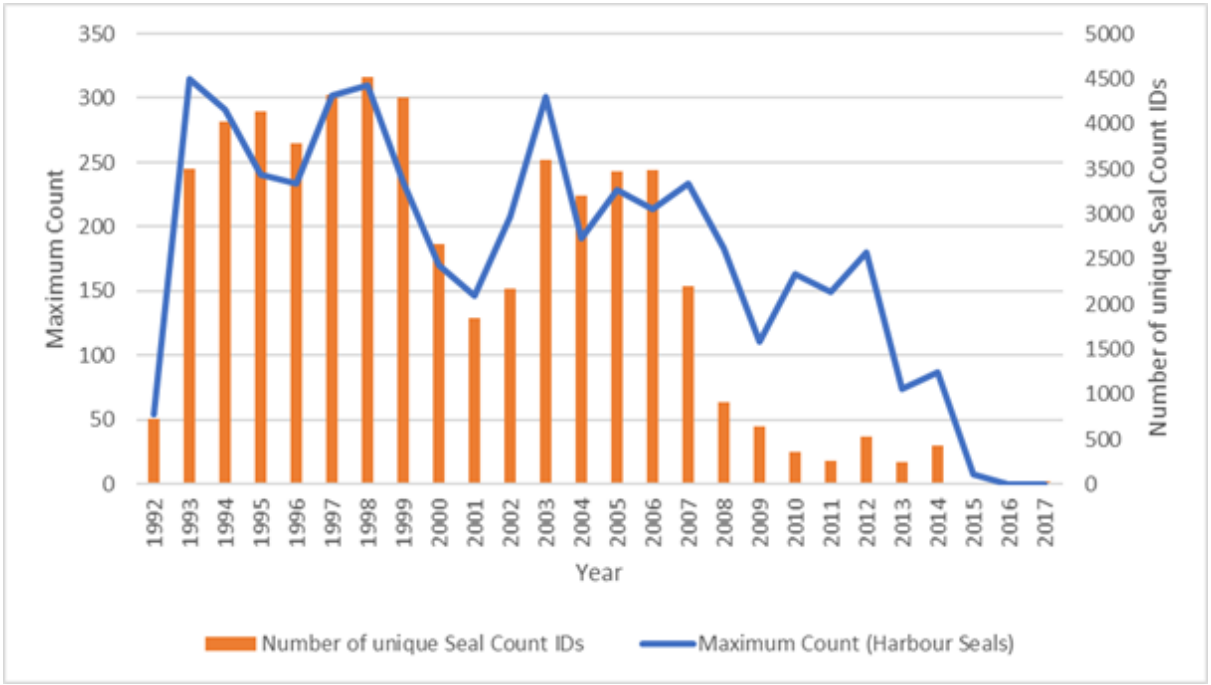

Figure 32: Maximum Counts of harbour seals in Strangford Lough each year (blue line) with the number of unique Seal Count IDs for that year plotted as orange bars.

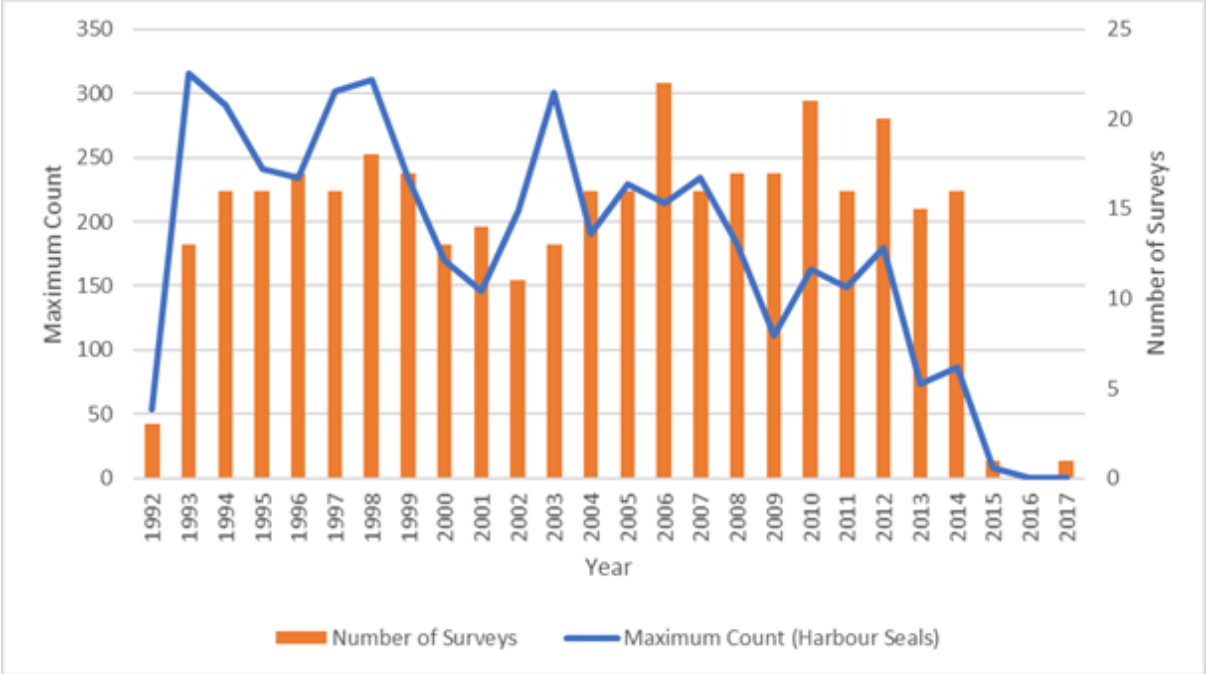

Figure 33: Maximum Counts of harbour seals in Strangford Lough each year (blue line) with the number of surveys for that year plotted as orange bars.

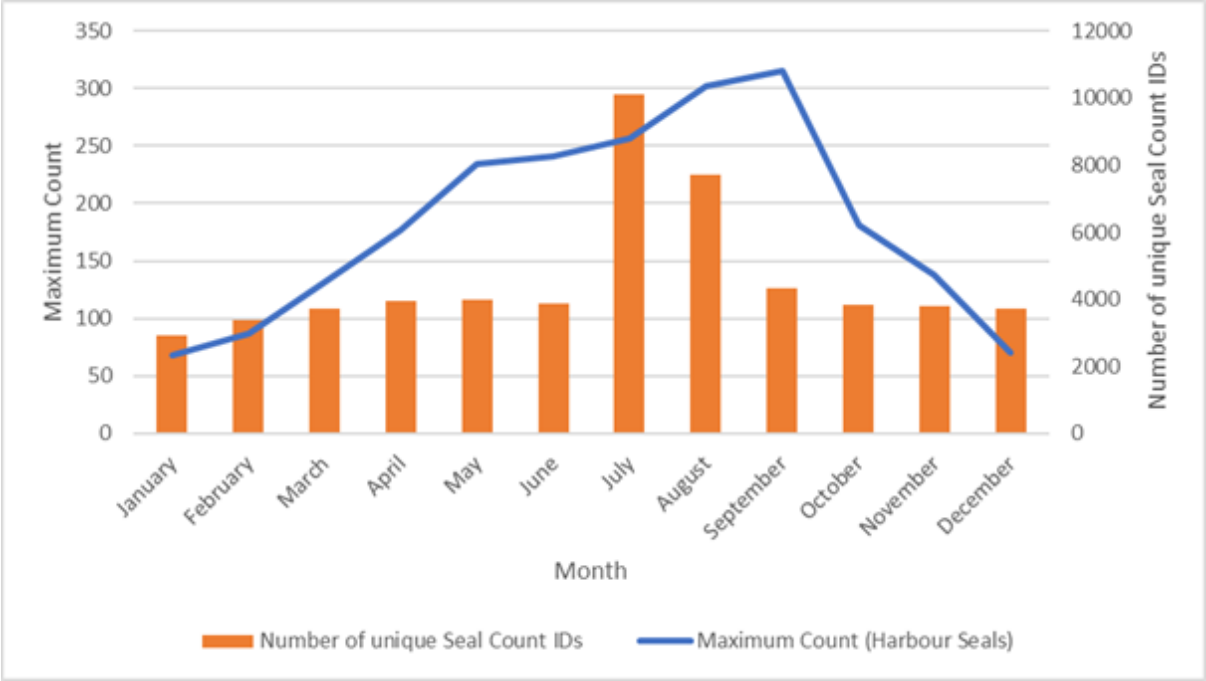

Figure 34: Maximum Counts of harbour seals in Strangford Lough each month (blue line) with the number of unique Seal Count IDs performed in that month plotted as orange bars.

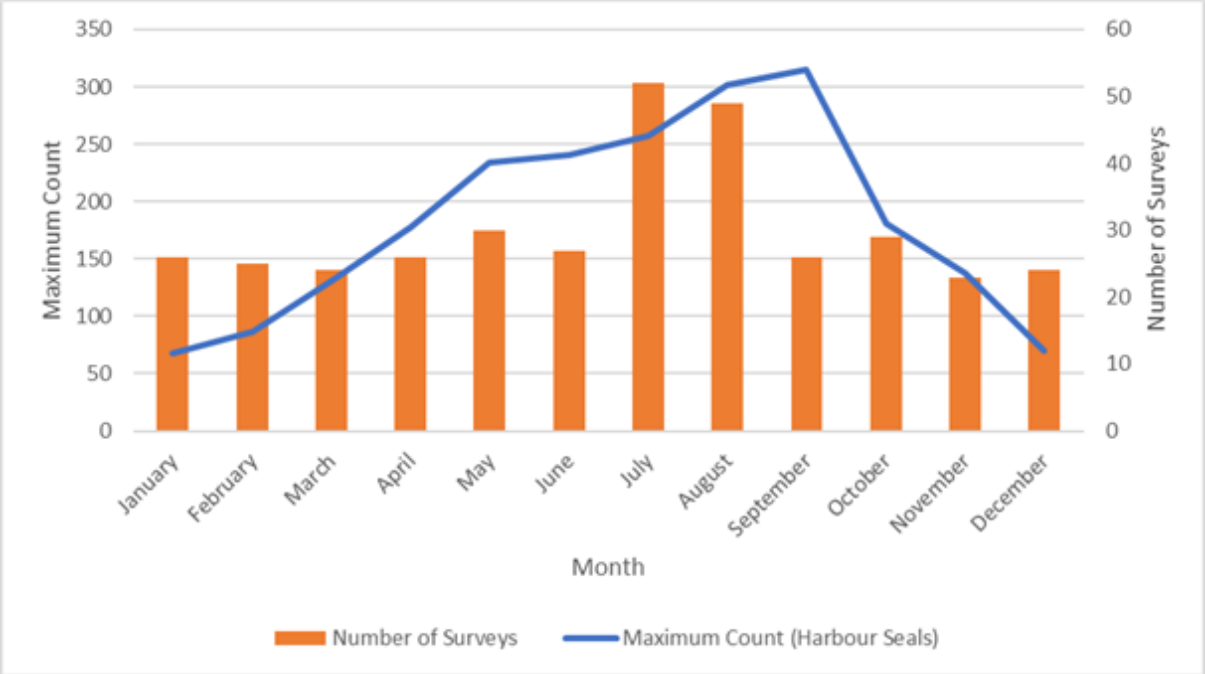

Figure 35: Maximum Counts of harbour seals in Strangford Lough each month (blue line) with the number of surveys performed in that month plotted as orange bars.

5.2.3. Trends in harbour seal pup counts from Strangford Lough

Using survey data from all months, the maximum seal counts for pups for each year are not as well reflected in the number of unique Seal Count IDs (Figure 36) or the number of surveys undertaken (Figure 37); these patterns were similar to that of the adults. As noted for the adults, the number of unique Seal Count IDs from 2007 onwards have been low, yet there is not a corresponding decrease in surveys. For Strangford Lough, the exploratory analysis did find that one unique Seal Count ID was associated with one Parent Location ID; therefore, if surveys of the Lough were complete, then the pattern in number of surveys and number of unique Seal Count IDs would be similar. This does suggest that since approximately 2007, the entire Lough has not been surveyed in its entirety. Therefore, although the data generally suggest a decline in the number of pups, from 2007 onwards (with the exception of a peak in the count for 2014), caution should be exercised as this may, at least in part, be related to effort. For month, the majority of the effort was in July and August, with the highest counts occurred in July (Figure 38).

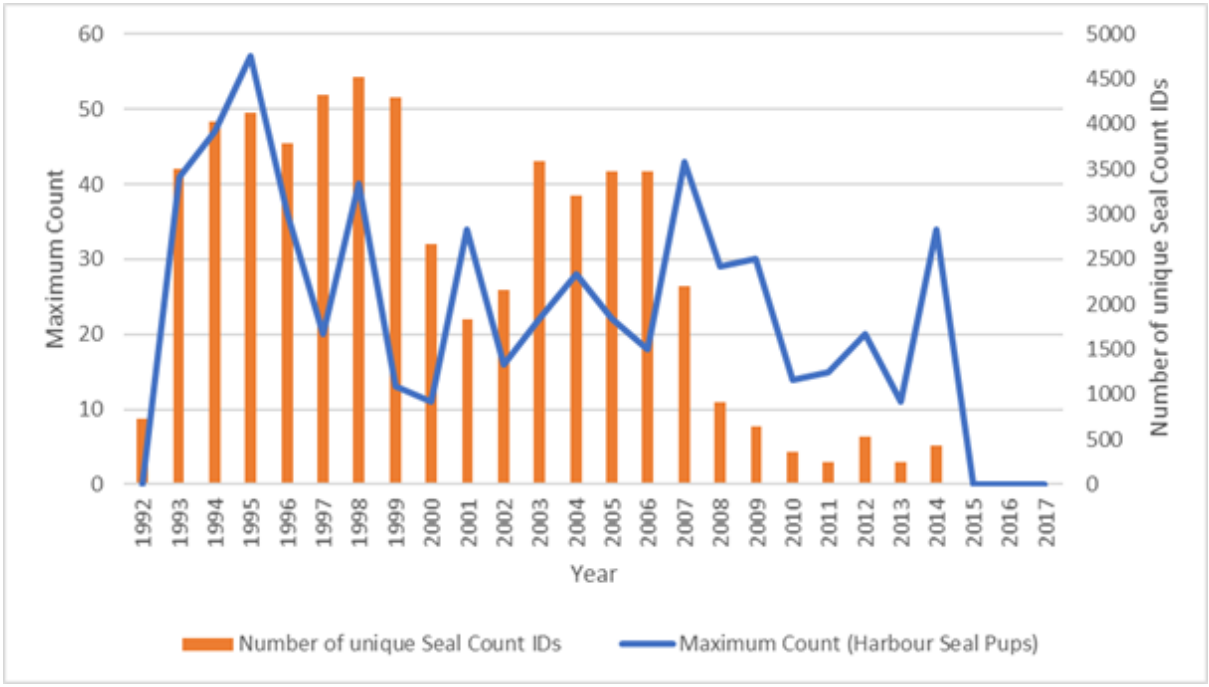

Figure 36: Maximum Counts of harbour seal pups in Strangford Lough each year (blue line) with the number of unique Seal Count IDs for that year plotted as orange bars.

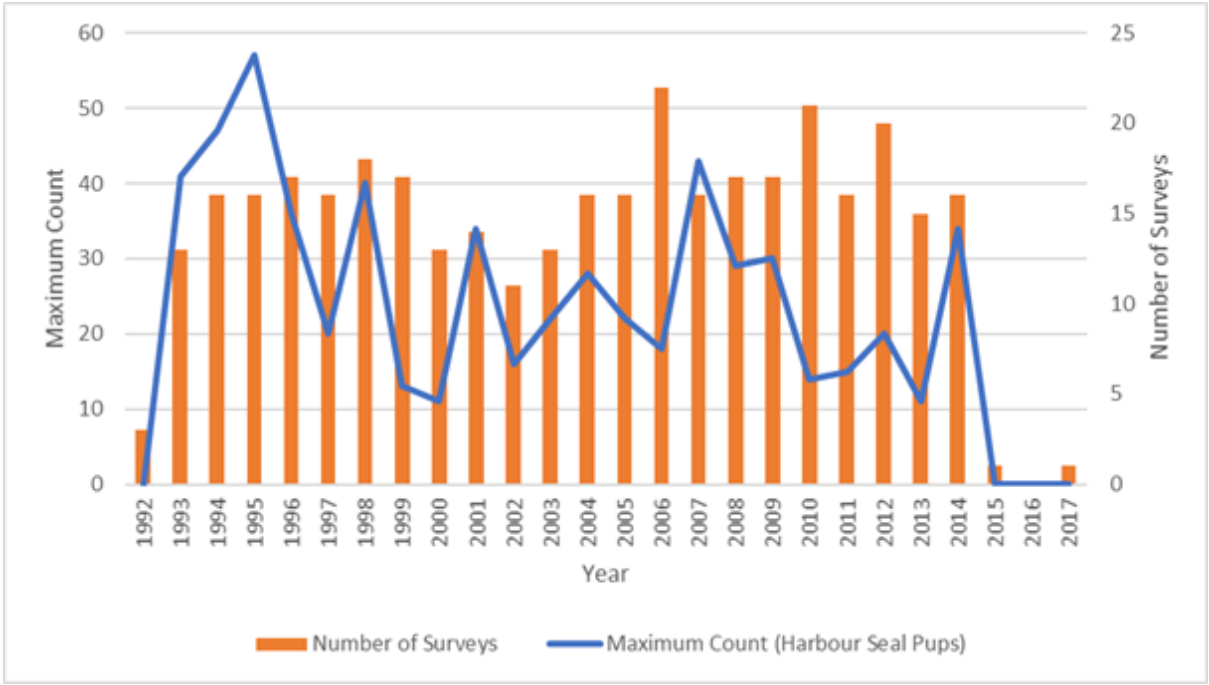

Figure 37: Maximum Counts of harbour seal pups in Strangford Lough each year (blue line) with the number of surveys for that year plotted as orange bars.

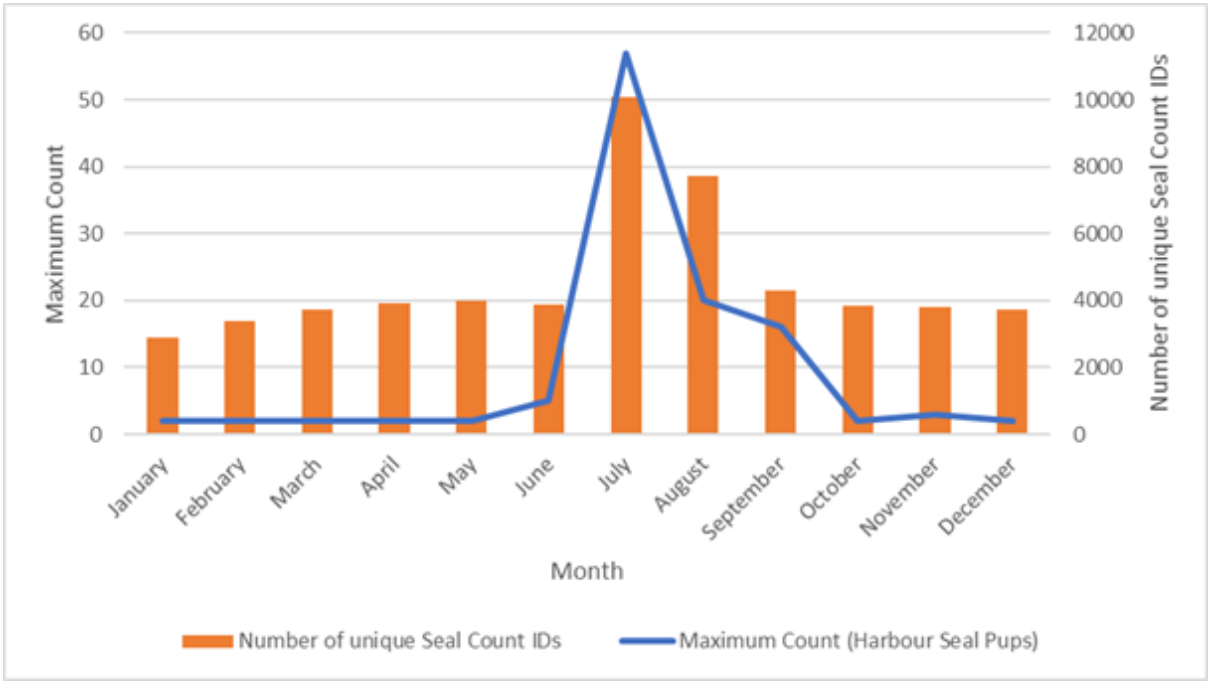

Figure 38: Maximum Counts of harbour seal pups in Strangford Lough each month (blue line) with the number of unique Seal Count IDs performed in that month plotted as orange bars.

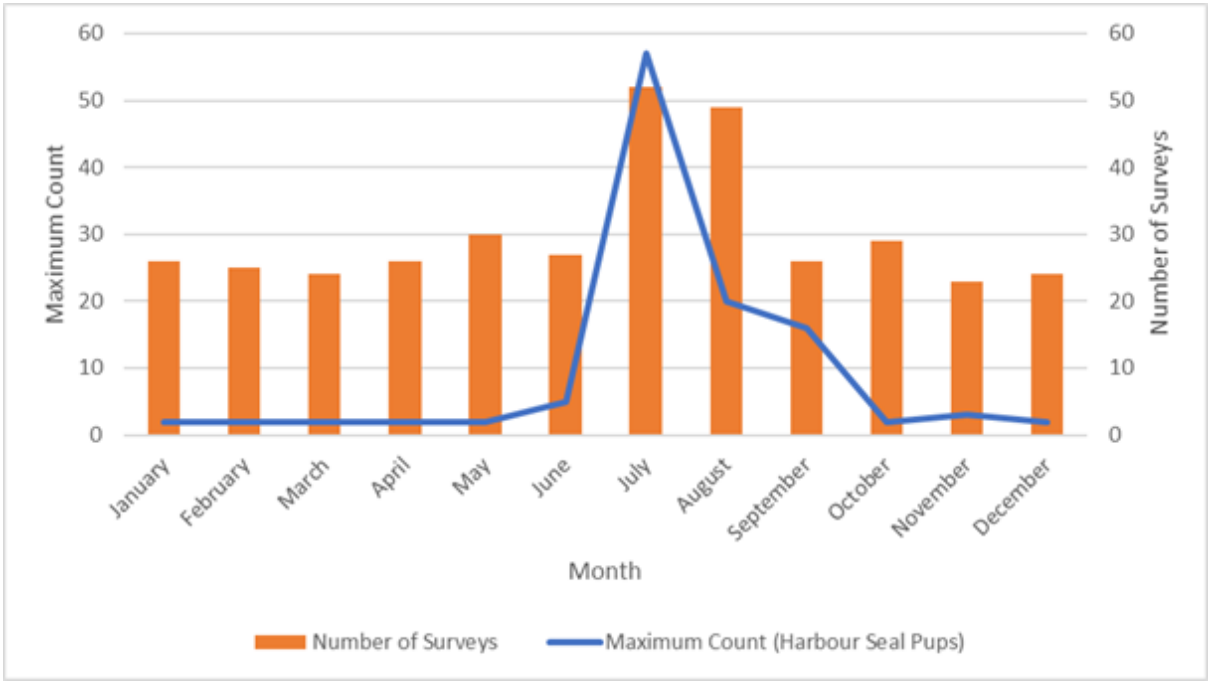

Figure 39: Maximum Counts of harbour seal pups in Strangford Lough each month (blue line) with the number of surveys performed in that month plotted as orange bars.

5.2.4. Harbour seal population trends for Strangford Lough

Using the maximum counts for each year for Strangford Lough, it is evident that for adult harbour seals, counts were low in the earliest year (1992) and for the most recent years. In general, a similar pattern was seen in the harbour seal pup counts. In using the entire data set, the regression lines in Figures 40 & 41 show a 1.16% decline and a 0.86% increase since 1992 for adults and pups, respectively. However, it is apparent that there was lower effort in 1992, with less Area IDs surveyed (Figure 10) and fewer surveys undertaken (Figure 33) and, as the correlation statistics showed (Table 11 and Figures 40 – 41), this would likely result in reduced counts. If these data were omitted, and only 1993 – 2014 are considered, then there is a 2.01% and a 1.31% annual decrease in adults and pups, respectively.

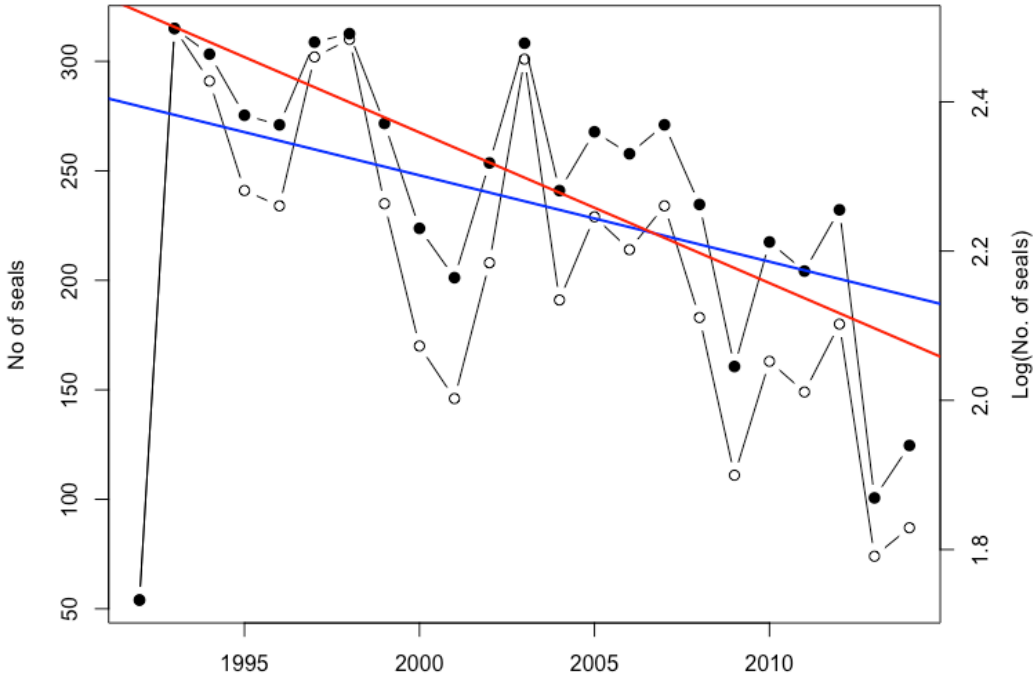

Figure 40: The maximum count of adult harbour seal (open circles) and the log10 of those counts (black circles) by year in Strangford Lough. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 11.

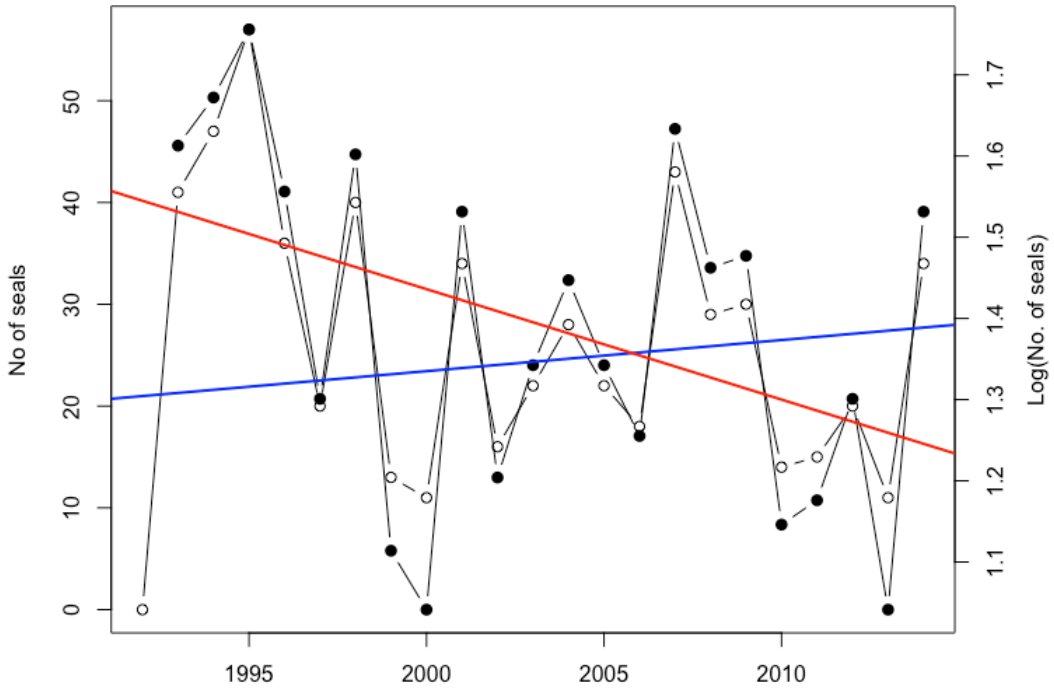

Figure 41: The maximum count of harbour seal pups (open circles) and the log10 of those counts (black circles) by year in Strangford Lough. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 11.

Table 11: The annual percentage change for each age class of harbour seal, using subsets of data based on the exploratory analysis on the completeness of surveys. The line colour column relates to the respective Figures for adults (Figure 40) and pups (Figure 41).

	Years	% annual change	Line colour
Adult	1992 – 2014	-1.16	Blue
	1993 – 2014	-2.01	Red
Pup	1992 – 2014	0.38	Blue
	1993 – 2014	-1.31	Red

5.2.5. Trends in adult grey seal counts from Strangford Lough

The proxies for effort do not reflect the maximum grey seal counts for Strangford Lough (Figures 42 & 43). In particular, there are greater numbers of surveys and unique Seal Count IDs in the earlier years, but this corresponds to low maximum counts, which do show a general increase until 2007, peaking in 2010. The number of unique Seal Count IDs from 2007 onwards have been low, yet there was no corresponding decrease in surveys. For Strangford Lough, the exploratory analysis did find that one unique Seal Count ID was associated with one Parent Location ID; therefore, if surveys of the Lough were complete, then the pattern in number of surveys and number of unique Seal Count IDs would be similar. This does suggest that since 2007, the Lough has not been surveyed in its entirety. Therefore, although the data suggest a decline in the population, caution should be exercised as this may, at least in part, be related to effort. For month, the majority of the effort was in July and August, although the highest counts (although comparable to August), were in September (Figure 45). Despite the majority of the effort occurring in July and August, the maximum counts for adult grey seals was in September, just before the breeding season (Figure 45).

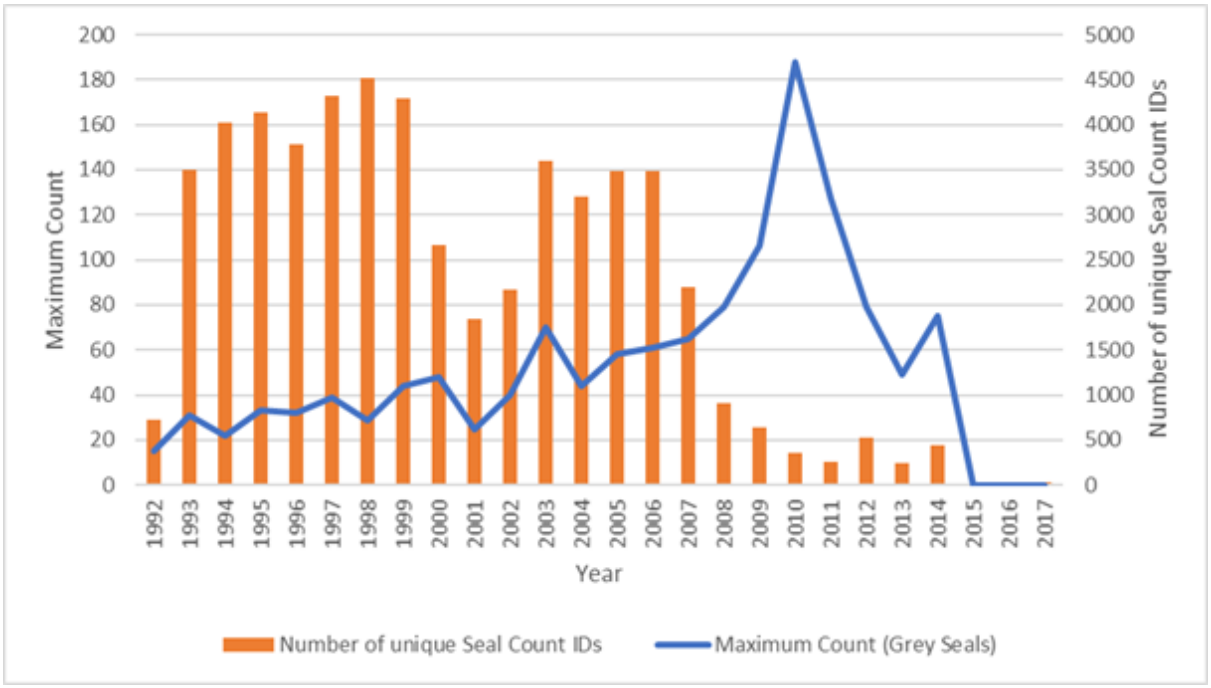

Figure 42: Maximum Counts of grey seals in Strangford Lough each year (blue line) with the number of unique Seal Count IDs for that year plotted as orange bars.

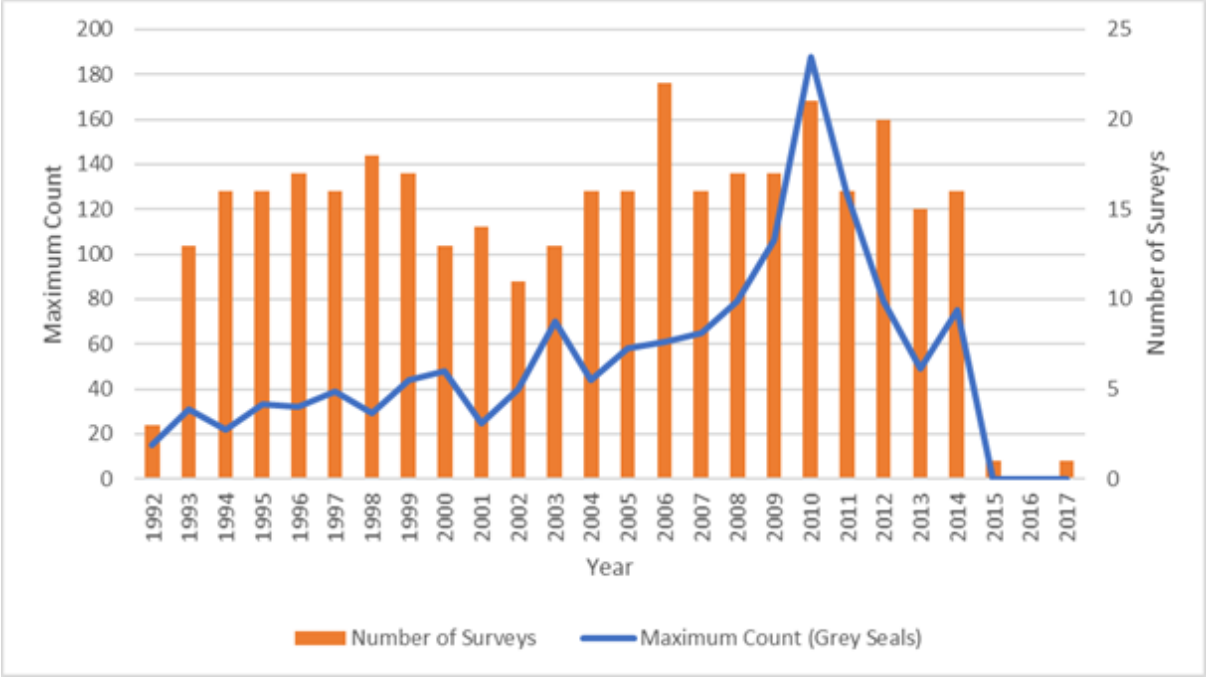

Figure 43: Maximum Counts of grey seals in Strangford Lough each year (blue line) with the number of surveys for that year plotted as orange bars.

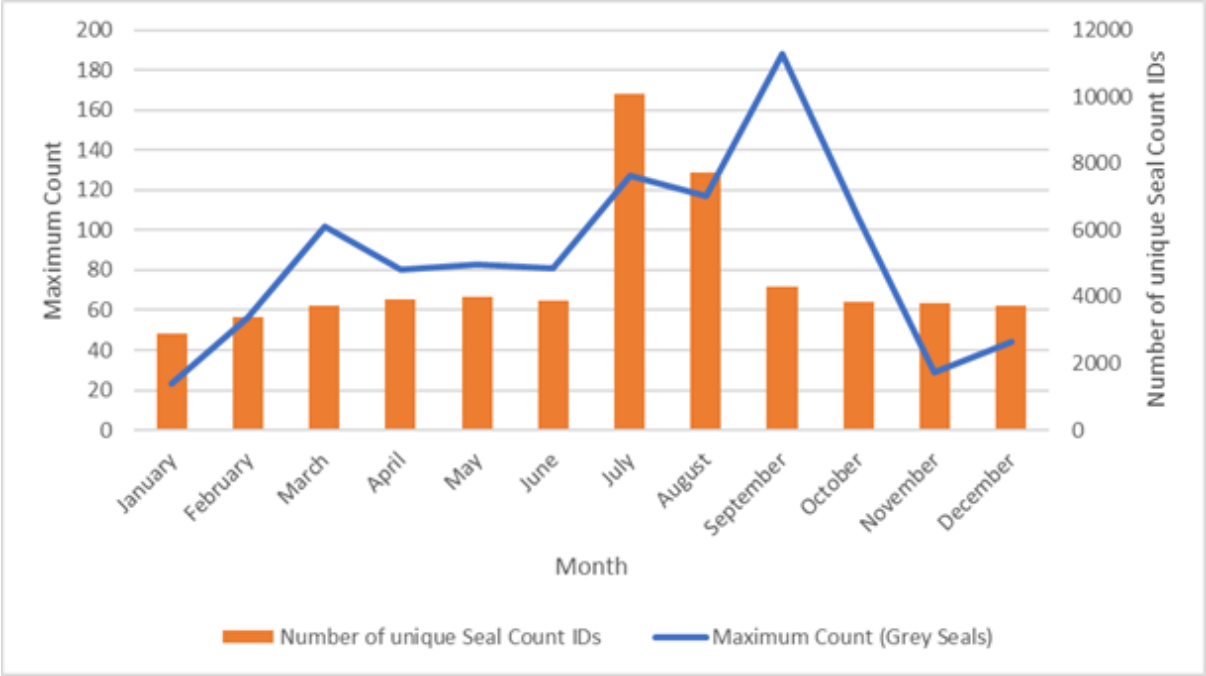

Figure 44: Maximum Counts of grey seals in Strangford Lough each month (blue line) with the number of unique Seal Count IDs performed in that month plotted as orange bars.

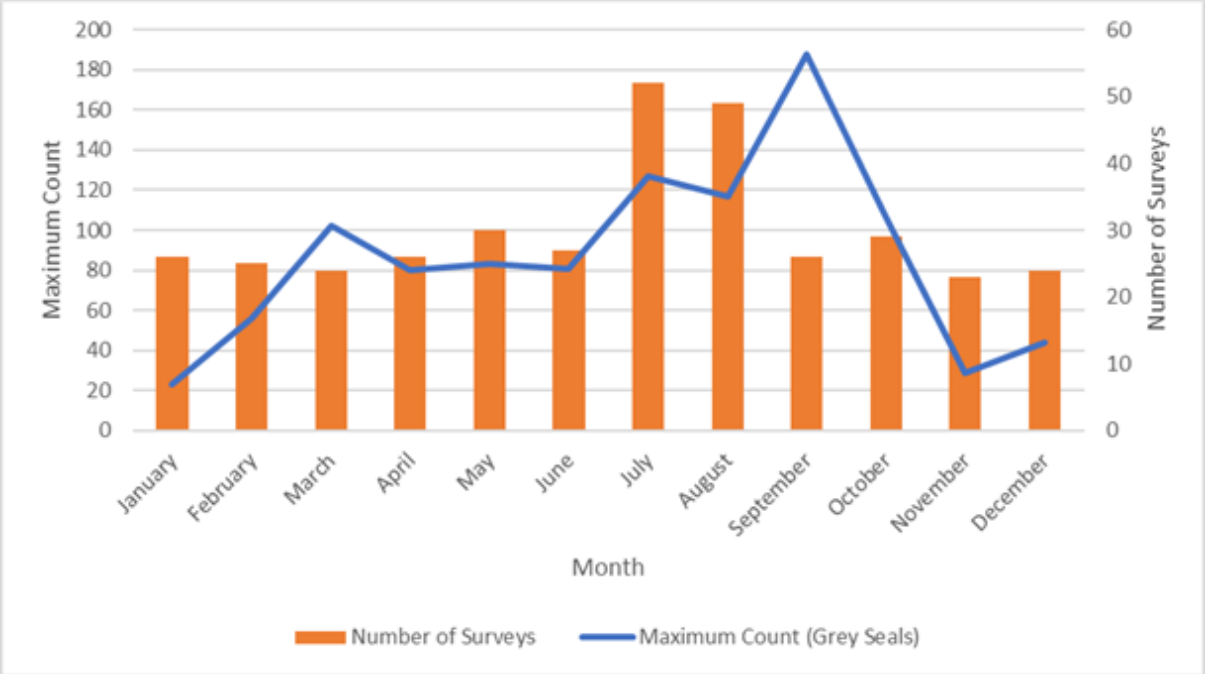

Figure 45: Maximum Counts of grey seals in Strangford Lough each month (blue line) with the number of surveys performed in that month plotted as orange bars.

5.2.6. Trends in grey seal pup counts from Strangford Lough

As for the adults, the proxies for effort do not reflect the maximum counts for grey seal pups in Strangford Lough (Figures 46 & 47). In particular, there are greater numbers of surveys and unique Seal Count IDs in the earlier years, but this typically corresponds to low maximum counts. As noted for the adults, the number of unique Seal Count IDs from 2007 onwards have been low, yet there is not a corresponding decrease in surveys. For Strangford Lough, the exploratory analysis did find that one unique Seal Count ID was associated with one Parent Location ID; therefore, if surveys of the Lough were complete, then the pattern in number of surveys and number of unique Seal Count IDs would be similar. This does suggest that since approximately 2007, the entire Lough has not been surveyed in its entirety, yet the highest count for grey seal pups did occur in 2011. Nonetheless, caution should be exercised as these patterns may, at least in part, be related effort. For month, the majority of the effort was in July and August; despite this, the highest counts occurred in October, during the grey seal breeding season. There were counts of grey seal pups in April, which seems unlikely, and does suggest these are errors in the data base (Figures 48 & 49).

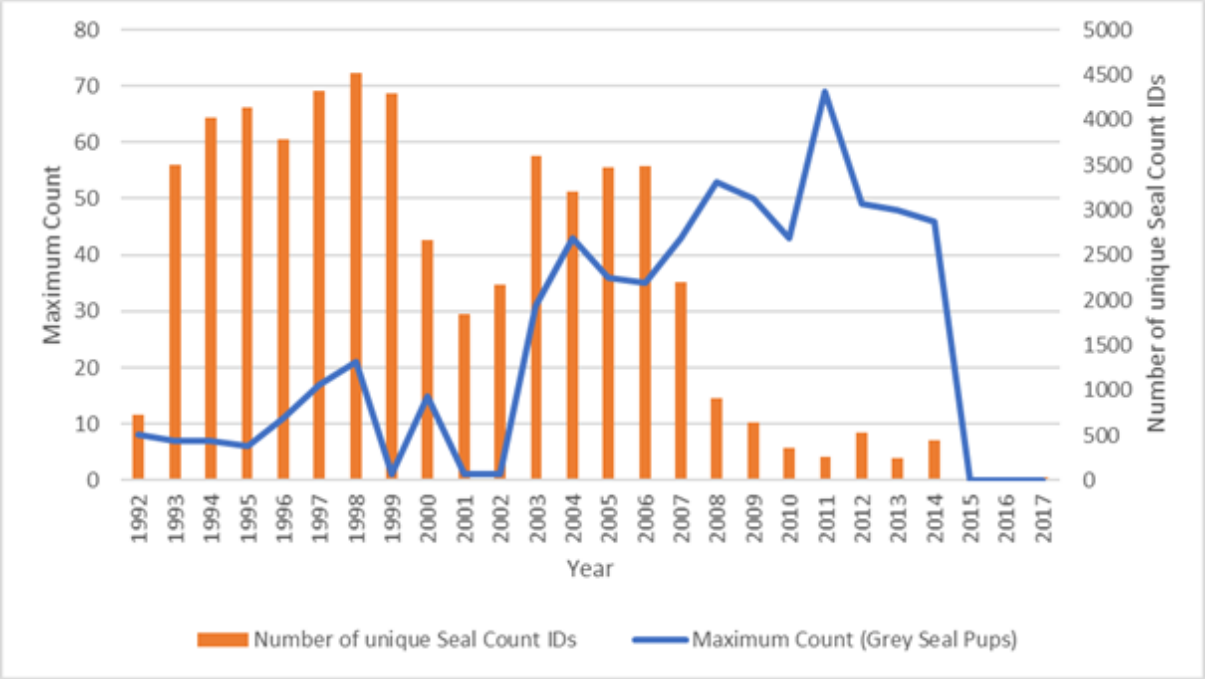

Figure 46: Maximum Counts of grey seal pups in Strangford Lough each year (blue line) with the number of unique count IDs for that year plotted as orange bars.

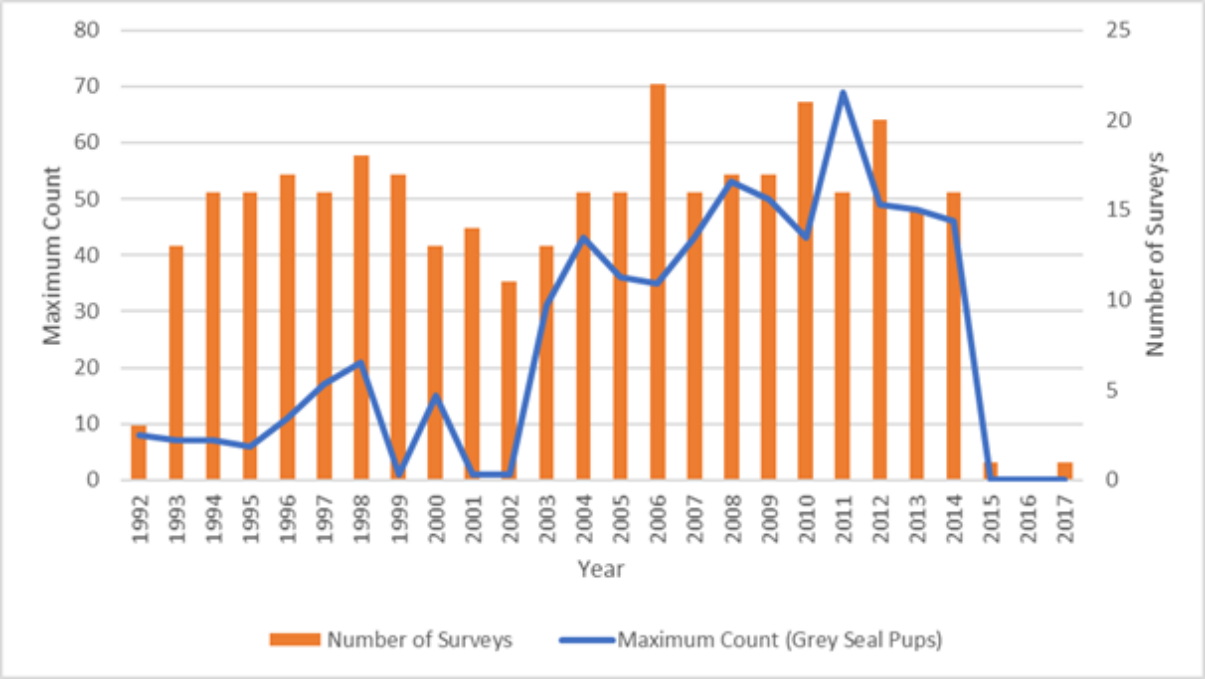

Figure 47: Maximum Counts of grey seal pups in Strangford Lough each year (blue line) with the number of surveys for that year plotted as orange bars.

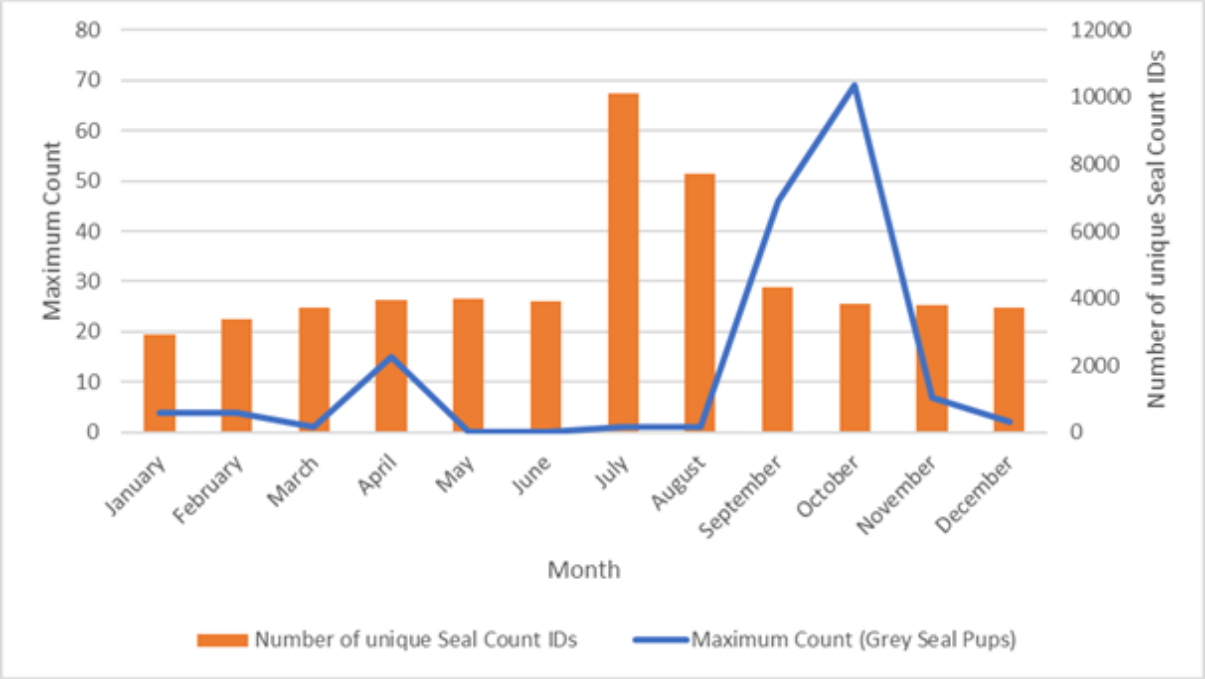

Figure 48: Maximum Counts of grey seal pups in Strangford Lough each month (blue line) with the number of unique Seal Count IDs performed in that month plotted as orange bars.

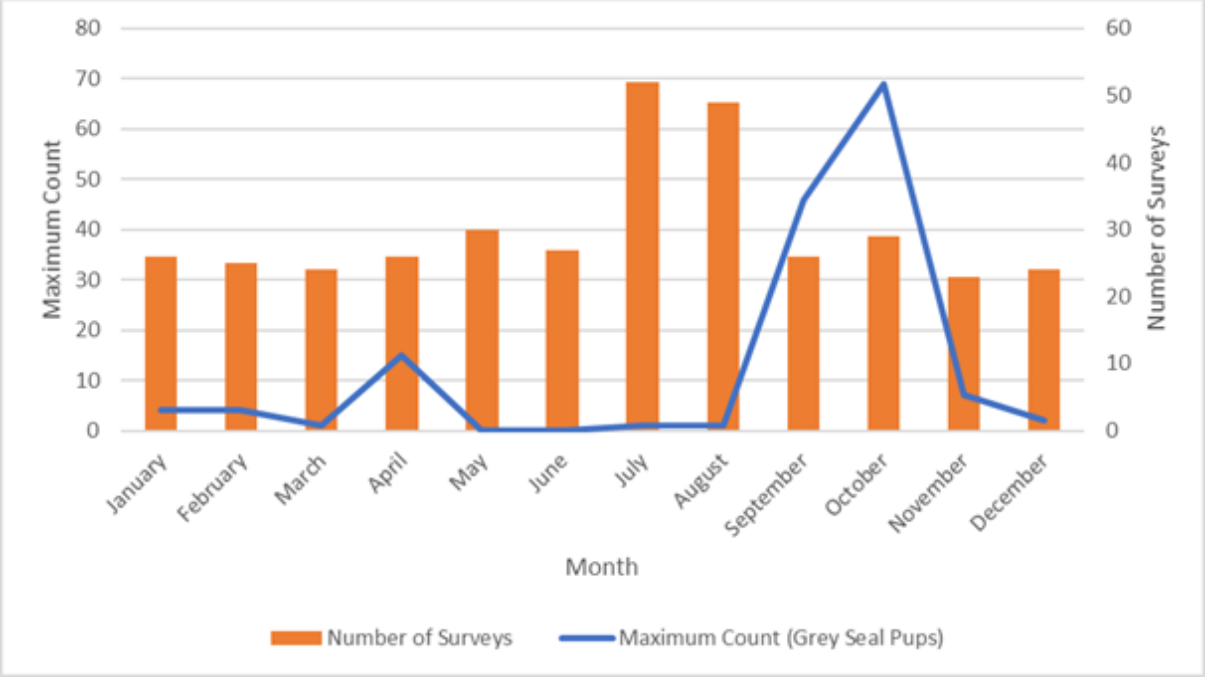

Figure 49: Maximum Counts of grey seal pups in Strangford Lough each month (blue line) with the number of surveys performed in that month plotted as orange bars.

5.2.7. Grey seal population trends for Strangford Lough

Using the maximum counts for each year for Strangford Lough, it is evident that for adult grey seals and pups, the counts were low from 1992 until approximately 2002, when they started to increase dramatically, then, in the most recent years, the maximum counts have dropped (Figures 50 – 51). In using the entire data set, the regression lines in Figures 50 & 51 show a 3.02% and a 4.93% increase since 1992 for adults and pups, respectively. However, it is apparent that there was lower effort in 1992, with less Area IDs surveyed (Figure 10) and fewer surveys undertaken (Figure 43) and, as the correlation statistics showed (Table 12 and Figures 50 – 51), this would likely result in reduced counts. If these data were omitted, and only 1993 – 2014 are considered, then there is a 2.8% and a 5.21% annual increase in adults and pups, respectively.

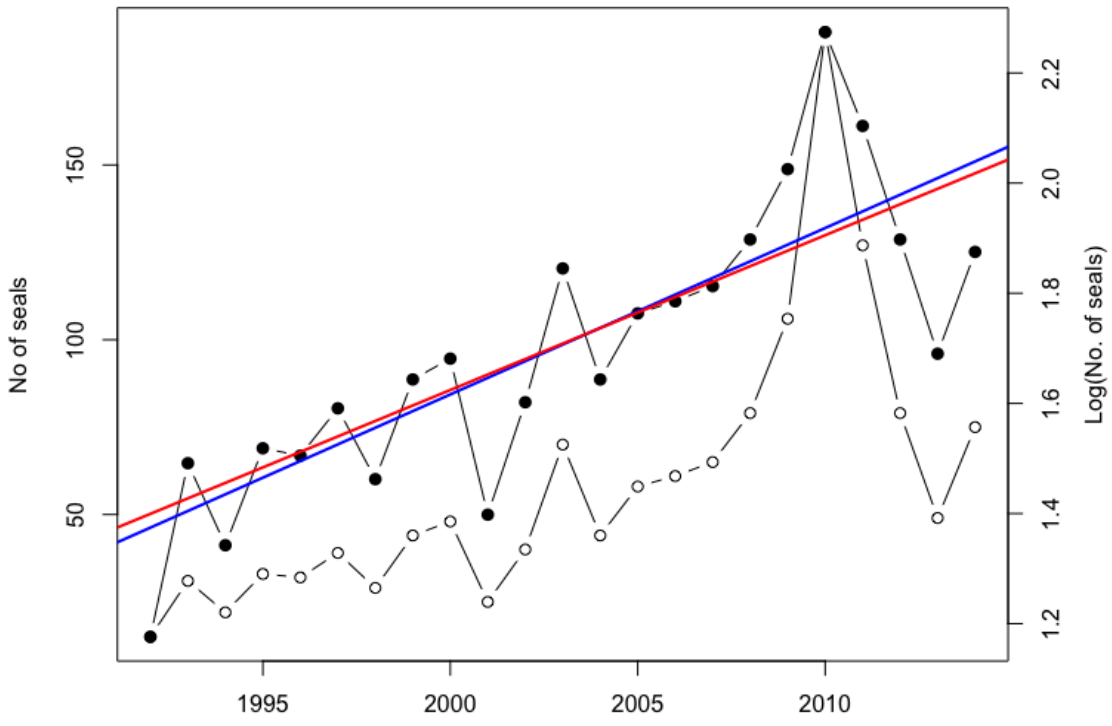

Figure 50: The maximum count of grey seal adults (open circles) and the log10 of those counts (black circles) by year in Strangford Lough. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 12.

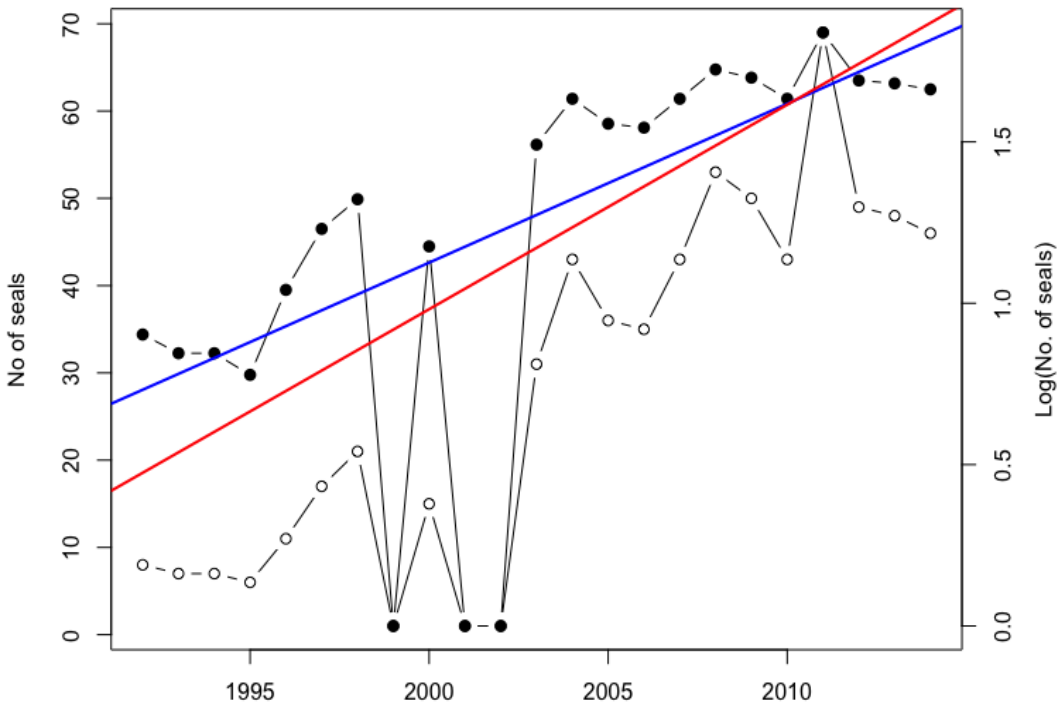

Figure 51: The maximum count of grey seal pups (open circles) and the log10 of those counts (black circles) by year in Strangford Lough. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 12.

Table 12: The annual percentage change for each age class of grey seal, using subsets of data based on the exploratory analysis on the completeness of surveys. The line colour column relates to the respective Figures for adults (Figure 50) and pups (Figure 51).

	Years	% annual change	Line colour
Adult	1992 – 2014	3.02	Blue
	1993 – 2014	2.8	Red
Pup	1992 – 2014	4.93	Blue
	1993 – 2014	5.21	Red

5.2.8. Use of Parent Location IDs in Strangford Lough

Using all the data available (1992 – 2015), the counts of harbour seal and grey seal adults by Parent Location ID was investigated (Figures 52 & 53; Table 13). There was variability in the Parent Location IDs used, where some areas appear to be rarely used, such as Portaferry and Kircubbin (IDs 267 and 281, respectively), some did have high numbers, particularly those in

the narrows (see Figure 2), such as Ballyquintin, Cloughy Rocks and Granagh Bay (IDs 263, 264 and 265, respectively). These Parent Location IDs, however, do not correspond to the highest number of harbour seal pups, which (relative to counts of adults), were at Boretree A, Boretree B, North/South/West and Quoile Estuary (IDs 284, 285, 286 and 270 respectively). This suggests that harbour seals may be using different locations in the Lough during the breeding season. However, it is important to note that these data are for the entire duration of the study; therefore, if there has been shifts between locations over time, this would not be reflected here. A more detailed temporal analysis of these data would be required to identify any changes in haul out use over time. For grey seals, counts at some Parent Location IDs in the narrows are comparably high, for example, Ballyquintin and Cloghy Rocks (IDs 263 and 264, respectively). There is a cluster of four Parent Location IDs: Black & Brown Rocks, Long Sheelah, Parton Island and Sketrick (IDs 274, 276, 278 and 280, respectively) that have high numbers of both adult grey seals and pups.

Table 13: Seal counts by Parent Location ID for Strangford Lough. The names of Parent Location IDs within Strangford Lough and their associated ID number, which corresponds to Figures 52 and 53. The names can be matched to those in the map of Strangford Lough presented in Figure 2. The table continues overleaf.

			Harbour				**Grey**			
			Hauled Out		**At Sea**		**Hauled Out**		**At Sea**	
Parent Location ID	**Name**	**Number of surveys**	**Adult**	**Pups**	**Adult**	**Pups**	**Adult**	**Pups**	**Adult**	**Pups**
260	Killard Point	237	415	15	32	1	718	17	38	0
261	Kilclief	212	1471	39	48	2	105	1	10	0
262	Angus Rocks	246	1684	22	60	0	429	7	38	0
263	Ballyquintin	259	3808	106	106	8	2218	32	119	0
264	Cloghy Rocks	204	3368	82	102	2	901	7	63	0
265	Granagh Bay	264	3739	158	129	16	397	8	30	0
266	Strangford	249	353	27	32	1	14	0	2	0
267	Portaferry	249	0	0	14	0	0	0	3	0
268	Castleward Bay	251	323	55	74	1	5	1	4	0

269	Walter Rocks	246	56	3	14	0	1	0	3	0
270	Quoile Estuary	209	974	165	54	3	20	1	3	0
271	Ballyhenry	247	825	55	29	1	33	0	4	0
272	Limestone Pladdies	240	1309	77	39	1	148	20	21	0
273	Marlfield	242	7	0	4	0	0	0	2	0
274	Black & Brown Rocks	244	317	19	19	1	338	111	100	0
275	Dorn	201	1626	39	47	1	55	1	24	1
276	Long Sheelah	235	700	23	25	1	1057	263	120	5
277	Yellow Rocks	240	1140	102	55	5	128	6	54	0
278	Parton Island	254	1362	50	45	3	723	205	107	2
279	Buckey Rocks	239	280	69	26	5	208	30	36	2
280	Sketrick	248	550	63	35	8	94	65	35	2
281	Kircubbin	174	30	10	1	1	10	0	1	0
282	Bird Island	247	521	56	41	2	21	0	10	0
283	Gabbock	238	54	3	15	2	59	45	41	1
284	Boretree Rocks A	238	1344	151	91	10	59	5	28	0
285	Boretree Rocks B	238	203	49	27	9	34	18	11	1
286	North/South/ West	223	498	83	28	5	217	0	21	0
416	Unknown/No seal/The Scotchman	192	92	7	17	1	0	0	1	0

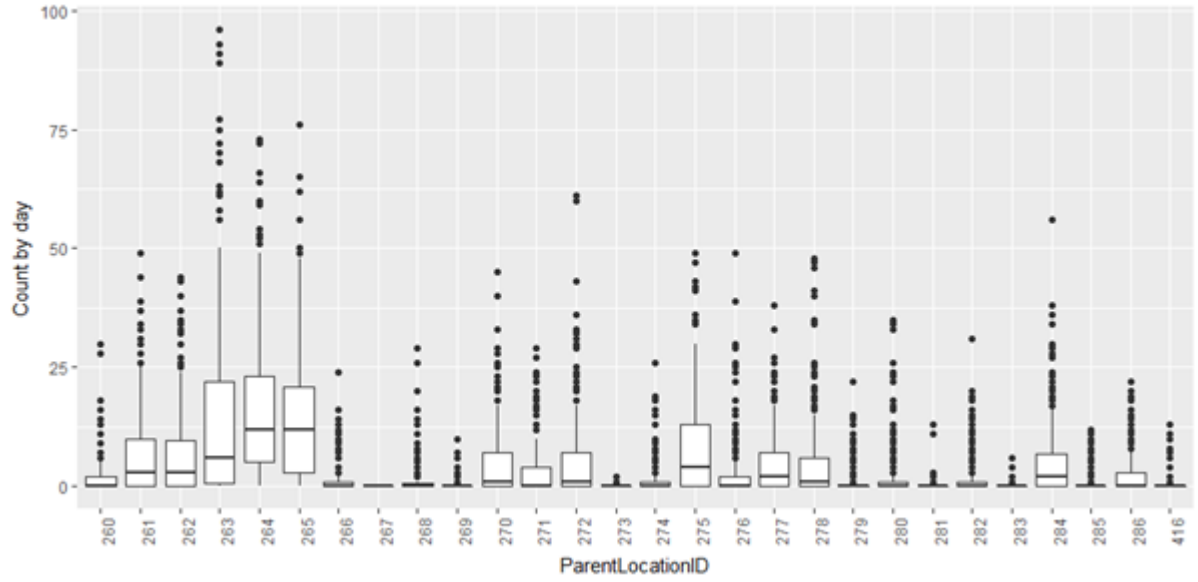

Figure 52: Counts of hauled out adult harbour seals for each Parent Location ID within Strangford Lough. Each count is from a survey; all data from 1992 – 2014 are included. The box displays the mean and interquartile range; the whiskers show the value furthest from the mean that is no more than 1.5 times the interquartile range, all values beyond this are displayed as points.

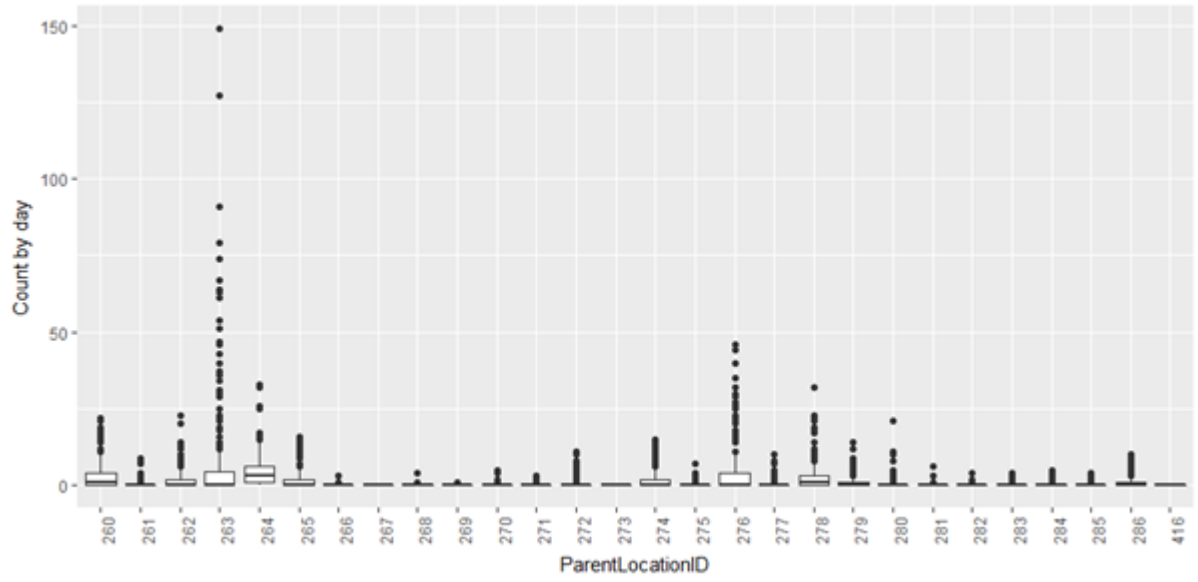

Figure 53: Counts of hauled out adult grey seals for each Parent Location ID within Strangford Lough. Each count is from a survey; all data from 1992 – 2014 are included. The box displays the mean and interquartile range; the whiskers show the value furthest from the mean that is no more than 1.5 times the interquartile range, all values beyond this are displayed as points.

5.2.9. Murlough

Surveys were carried out between 1993 and 2014 totalling 255 individual days of surveys. Some data was incorrectly associated with Dundrum, which needed to be corrected. This was done so by matching the 'LocationDescriptions' and altering the 'LocationIDs' on corresponding counts. There was only one Parent Location ID for Murlough; therefore, there was no detailed analysis of Parent Location ID use (as was presented for Strangford Lough).

5.2.10. Trends in adult harbour seal counts from Murlough

Using survey data from all months, the maximum seal counts for each year are not reflected in the number of unique Seal Count IDs (Figure 54) or the number of surveys undertaken (Figure 55). In general, there appears to have been a relatively stable population, which then showed a dip in 2004, followed by a peak in 2011; there is evidence to suggest that this is now decreasing again. In recent years, the number of surveys has remained relatively high, yet the number of unique Seal Count IDs have decreased. This may be an indication of incomplete surveys in recent years (which does correspond to a decrease in the maximum counts), or it may be that the protocols changed and fewer unique Seal Count IDs were used in recent years. It was not possible to assess which, if either, may be responsible for this pattern. The monthly data did show a peak in effort in July and August, yet the higher maximum counts were from September, followed by May (Figure 56).

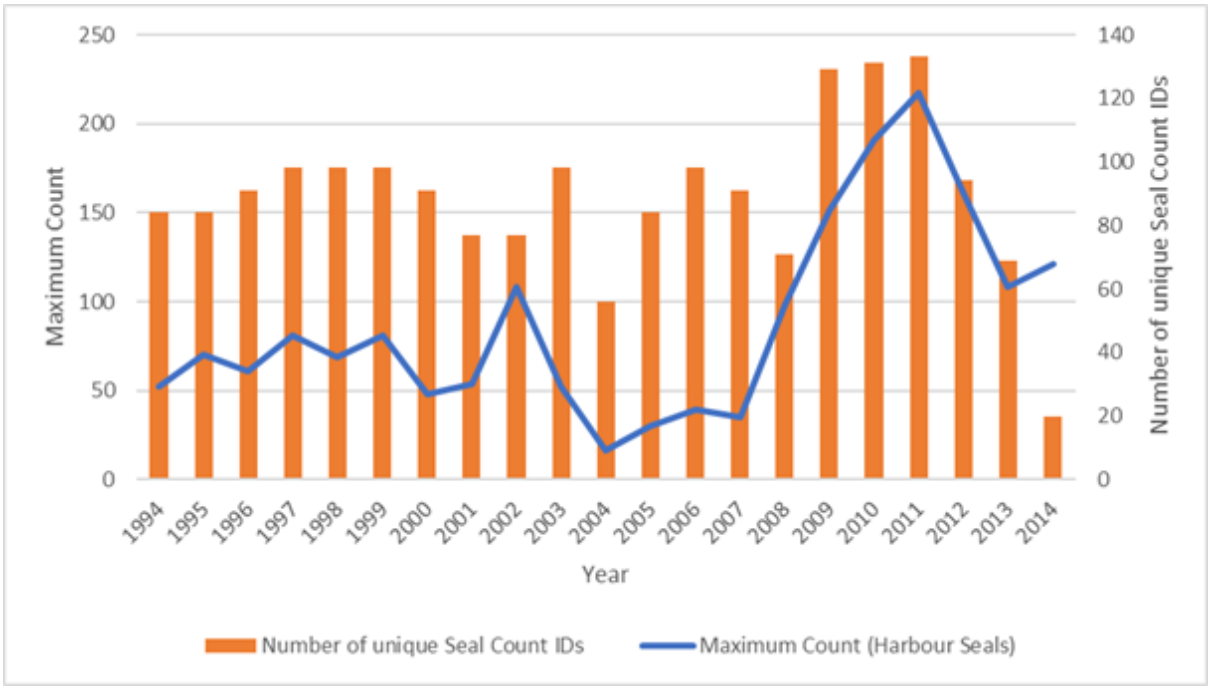

Figure 54: Maximum counts of harbour seals for Murlough for each year (blue line) with the number of unique Seal Count IDs for that year plotted as orange bars.

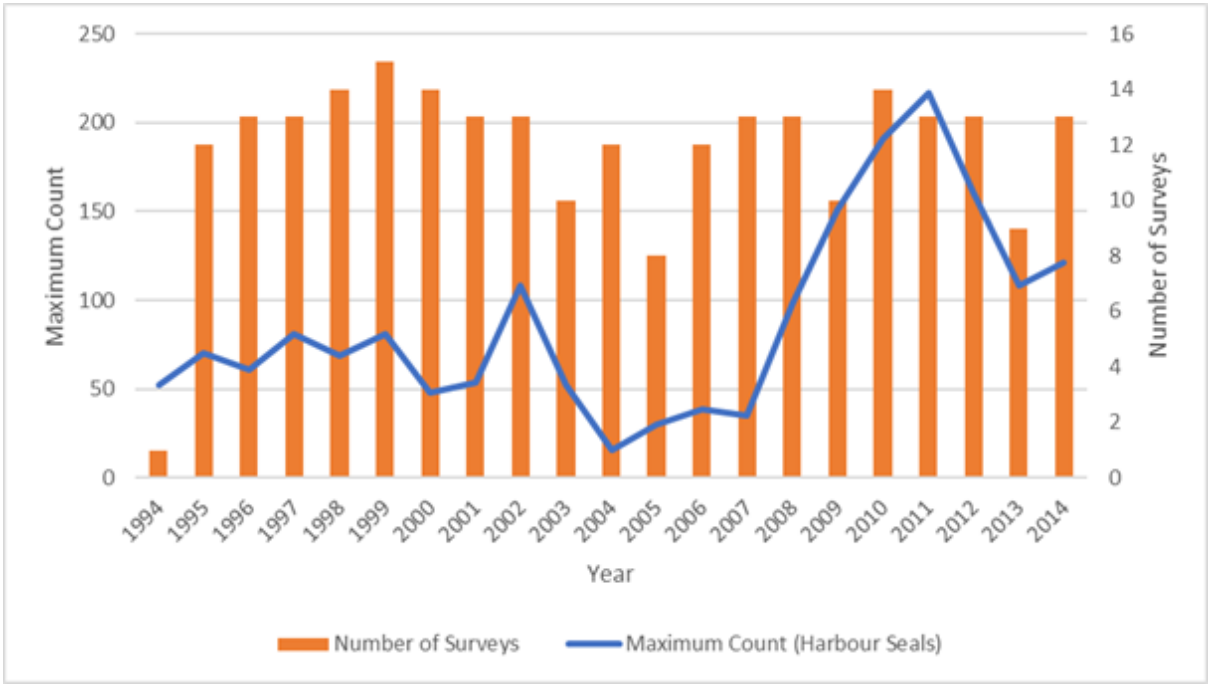

Figure 55: Maximum counts of harbour seals for Murlough for each year (blue line) with the number of Surveys for that year plotted as orange bars.

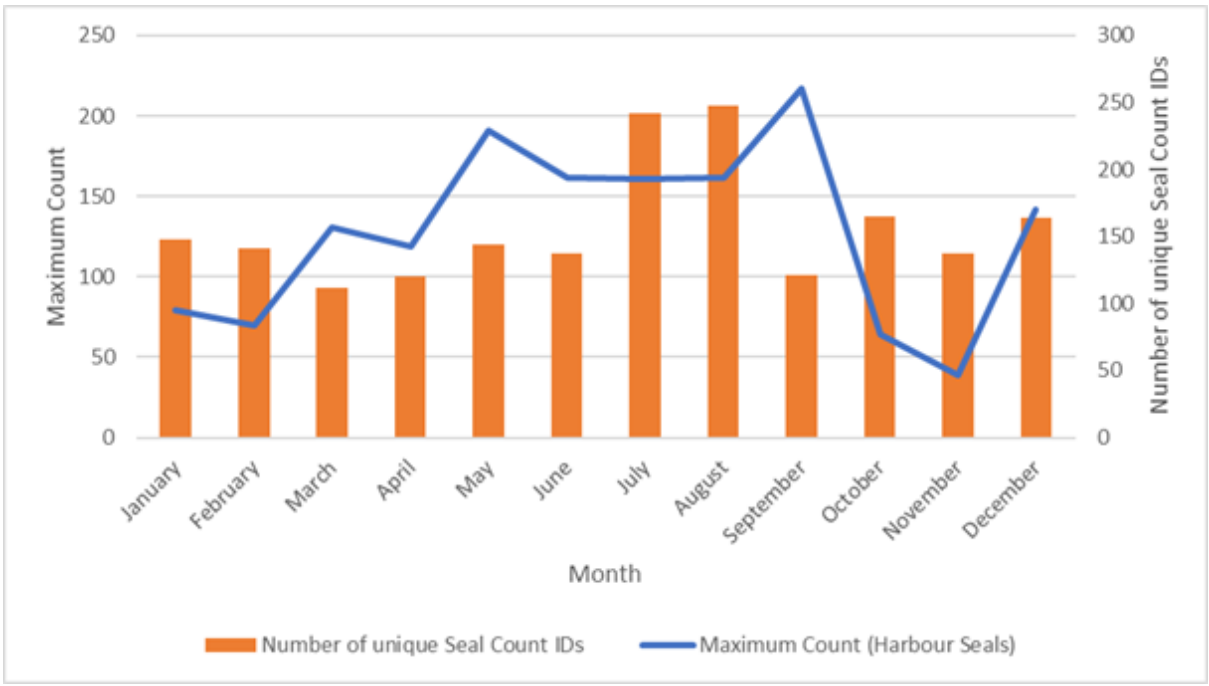

Figure 56: Maximum counts of harbour seals for Murlough for each month (blue line) with the number of unique Seal Count IDs for that month plotted as orange bars.

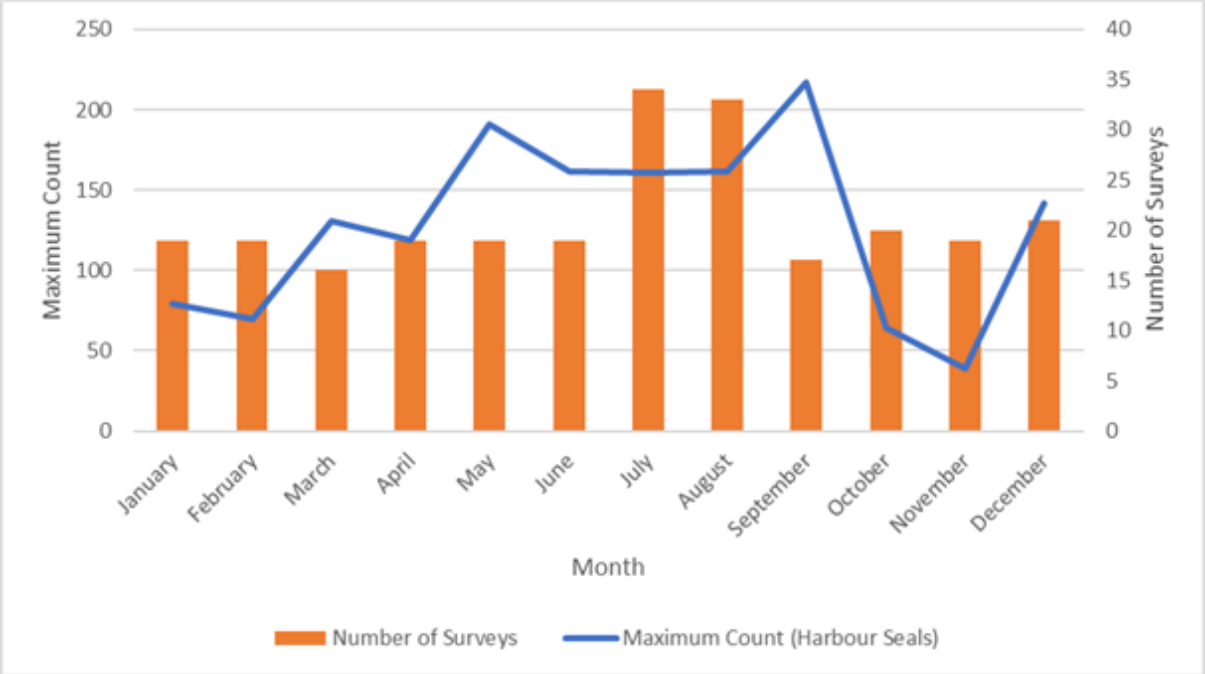

Figure 57: Maximum counts of harbour seals for Murlough for each month (blue line) with the number of surveys for that month plotted as orange bars.

5.2.11. Trends in harbour seal pup counts from Murlough

Using survey data from all months, the maximum seal counts for pups for each year are not as well reflected in the number of unique Seal Count IDs (Figure 58) or the number of surveys undertaken (Figure 59); these patterns were similar to that of the adults. In general, numbers appear to have shown a subtle increase, followed by a dip in 2004, and then a peak in 2009. The relatively high pup counts were maintained until 2011; thereafter, there is evidence to suggest that this is now decreasing again. As noted for the adults, in recent years, the number of surveys has remained relatively high, yet the number of unique Seal Count IDs have decreased. This may be an indication of incomplete surveys in recent years (which does correspond to a decrease in the maximum counts), or it may be that the protocols changed and fewer unique Seal Count IDs were used in recent years. It was not possible to assess which, if either, may be responsible for this pattern. The monthly data did show a peak in effort in July and August, and the higher maximum counts were from July; the harbour seal breeding season (Figure 60).

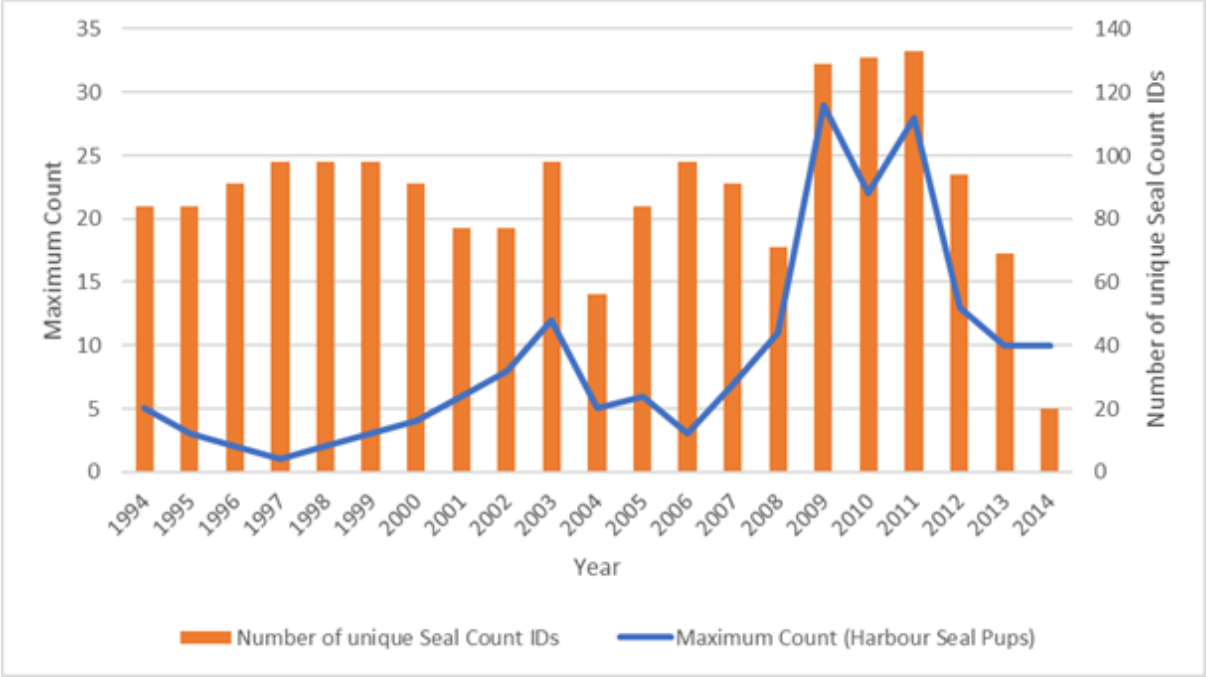

Figure 58: Maximum counts of harbour seal pups for Murlough for each year (blue line) with the number of unique Seal Count IDs for that year plotted as orange bars.

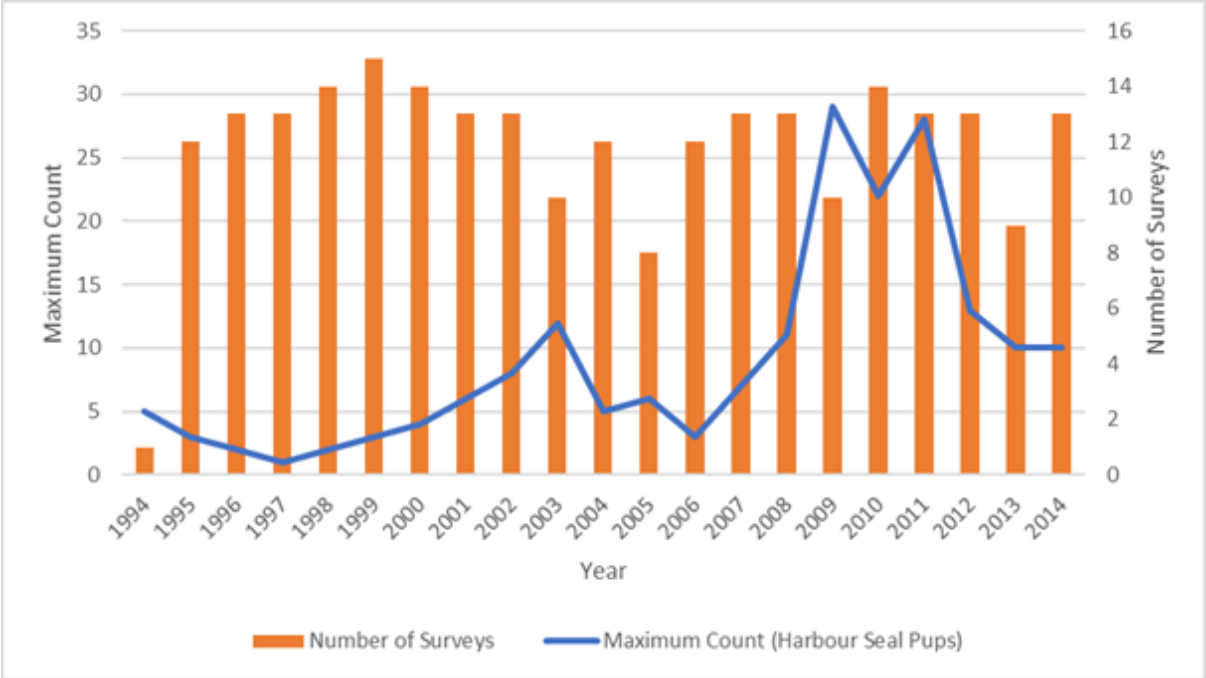

Figure 59: Maximum counts of harbour seal pups for Murlough for each year (blue line) with the number of surveys for that year plotted as orange bars.

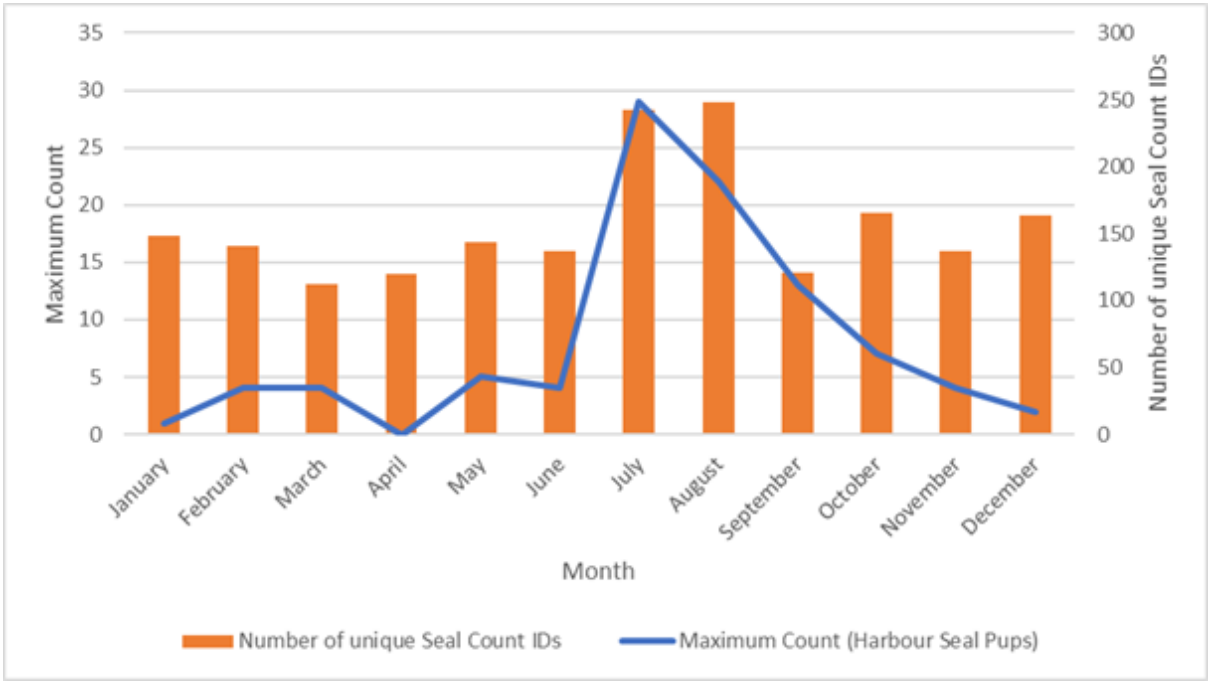

Figure 60: Maximum counts of harbour seal pups for Murlough for each year (blue line) with the number of unique Seal Count IDs for that month plotted as orange bars.

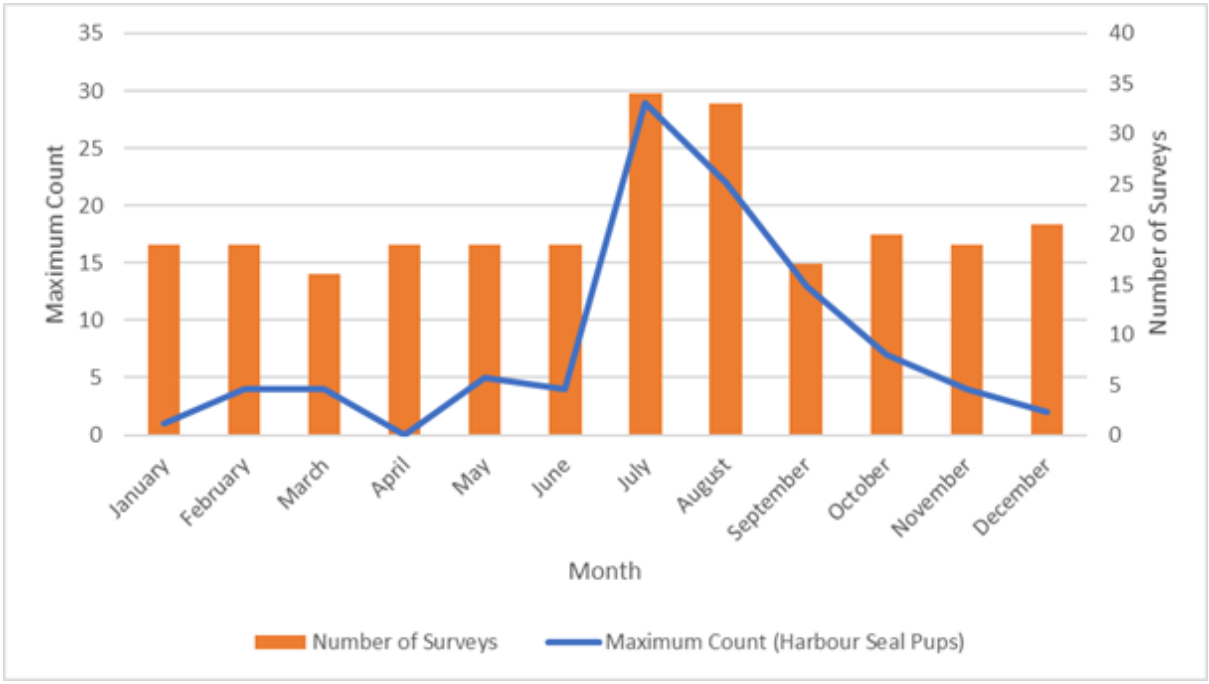

Figure 61: Maximum counts of harbour seal pups for Murlough for each year (blue line) with the number of surveys for that month plotted as orange bars.

5.2.12. Harbour seal population trends for Murlough

Using the maximum counts for each year for Murlough, it is evident that for adult harbour seals, counts were low in the earlier and most recent years. In general, a similar pattern was seen in the harbour seal pup counts. In using the entire data set, the regression lines in Figures 62 & 63 show a 1.97% and a 3.96% increase since 1994 for adults and pups, respectively. However, it is apparent that there was lower effort in 1994, with less Area IDs surveyed (Figure 10) and fewer surveys undertaken (Figure 55) and, as the correlation statistics showed (Table 14 and Figures 62 – 63), this would likely result in reduced counts. If these data were omitted, and only 1995 – 2014 are considered, then there is a 2.05% and a 4.41% annual increase in adults and pups, respectively.

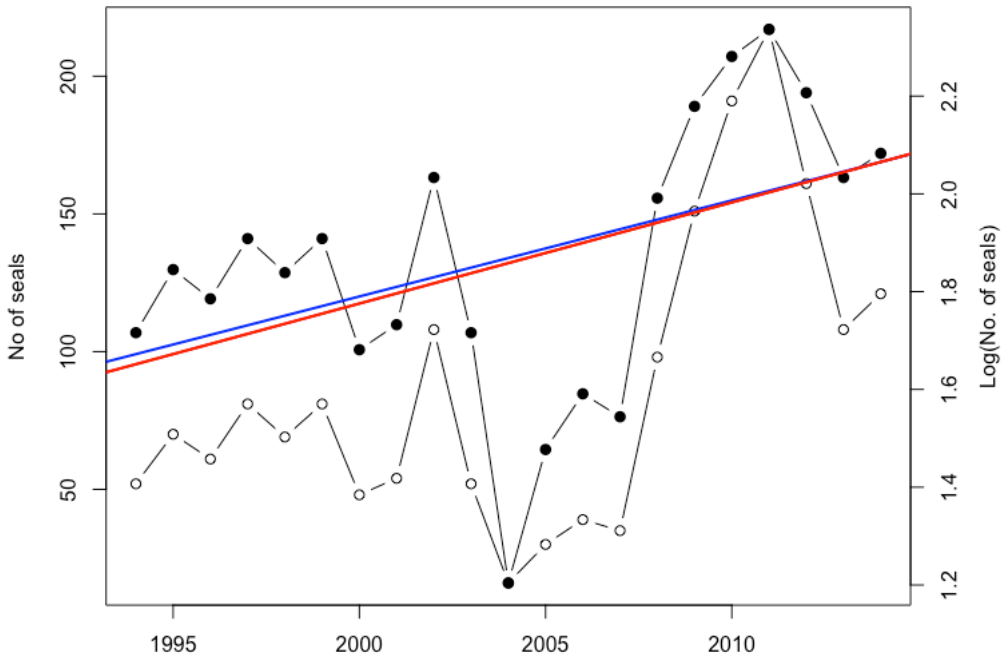

Figure 62: The maximum count of adult harbour seals (open circles) and the log10 of those counts (black circles) by year. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 14.

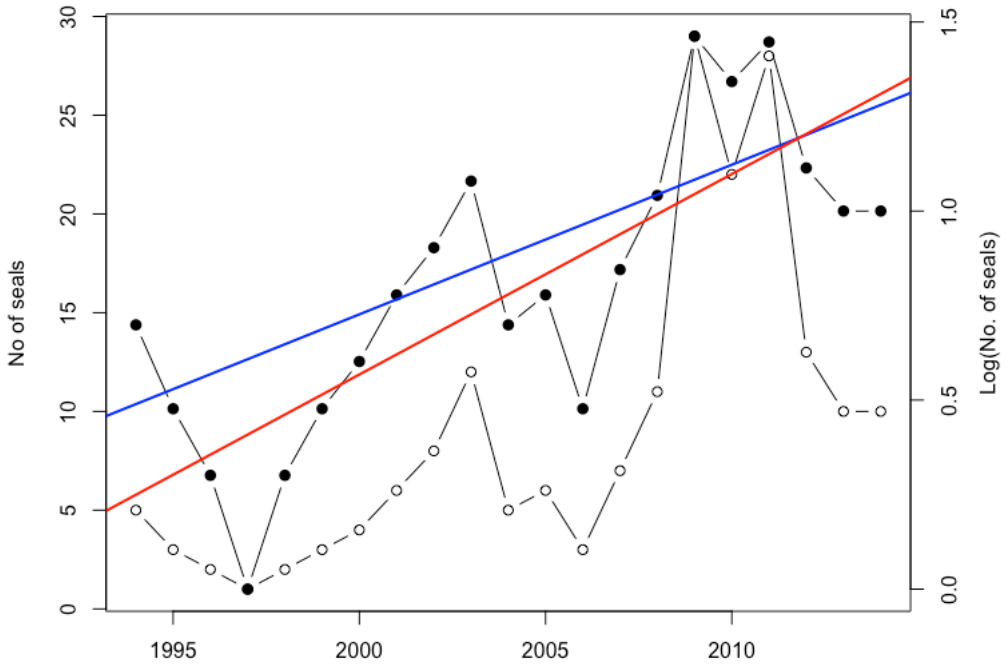

Figure 63: The maximum count of harbour seal pups (open circles) and the log10 of those counts (black circles) by year. The Regression lines are plotted using the log10 transformed data. The coloured lines relate to the information in Table 14.

Table 14: The annual percentage change for each age class of harbour seal, using subsets of data based on the exploratory analysis on the completeness of surveys. The line colour column relates to the respective Figures for adults (Figure 62) and pups (Figure 63).

	Years	% annual change	Line colour
Adult	1994 – 2014	1.97	Blue
	1995 – 2014	2.05	Red
Pup	1994 – 2014	3.96	Blue
	1995 – 2014	4.41	Red

5.2.13. Trends in grey counts from Murlough

The numbers of grey seals hauled out at Murlough are much lower than those of harbour seals and were therefore not analysed in detail. The maximum counts are variable across years; however, it does appear that higher maximum counts have occurred in the more recent year, with the highest maximum count of 88 adults on 2013 (Table 15). Few pups were counted in Murlough in earlier years, but this may be due to surveys targeting the harbour

seal breeding period and moult. Again, maximum counts are variable, with the highest being 10 in 2011 (Table 15).

Table 15: Maximum counts for grey seals in Murlough for each year; only hauled out seals are presented, and juveniles were counted as adults. The number of surveys undertaken in each year are provided.

Year	Number of Surveys	Adult	Pups
1993	1	0	0
1994	12	8	0
1995	13	26	0
1996	13	6	0
1997	14	21	0
1998	15	9	0
1999	14	12	0
2000	13	10	1
2001	13	5	0
2002	10	8	1
2003	12	17	4
2004	8	4	2
2005	12	2	1
2006	13	2	0
2007	13	8	4
2008	10	35	2
2009	14	14	2
2010	13	14	3
2011	13	57	10
2012	9	86	0
2013	13	88	0
2014	7	68	4

6. Discussion

The conclusion on population trends was strongly influenced by which subset of data were used. Generally, with the exception of grey seal pups (which were stable), regression analysis of the complete data set (1992 – 2017) showed an annual decline for both species and harbour seal pups. Conversely, for the other two subsets investigated (1992 – 2014 and 1995 – 2014), both species of both age classes showed an annual increase in population size. The need to examine subsets of the data was highlighted by the exploratory analysis of the proxies for survey effort and completeness of a survey, which showed that it is extremely likely that these factors would influence the results presented. Consequently, all results should be interpreted with caution. The variability in these results based on the subsets of data does demonstrate the issues associated with survey effort that was variable over time and space.

Notably, Strangford Lough, the area with the most comprehensive data set did find a pronounced increase in grey seals, both adults and pups; and a pronounced decrease in harbour seals, particularly adults. Again, caution must be exercised here, as the most recent years had extremely few data. Furthermore, after discussions with DAERA, in 2013 and 2014, only the Southern part of Strangford Lough was surveyed as a result of a lack of resources. This would likely explain, at least in part, the comparably lower number of seals counted in Strangford Lough in recent years. However, this once again highlights the need for systematic surveys and, even more importantly, accurate recording of survey effort, in order to prevent erroneous conclusions being drawn from the data. Specifically, lower counts may be the result of reduced survey effort and may not be an indication of a population decline.

6.1. Comparisons between boat-based and Infra-red helicopter surveys

To obtain a better understanding of how effective boat-based counts are at obtaining accurate maximum counts at haul outs, it is possible to compare the results herein to those of Infra-Red camera surveys conducted from a helicopter in 2002 and 2011, covering the whole of Northern Ireland (Duck & Morris, 2012). For these surveys, pups were included in the counts with adults (as they cannot be differentiated using an IR camera). In 2002 there were 1,276 harbour seals counted and in 2011, there were 948, representing a 25% decline in the Northern Irish population over the nine-year period. However, for the boat-based counts, there were 736 and 780 harbour seals counted in 2002 and 2011, respectively. These figures suggest a modest increase over the nine-year period. In using these counts, Duck & Morris (2012) showed, using the same statistical approach used in this report, that there was a 3% annual decline in harbour seals (including both adults and pups) between 2002 and 2011. In the present report, 3.37% and 1.21% annual declines of adult harbour seals and pups, respectively, was calculated for the 1992 – 2017 dataset. However, as noted caution should be exercised, because if the more recent data are omitted 1.52% and 2.53% annual increases of adult harbour seals and pups, respectively, was calculated for 1992 – 2014.

For grey seals, haul out numbers during the summer months are variable day to day; therefore, Duck and Morris (2012) do urge the reader to interpret the results with caution. Nonetheless, they estimate a 5.3% annual increase in grey seals in Northern Ireland, based on a count of 107 in 2002 and 468 in 2011. The boat-based surveys provided maximum counts of 218 and 274 adult grey seals in 2002 and 2011, respectively; suggesting a considerably more modest increase as compared to the IR surveys. Once again, depending on which subset of data were used, this could result in an annual decrease in population (1.2%, 1992 – 2017)

or an annual increase in population (3.34%, 1992 – 2014). Similar to the note of caution provided by Duck and Morris (2012); it is likely that at points in time, and particularly during the earlier years, counts targeted for harbour seals do mean that the concurrent counts of grey seals may not be representative of the population. For example, in 2002, the boat-based surveys counted 8 grey seal pups, whereas in 2011, they counted 86. In part, this may be a reflection of an increase in grey seals breeding in Northern Ireland; however, it is likely that in more recent years surveys were specifically targeting the grey seal breeding season, when in earlier years, they were not.

In addition to those comparisons between the reports, with the exception of the grey seal count in 2002, the maximum counts from boat-based surveys were lower for the respective years and species. This should be expected when one approach is surveying the entire coastline from above using IR technology, particularly for rocky coastal areas where seals may be out of sight from sea level (e.g. behind rocks) and/or camouflaged. However, the helicopter surveys are typically smaller sample sizes (e.g. one fly over) whereas the boat-based surveys (albeit to variable degrees across years) are repeated more regularly (e.g. more recently, typically two counts per year during the harbour seal moult and the grey and harbour seal breeding season), which gives greater opportunity to obtain a higher maximum count and ultimately gives more statistical power to the data. Lastly, on the comparison between the two reports, it is important to note that Duck and Morris (2012) calculated the percentage annual changes for both species by using data from "Carlingford Lough and the Copeland Islands, including Strangford Lough", whereas the present report has calculated the percentage annual changes for the whole of Northern Ireland. It is also important to note, that the counts from Duck and Morris (2012) presented in the text are from helicopter surveys covering all of Northern Ireland. The regression in the report used additional data from intervening years collected by SMRU during the installation of SeaGen, which were restricted to areas close to Strangford Lough, see Duck and Morris (2012) for more details.

6.2. Conservation Objectives

Harbour seals are qualifying features under both the Murlough and Strangford Lough Areas of Special Scientific Interest (ASSI) and Special Areas of Conservation (SAC). Within the conservation objectives for both Murlough and Strangford Lough, it is stated that the harbour seal population is to be maintained and enhanced as appropriate, as are the physical features used by this species within the site.

The conservation objective for Strangford Lough provides an estimated population of 210 and the target is to have at least 200 adults in the population, with at least 25% of the population being pups. The Strangford Lough data do suggest that there is a decline in the population within this Area; however, it is advised that this is interpreted with some caution, with respect to the influence that survey effort will have on these numbers. Nonetheless, the highest maximum count was in 1993, of 315 adults and 41 pups, which equates to pups making up approximately 11.5% of the population. The most recent year that has any notable survey effort is 2014, where the maximum count was 87 adults and 34 pups, which equates to pups making up approximately 28% of the population.

The conservation objective for Murlough provides an estimated population of 84, and states that this number needs to be, at the very least, maintained; there is no conservation objective

relating to pups for this SAC. The Murlough data do suggest that there has been an increase in the population within this Area; however, it is advised that this is interpreted with some caution, with respect to the influence that survey effort will have on these numbers. Nonetheless, the highest maximum count was in 2011, of 217 adults and 28 pups, which equates to pups making up approximately 11.4% of the population. The most recent year that has any notable survey effort is 2014, where the maximum count was 121 adults and 10 pups, which equates to pups making up approximately 7.6% of the population.

With respect to meeting conservation objectives, it is important to note that there are studies that have estimated that, the counts of harbour seals hauled out during the moult represent somewhere approximately 60% - 70% of the population (see Duck & Morris, 2011). Therefore, for the 2014 counts, this would be estimated to be somewhere between 124 and 145 adults for Strangford Lough and somewhere between 173 and 202 for Murlough. Note that both these estimates exclude the pup counts; if these were included, the estimates would between 173 and 202 for Strangford Lough and between 187 and 218 for Murlough. It is also worth considering the maximum counts from the helicopter surveys, which were greater for the same areas counted; therefore, boat-based counts are likely to be an underestimate of seals hauled out. However, no correction factor for this exists, and it is likely to be site specific.

It is important to note that haul out behaviour in the breeding season does differ as compared to the moult. Higher counts of adults are always expected during the moult; therefore, if surveys over time began to focus more on the breeding season, rather than the moult, it is plausible that pup counts would increase, whereas adult counts would decrease. Therefore, where conservation objectives require information on both adults and pups, it is important to be aware of these behavioural differences in haul out behaviour in order to increase the opportunity to obtain maximum counts for the respective demographics.

6.3. Effects of environmental and observational variables: informing power analysis

As part of the initial exploratory analysis, the intention was to consider the effects of environmental and observational variables on haul out patterns. These analyses could give important information both generally (to Northern Ireland) and more specifically to particular sites, as to what influences haul out counts. With this information it would have been possible to assess survey design and potentially undertake a power analysis of the data to give an indication of how many surveys are required to obtain a certain level of statistical confidence in the patterns observed. More often than not, the most common covariate influencing seal haul out patterns is the state of the tide. In the beginning of the process of analysing these data, the volume of missing data across environmental and observational covariates was highlighted in the preliminary report to CeDAR. In the intervening time, the vast majority of the missing data could not be rectified prior to undertaking this report. For example, approximately 18% of the tide time and 44% of the tide height data were missing (Table 5). Our next approach for trying to include this information was to take the mid-point time of Seal Count IDs and the GIS mid-point of the relevant Parent Location ID (see Section 3.2) and use a hydrographical model to extract the tide time. However, with the incorrect time date stamps for Seal Count IDs, this approach was also not possible.

Similar surveys to Northern Ireland have been undertaken in the Republic of Ireland, where National Parks and Wildlife Services (NPWS) have been conducting seal haul out counts since

2009 at 12 sites from land and four from a boat (Rakka & Minto, 2015). In general, they found that the power to detect trends was typically higher for the boat-based counts. However, they did note that number of years and inter-annual variability also had similar effects on power to detect trends. Furthermore, the boat-based models used fewer covariates (only day of year and tidal state) primarily due to the smaller sample sizes for these surveys, as compared to land-based surveys. The results of the power analysis presented by Minto & Rakka (2015) will be specific to the locations studied and the survey protocols used; therefore, they are not discussed further. However, the approaches outlined in these Republic of Ireland reports could be applied to the seal count data from Northern Ireland, if the issues with missing data are addressed.

7. Recommendations

The following section provides recommendations on two key aspects of the survey approaches and data management, moving forward. However, two important recommendations pertinent to historic data are that:

1. The errors in the database identified in this report are cross-referenced with the datasheets from the field in an effort to maximise the volume of data for future analysis.

With accurate times and locations, it would be possible to obtain historic tide data, which could then be used in the analyses to better inform to what extent trends in counts are influenced by the tidal state during the surveys (e.g. low counts in areas may be due to higher tides meaning limited land for hauling out, rather than being a true reduction in the population).

2. Every effort should be made to ensure that the database is up-to-date; specifically, any data that has been collected in previous years should be entered, as a priority and the analyses presented herein should be replicated with the complete counts in order to re-assess population trends.

7.1. Survey Approaches

7.1.1. Aerial and boat-based surveys

The aerial surveys do prove to provide higher maximum counts; however, they are not capable of differentiating between harbour seal pups and adults, which is a requirement for Strangford Lough ASSI and SAC. These surveys are also subject to low statistical power (i.e. low repeat surveys over large time frames) but certainly can be extremely informative with respect to giving a general snapshot of seal counts across Northern Ireland as a whole. Therefore, it is recommended that these albeit sporadic counts do continue, where financially viable, but are always considered in relation to the boat-based counts (which will have greater statistical power to detect trends). Ideally, both surveys (aerial and boat-based) should be conducted in important areas e.g. Strangford Lough and/or Murlough on the same day, to compare counts (Cowles et al., 2013).

7.1.2. Temporal resolution and targeting species

As the aim of these surveys is to obtain maximum counts of each species and of adults and pups, it is suggested that the approach of target boat-based surveys is continued. If counts

out-with these times outlined below are used to infer maximum counts, then they should be interpreted with caution.

Specifically:

- Harbour seal adults, during the moult
- Harbour seal pups, during the breeding season
- Grey seal adults and pups, during the breeding season

Counts should be prioritised to those animals hauled out, not at sea. Unidentified species should be counted, but these should not be included in any population estimates.

It is recommended that (until power analyses can be carried out with these data), two counts for each targeted species/demographic is maintained. Therefore, to ensure the best approach to monitoring harbour seal adults, harbour seal pups and grey seals (adults and pups), six surveys per year for each Area ID of interest would be required. If the priority was to monitor harbour seals, these could be reduced, but the caveats noted in Section 5 would need to be applied, i.e. it is likely that counts of grey seals during the harbour seal breeding season and moult would be extremely variable and likely an underestimate. If counts for harbour seal adults and pups were combined, i.e., targeted more towards the breeding season, then it is likely that the counts for adults will be more variable, which is not beneficial for investigating population trends (Thompson et al., 1989).

7.1.3. Environmental considerations

With respect to environmental conditions during surveys it is essential that these are:

- undertaken +/- 2 hours from low tide
- avoid carrying out surveys during or shortly after periods of medium to heavy or prolonged rain

Tidal state is typically always the most influential factor for seal haul out counts and the guidance given in this report is standard and has been used by all regulators, consultants and scientific researchers that conduct or advise on undertaking seal counts at haul outs (e.g. Thompson et al., 1989; Duck & Morris, 2011). In certain areas a more dynamic tidal system may be present, such as in Strangford Lough (Kregting & Elsäßer, 2014). In which case, particular attention to tide is needed when planning the survey route. With respect to rain, seals tend to return to the water during periods of medium to heavy or prolonged rain; therefore, it is recommended that surveying under these conditions is avoided.

It is essential that surveys consider environmental factors, which can be difficult when those undertaking surveys have other roles to fulfil and may need to schedule a given day for surveys. However, it is strongly advised that dates of surveys must remain flexible to allow for changes in environmental conditions that could result in lower counts. In brief, the survey should be undertaken in the best possible conditions to allow for the maximum seal count.

7.1.4. Monitoring effort and environmental conditions

To better understand the effects of environmental and temporal variables on haul-out counts the covariates that should be collected are:

- Date
- Time of day
- Tidal state
- Tidal range
- Disturbance (presence/absence)
- Precipitation type
- Precipitation intensity
- Wind direction
- Wind force
- Observer ID (to account for any potential observer bias)

These covariates are typically seen to have a significant effect broadly across haul outs (e.g. tidal state/range) and in some cases these will be more site specific (e.g. wind direction).

Well defined Parent Location IDs within Area IDs should be used during every survey, these could be provided to those undertaking surveys as maps (e.g. Figure 2). For each of these Parent Location IDs it should be possible to derive environmental and observational covariates (e.g. the start and end time of the count(s) for that Parent Location ID, the average sea state during the counts in that Parent Location ID, etc.; see below). In breaking larger Area IDs down, it would be possible to identify whether a complete survey of the Area ID was undertaken and what the environmental conditions, which can be used to quantify haul out patterns in relation to environmental and observational covariates at an appropriate temporal and spatial scale.

Location IDs (those that are geographically within a Parent Location ID) have varied over time; it appears that more Location IDs were used in earlier years. In many cases, these are consistently 0 counts. These are likely redundant and may be leading to wasted time in the field and when it comes to data entry during desk-based work. Whether these are redundant or not should be discussed with those undertaking the surveys and if they are needed, they should conform to specific geographic locations to assist in both data collection in the field and data entry in to the Microsoft Access database.

Ensuring that effort, with respect to how complete a survey of an Area ID was, is extremely important. If an Area ID was not surveyed in its entirety, and this was not recorded in a systematic way, then the assumption is that the survey is complete. Inevitably, a partial survey will have a lower count, as compared to a complete survey. Therefore, there is a real danger of concluding that the population is in decline, when in reality, this may be an artefact of reduced survey effort.

7.2. Data management

Prompt entry of data in to the database is essential for minimising human error. Ideally this should be the person(s) collecting the data, to further minimise issues with interpreting handwriting, for example. It is essential that dedicated time is assigned to these tasks to prevent errors and/or hard copies of data being lost over time.

It is recommended that Seal Count ID is created chronologically for each survey of each Area ID. This would have the benefit of providing an informative spatially and temporally accurate account of the survey.

As noted above, in Section 7.1.4, Location IDs (those that are geographically within a Parent Location ID) have varied over time and in many cases, these are consistently 0 counts. If these are not required, it is suggested that the database is restructured; for example, at present, a unique Seal Count ID may have multiple Location IDs associated, these should be combined so there is only one entry (i.e. row of data) per unique Seal Count ID in the seal count spreadsheet. This would save considerable time, both in the field and during data entry in to the Microsoft Access database. It would also lead to a smaller database, which typically results in fewer errors during data entry and management.

7.3. Special Committee on Seals (SCOS)

It is strongly recommended that Northern Ireland provides representation at the Special Committee on Seals (SCOS), where scientific advice to government on matters related to seal populations is discussed. In this forum, meeting annually, formal advice is given based on the latest scientific information provided to SCOS by the Sea Mammal Research Unit.

8. References

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9. Appendix

The following tables provide summary information on the counts of harbour and grey seals at the other Area IDs.

Table 16: Maximum Counts for each year surveyed at **Carlingford Lough** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
1996	7	43	5	5	0
1997	9	81	2	2	0
1998	12	88	2	2	1
1999	13	64	0	0	0
2000	8	88	0	0	0
2001	5	92	0	0	0
2002	8	70	0	0	0
2003	13	212	0	0	0
2004	9	180	0	0	0
2005	8	128	0	0	0
2006	8	71	0	0	0
2007	5	132	6	6	0
2008	9	90	20	20	0
2009	3	158	0	0	2
2010	3	103	0	0	0
2011	8	38	2	2	1
2012	1	2	0	0	0

Table 17: Maximum Counts for each year surveyed at **North Antrim and The Skerries** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
2002	1	0	0	0	0
2006	1	0	0	0	0
2007	8	0	0	0	2
2008	10	2	0	0	0
2009	15	0	0	0	1
2010	12	0	0	0	2
2011	10	2	2	2	1
2012	2	0	0	0	0
2016	3	0	0	0	0

Table 18: Maximum Counts for each year surveyed at **The Maidens** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adult	Pups	Adult	Pups
2000	1	0	0	0	0
2002	1	0	0	0	0
2006	1	4	0	0	0
2007	2	5	1	1	0

Table 19: Maximum Counts for each year surveyed at **Rathlin Island** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
1999	1	18	0	0	0
2002	2	121	0	0	0
2011	8	86	5	5	0
2012	4	114	0	0	0
2013	12	190	0	0	0
2014	12	115	3	3	0

Table 20: Maximum Counts for each year surveyed at **Loch Foyle** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
2008	6	0	0	0	0
2009	11	0	0	0	0
2010	12	0	0	0	0
2011	12	0	0	0	0
2012	6	0	0	0	0
2013	13	66	12	12	0
2014	8	0	0	0	0

Table 21: Maximum Counts for each year surveyed at **Outer Ards** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
1993	1	17	1	1	0
1994	2	49	7	7	0
1995	2	49	2	2	1
1996	2	45	4	4	1
1997	2	32	12	12	0
1998	8	19	1	1	0
1999	2	3	0	0	0
2000	3	4	0	0	0
2005	15	88	9	9	12
2006	16	45	3	3	0
2007	18	29	7	7	0
2008	16	15	3	3	1
2009	15	70	8	8	1
2010	15	50	20	20	4
2011	14	60	9	9	3
2012	13	77	10	10	1
2013	14	55	12	12	0
2014	12	31	2	2	0
2016	4	11	1	1	0

Table 22: Maximum Counts for each year surveyed at **Larne Lough** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
2009	12	4	0	0	0
2010	13	5	0	0	0
2011	13	4	0	0	0
2012	8	4	1	1	0
2013	12	3	0	0	0
2014	6	5	0	0	0

Table 23: Maximum Counts for each year surveyed at **South Belfast Lough** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Seals	Pups	Seals	Pups
1995	1	7	0	0	0
1996	12	26	0	0	0
1997	12	31	0	0	1
1998	13	31	6	6	0
1999	10	17	0	0	0
2000	10	16	0	0	0
2001	6	26	0	0	0
2002	1	3	0	0	0
2003	1	13	0	0	0

2009	5	42	0	0	0
2013	12	28	0	0	0
2014	9	33	1	1	0

Table 24: Maximum Counts for each year surveyed at **North Belfast Lough** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
1996	3	0	0	0	0
1997	11	28	0	0	0
1998	13	30	1	1	0
1999	10	19	0	0	0
2000	10	21	0	0	0
2001	4	18	0	0	0
2002	3	10	0	0	0
2003	12	25	3	3	0
2004	11	37	4	4	0
2005	13	41	3	3	0
2006	14	27	6	6	0
2007	12	31	0	0	0
2008	3	21	0	0	0
2009	3	23	2	2	0
2015	5	28	11	11	0

Table 25: Maximum Counts for each year surveyed at **The Copelands** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
1995	1	0	0	0	0
1996	9	36	1	1	2
1997	3	33	3	3	2
1998	5	31	0	0	0
1999	3	22	4	4	0
2000	2	22	5	5	0
2001	1	70	0	0	0
2002	1	20	1	1	0
2003	2	29	2	2	1
2004	2	29	7	7	1
2007	3	2	0	0	5
2008	3	13	0	0	0

Table 26: Maximum Counts for each year surveyed at **Dundrum** and the number of surveys undertaken in each year**.**

		Harbour		Grey	
Year	Number of Surveys	Adults	Pups	Adults	Pups
1993	1	8	0	0	0
1994	12	58	14	14	0
1995	13	63	2	2	0

1996	14	79	3	3	0
1997	15	86	4	4	0
1998	15	109	3	3	0
1999	14	115	7	7	0
2000	13	137	7	7	10
2001	14	114	15	15	7
2002	10	143	28	28	8
2003	12	134	22	22	10
2004	9	100	34	34	2
2005	12	97	26	26	3
2006	14	136	57	57	4
2007	13	152	21	21	3
2008	9	86	7	7	2
2009	14	121	11	11	0
2010	13	118	13	13	3
2011	13	113	8	8	2
2012	9	91	11	11	0