Disturbances to wild Harbour seals (*Phoca vitulina)* during the birthing season in the Dollard estuary, The Netherlands

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Abstract

The Seal Research and Rescue Centre (SRRC) in The Netherlands, carries out annual research into the population of Common or Harbour seals (*Phoca vitulina*) found in the Dollard area of the Wadden Sea during pupping season (May to August). The objective of these studies, is to formulate an understanding of the abundance, habits, movements and population numbers of the colony, and how these are affected year on year, not least by human interruption.

Previous papers led to the conclusion that construction of a viewing platform was necessary to minimise disturbance to nursing females from humans using the area. Thus, in 2012, the focus was on how effective its' creation may have been. It has been speculated that disturbance amongst a seal colony, could lead to permanent separation of mothers from their pups, and therefore impact upon how many orphaned pups are brought in for rescue to the SRRC.

Overall, the seal and pup abundance rose this season, in keeping with the general trend. There was also a fall in orphaned pup numbers from the Dollard, when compared with the previous year. It was expected that the percentage of occasions potential disturbance events had an impact would be lower than in previous years, and this is true of 2011. However, it was not the lowest seen, and research this year looked at how other factors (particularly environmental such as bad weather) may be impacting the colony and the chances of pups becoming stranded.

It was noted using the addition of control observations, that seals would often display so called 'disturbance indicator' behaviours frequently, and not necessarily just in the presence of 'disturbance.' However, something that was observed less frequently this year was the more extreme of these reactions- the moving into water behaviour. This could be indicative of an effective platform, or point simply to a colony becoming habituated. A further parameter was introduced to observations this year, measuring the latency between apparent stimulus and associated behavioural response. This seemed to add a further angle to the discussion over the platform, i.e. although disturbance may have been reduced where the platform was used as designed, if users did stray onto the central area outside the platform's edges, there would be more immediate and violent reactions from the seals.

In summary, the results point to some marked benefits to the platform's creation. However, overall results are insufficient to draw firm conclusions, and further study will be required in subsequent years.

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1. Introduction

The Dollard is part of an estuary in the northeast of the Netherlands, joining the Eems river to the Wadden Sea. Water flows from the river to the Dollard bay between the borders of the Netherlands and Germany, on to the Eems harbour, and arrives at the Wadden Sea; see the blue area on figure 1. Tidal fluctuation in the Dollard causes a series of sandbanks to be exposed at low tide. In 2001, an artificial culvert was dug in front of the dyke, in order to allow tidal water to flow to a reconstructed wetland behind the dyke, this resulted in a channel forming leading out to sea from the water inlet.

Two species of Pinniped are found commonly in the Wadden Sea: these are the Grey seal (*Halichoerus grypus*) and Common or Harbour seal (*Phoca vitulina*). This study will be focused on the Harbour seal (*P. vitulina*). During breeding season (may-august), the Dollard region's sandbanks provide haul-out sites for large numbers of these seals, particularly nursing females and their pups.

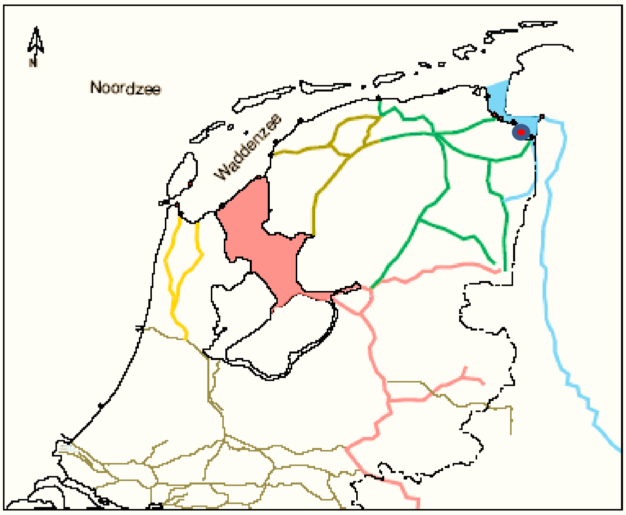


Figure 1: Map of Netherlands and Dollard estuary

Amongst orphaned seal pups taken into the Seal Rehabilitation and Research Centre (SRRC) each summer, a number come from this area. For the past five years the SRRC has carried out observations on the colony; looking at abundance and distribution of the animals, mother-pup bonds and interactions, and to what extent human activity may have an impact on their behaviour and wellbeing. Previous studies have ascertained that the seals here are subject to a range of disturbances during these crucial months, due in part to their proximity to the shore. The area is protected between 15th May and 1st September so that recreational water use and aircraft flying at heights less than 450m are prohibited. However despite this, the public still frequent the landside in high volumes.

When a pinniped is disturbed by a visual, audible or other stimulus on land, a range of reactions varying in severity have been identified (Bakker and de Vries, 2007). When a nursing seal is exposed to enough of a stimulus, the result can be that the animal flees into the water (Venables et al., 1955; Richardson et al., 1995). There is evidence that after such an event, they do not always return immediately to the same area, and it is theorised that this could cause or at least be a factor in the separation of pups and their mothers. This could be due either to confusion amongst the chaos and losing each other, or because the pup is unable to follow into the water quickly enough and the adult is unwilling to return to the scene of the disturbance for long periods, leaving the young seal effectively abandoned (Johnson, 1977, cited by Richardson et al., 1995). Colegrove et al. (2005) found that human interaction was a frequent secondary cause of stranding in *P.vitulina* on the Californian coast, and the primary cause in 19 cases. This did however include unauthorised contact with the animals as well as general disturbance.

As a result of this information, last year on the advice of the SRRC, a wooden viewing platform was built on the top of the dyke to enable the public to observe the seals without their presence being known. Where used correctly this seemed to be effective in reducing reactions from the seals, but incidences actually increased where humans did not use the viewing area as designed (Jenkins and Cimmino, 2011).

The aims of this year's study are first and foremost, to continue the monitoring of the *P. vitulina* colony at the Dollard in order to build up a long term bank of information on abundance, and use of the sandbanks. Secondly, it is to study the disturbances that occur in the area, and to what extent they may affect normal behaviour or contribute to pup strandings. There are many factors that could cause this problem, and effort is being made to discover the predominant ones. Finally, with the recent addition of the viewing platform, it will be interesting to look at whether there is a difference in patterns of disturbance from previous years. The research will focus on finding out if the platform is working, and if necessary what other changes could be made to better the area for the seals.

2. Methods

Part of an ethogram for a *Phocidea* (true seal) in table 1 categorises possible responses to disturbance, and some of the more common seal behaviours seen on land.

Table 1: Excerpt of *Phocidae* Ethogram (Sullivan, 1982; Terhune and Brillant, 1996; Curtin et al., 2009)

No response	No change in behaviour that is recognisable to the observer
Heads up	Looking up/around with eyes or lifting/turning of entire head to any extent. Does not include raising the head into the 'banana' position
Commotion	Movement of other parts of the body, i.e. flippers or torso. Shifting position without actually moving in any direction. This does not include the 'banana' position
Movement towards water	Some locomotion in any direction, usually towards the water if it is accessible
Movement into water	Any part of the seal's body enters the water
'Banana' position	Raising of hind flippers, and sometimes the head as well, simultaneously, and usually remaining in the position. The seal's body resembles a banana
Resting	Seal laying on stomach, side or back, and remaining largely still, eyes open or shut
Sleeping	Seal laying on stomach, side or back, and remaining still, eyes shut
Stretching	Seal raises one or both front flippers and/or tail flippers, and holds them in that position for an interval of more than 2 seconds
Yawning	Seal opens mouth wide, and then closes it slowly. Often with eyes closed
Flipper slap	Seal flaps one or both front flippers, one or more times. Usually an aggressive/territorial behaviour
Jaw snap	Seal opens and closes mouth abruptly and often audibly. Often repeated. This is also an aggressive behaviour
Flipper slap-contact	The flipper slap which makes contact with another animal/object
Bite	Similar to the jaw snap but teeth make contact with another animal/object
Nuzzle	Touching another animal/object with nose in a non-aggressive manner
Suckling (pups)	Mouth of pup in contact with body of another seal or object (usually the teat of an adult female) for a period of time, combined with sucking action

In order to keep the findings comparable to previous years, much of the data collection was done in a similar way to previous years. However, there was much discussion on some of the techniques used and finally a few adaptations and additions were made.

P. vitulina pup season begins in May, and most of the young are weaned and starting to become independent by July. The observations are therefore carried out between those two times by two researchers, three days a week.

The Dollard is a large tidal mudflat (± 11 x 10 km) containing brackish water (CWSS, 2010). As low tide arrives, a series of sandbanks are exposed. These different areas have been identified and labelled as shown in figure 2. The land facing the area consists of a beach, and then a dyke. Behind the dyke is a private road only in use by the Groningen Landschap, and then farmland. In the past, the top of the dyke was chosen as the observation site, due to the ability to see all the sandbanks in their entirety, as well as being able to sit just below the peak of the dyke and therefore not be seen by the seals. Figures 1 and 2 show this location with a red spot.

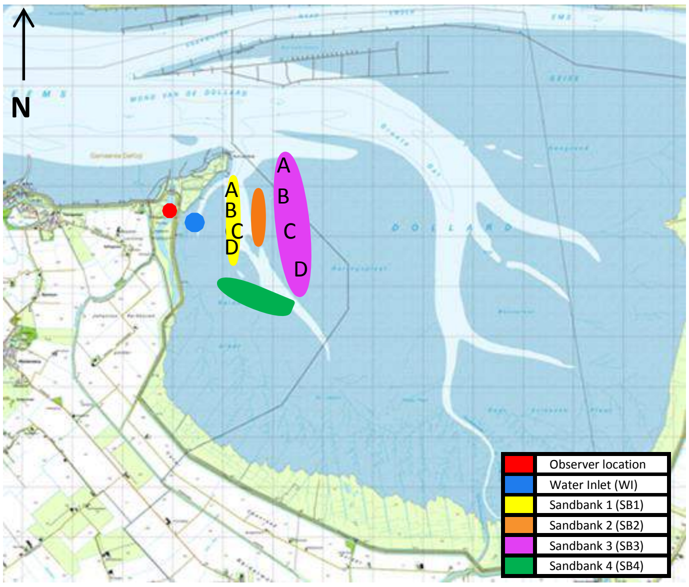


Figure 2: The Dollard region and different sandbanks

The Water Inlet (WI) – this is two sand ridges either side of the artificial culvert, directly beside the beach. The left side is WI L and the right side WI R. At high tide the only exposed area is actually at the beach, but as it lowers, there quickly becomes two large areas of sand with the channel in between.

Sandbank 1 (SB1) – Sandbank 1 is the next closest sandbank, further divided into four areas which represent favoured haul out sites for groups of *P. vitulina*. Sandbank 1 is present for a long period of time during the tide cycle.

Sandbank 2 (SB2) – Sandbank 2 is a small, narrow area of sand behind SB1. It is the first sandbank to disappear with the rising tide, and the last to reappear.

Sandbank 3 (SB3) – Sandbank 3 is the largest sandbank, and again, subdivided into areas A-D. This sandbank is probably 2-3 km out into the estuary, and contains several slopes, so a clear view of the seals is not always possible. Bad weather conditions also affect the visibility of this sandbank.

Sandbank 4 (SB4) – This is the least frequented and hardest to observe sandbank, but accounts for the far right side of the observation area.

In past years the areas differed slightly, but it appears the banks do shift slightly with time. This year, the map was reclassified and separate categories for sandbank 4 were left out after being deemed unnecessary.

Observations began 4 hours before low tide, and finished 3 hours after. Each hour the weather conditions were recorded using a 'Speedtech WindMate 200' handheld weather instrument. Next there was a basic abundance count. Adult seal and pup numbers were counted every 15 minutes, across all of the different sandbanks. To do this, a telescope with tripod and counter were used. Finally, every time a potential disturbance event occurred on the land in front of the dyke, in the water between the sandbanks, or in the air lower than 450m; it was recorded. For the purposes of this investigation, 'potential disturbance' meant anything that happened visibly within one of these areas, or was excessively noisy. Disturbance could occur in 5 different zones of the study area, identified at the start of observations this year, and illustrated in figure 3.

These were:

The platform (P) - for when the disturbance is behind the platform, theoretically minimising the impact on the seals

Central area (C) – this includes a 213m long stretch which starts just left of the observer point, passes the platform, and equal distance to the right. A disturbance is classed as in the centre if it is not on the platform but between these points, from the dyke forwards. This area is technically out of bounds to the public by an inactive electric fence

Left side (L) – from the left end of the central area extending left 91m to where the path bends round out of sight

Right side (R) – from the right end of the central area, 275m to the far fence, halfway to where the bank starts to extend out into the bay

Zero left (0L) – from the end of the left side to anything further left as far as the eye can see

Zero right (0R) – from the end of the right side to anything further right as far as the eye can see

All the areas begin at the dyke, and extend forwards right out across the bay as far as the furthest sandbanks. They also include air disturbances which were also classified according to zone.

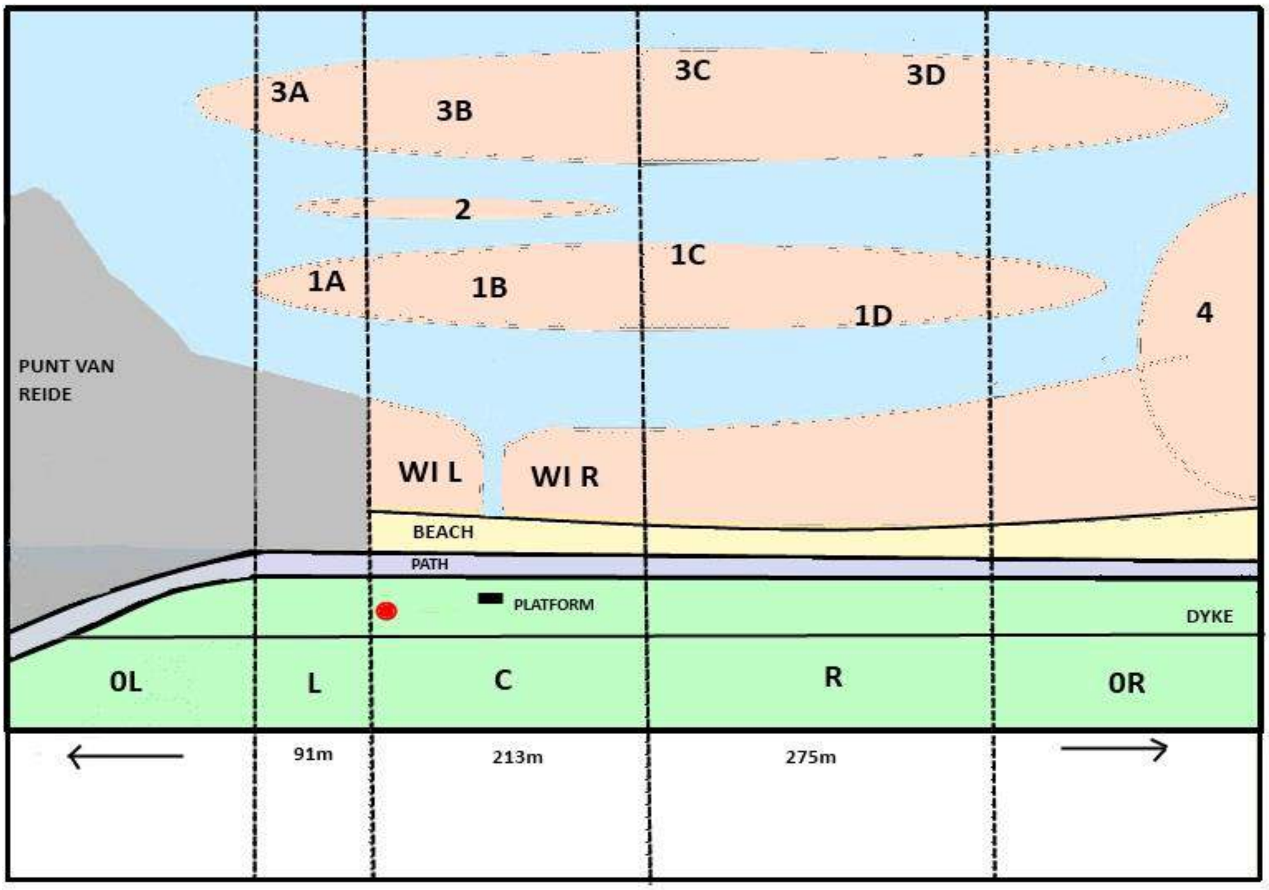


Figure 3: Zones of disturbance

Also noted were the numbers of a type of disturbance within a group, i.e. how many people. Then, for walkers or cyclists a score was given out of 3 for the amount of noise/movements they were producing/showing, as it was recognised it could vary dramatically. 1=silent/very discreet; 2=ambient/average; 3=loud/shouting/running etc.

Next, where possible, a continuous observation of seal behaviour was taken for 2 minutes after the event, using a sample group from the WI that could be seen simultaneously with either the telescope or binoculars. If no seals were on WI, a sample from a sandbank correlating to the disturbance by proximity would be used instead. The timing of 2 minutes began as soon as the potential disturbance entered one of the identified zones. Then, for the very first time each of the behaviours occurred (if they did), the time in seconds would be recorded independently- giving the latency between stimulus and behavioural change (or possible response to the stimulus). On top of that, it would be counted how many seals of the sample group had shown each of the disturbance indicator behaviours, overall. It was decided that after the 2 minute observation period, if no reaction had occurred it would be unlikely to. If a disturbance changed zones or intensity markedly, the sample would be repeated. If more than one disturbance overlapped however, it was not possible to take a behavioural scan as there would be no way of measuring which of the events had caused the disturbance. To avoid the assumption that these 'disturbances' caused an immediate and obvious reaction in the seals, control observations were also taken at random during other times of the day where there were no apparent disturbance events. Seal behaviour was recorded within five categories- (no response-0; heads up-1; commotion-2; movement towards water-3; and movement into water-4; as described in table 1) and the exact time written down in order to work out a latency for responses. Appendix I shows the survey sheets used, and a detailed protocol for use in carrying out the observations in future years is given in Appendix II.

In addition, a water sample test was taken at the beginning of the season at the water inlet, to establish water quality. At the end of the season, a sociological survey was carried out on a sample group of members of the public using the Dollard area recreationally.

The data has been analysed using both IBM SPSS Statistics v. 19 and Microsoft Excel 2007.

3. Results

3.1: Abundance

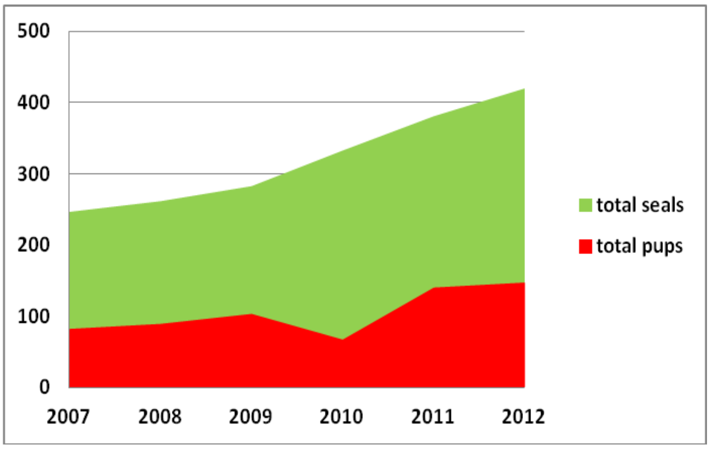


Figure 4: *P. vitulina* abundance by year

This year, a maximum of 281 adult seals were counted at one time on the sandbanks of the Dollard, this was on the 16/06 and the 28/06. The highest pup number recorded was on 29/06, at a total of 147 individuals. At 1500 on 28/06 observers counted 419 seals altogether on all sandbanks. Last year a total of 380 seals were seen at one time, with 140 of them being pups.

There is a general increasing trend in abundance over the last 6 years, with the exception of 2010 where there was an all-time drop in the number of pups seen at the Dollard (figure 4).

Figure 5 shows how seal numbers altered over the study period this year, using the daily maximum observed. This year the pups started to be born around week 3 which was the very end of May, though there was an unconfirmed sighting of a dead premature pup on 15/05. See table 2 for a comparison to previous years. There then seemed to be a drop off around week 6 (approximately the 20th June) where potentially pups were becoming independent and straying away from the adults.

This season, the SRRC received 145 *P. vitulina* pups altogether, which correlates with an increase every year, excluding 2011 where there was an exceptionally high figure of over 200 animals.

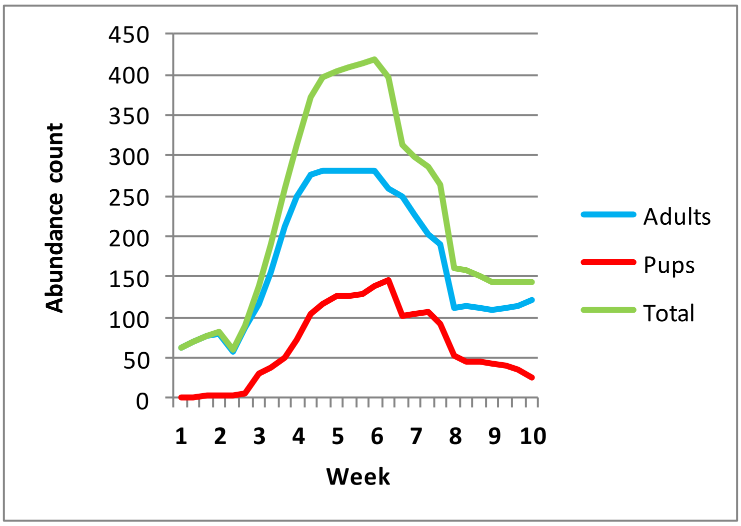


Figure 5: *P. vitulina* abundance 2012

Table 2: Date of first *P. vitulina* sightings of the season

2007	2008	2009	2010	2011	2012
27/05	30/05	31/05	26/05	27/05	27/05

With regards to animals from the Dollard, this year showed a decrease in pups coming to the centre in comparison to last year (Figure 6). However, the figure is not lower than previous years, and future studies will show whether or not the downward trend continues.

This year 24.8% of all the pups admitted were from the Dollard, which is almost the same as in 2011 at 25%. 2007, 2009 and 2012 have all had lower percentages than this though at an average of 19.2%. The highest percentage was recorded in 2008 of 27.4%.

Figure 7 highlights the overall numbers and trends over the past 6 years.

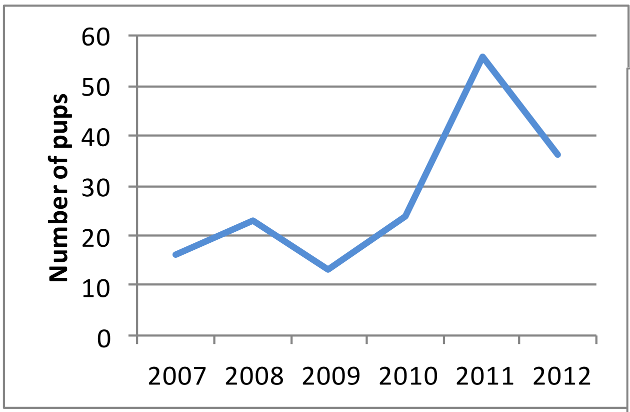


Figure 6: Pups admitted to SRRC from Dollard area each year

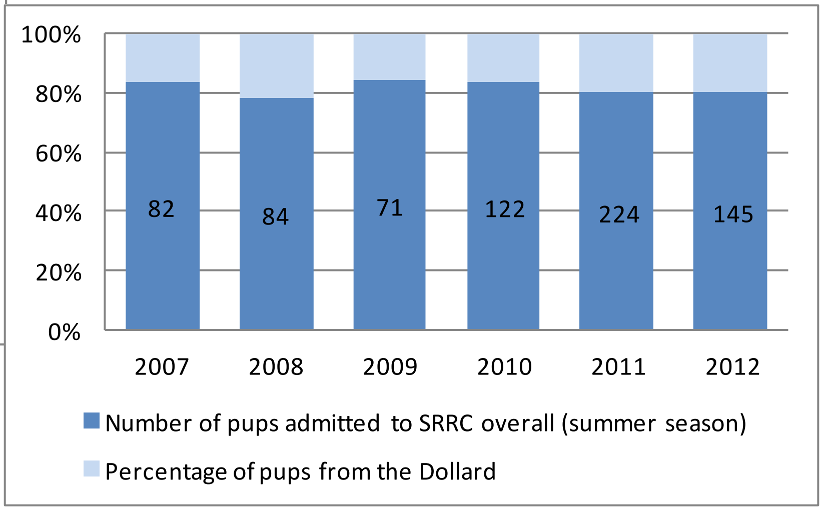


Figure 7: Percentage of total pups from Dollard

3.2: Disturbance

3.2.1: Potential and actual

The overall number of potential disturbances is subject to quite a lot of fluctuation each year (table 3). In 2007/8 it was around 300, falling to 93 in 2009 (but with many hours less observation), and rising right up to 762 in 2010. It fell again to 401 by 2011, and this year was down to 240. This was the lowest seen (with the exception of 2009 which was a bit of an anomaly) based on 122 hours of observation.

Disturbances which appeared to cause any response (referred to as actual disturbance for this report) were equally subject to fluctuation with 203 in 2008, only 29 in 2009, and 104 this year. Nearly 70% of events caused a disturbance in 2008, but only 8.5% in 2010. This year's figure was 43.3%, showing a massive range. Importantly, frequency with which seals were disturbed has been worked out for each year. In 2011, seals were disturbed every 0.9 hours, compared with only every 4.3 in 2009, which covers the range of disturbance intervals. This year actual disturbance occurred every hour and a bit (table 3).

Table 3: Effects of potential disturbance over the years of study

Year	Total observation hours	Total potential disturbances	Total actual disturbances	Percentage of potential disturbance causing a response (% actual disturbance)	Interval between successive actual disturbance (hours)
2007	224	306	58	19	3.9
2008	232	291	**203**	**69.8**	1.1
2009	126	93	29	31.2	4.3
2010	252	**762**	65	8.5	3.9
2011	168	401	192	47.9	**0.9**
2012	122	240	104	43.3	1.2

3.2.2: Type of disturbance

Table 4: Number of potential disturbances in each category, by month

	Trial	may	june	july	total
Groups of walkers/cyclists	10	53	38	112	213
car	4	2	1	0	7
agricultural vehicle	0	5	0	3	8
boat	1	1	1	1	4
airplane	2	0	0	2	4
other animal	0	0	1	0	1
other nature	0	0	0	3	3
total	17	61	41	121	**240**

The results this year show that July was by far the month with the most potential disturbance, at 121 individual events (table 4). The most common disturbance type by a large margin in all months was either people walking or cycling (213 of 240 events). These 2 types were grouped together as in all cases cyclists dismounted on the road behind the dyke, so when they entered an area, they were on foot. All other categories were very small (figure 8). In more broad categories, 98.3% of all potential disturbances were of human cause.

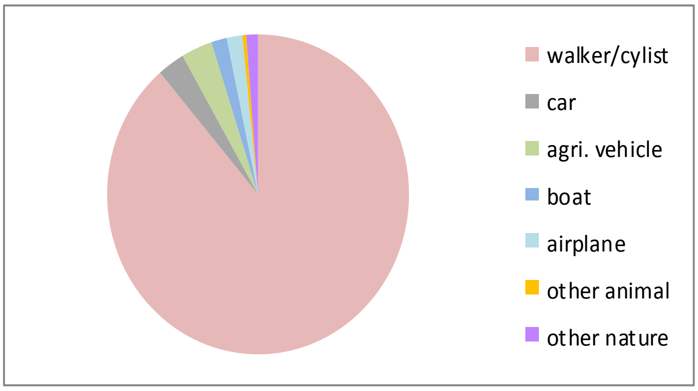


Figure 8: Occurrence of different categories of potential disturbance in 2012 (N=240)

Walkers and cyclists accounted for 79.8% of actual disturbances in this year's study. 39% of potential disturbances by walkers and cyclists turned out to provoke a reaction in the seals. Again, the incidences of other categories affecting the seals was very low (figure 9). However, although a tiny occurrence rate; 57.2% of times a car was present, a reaction was caused. Likewise, 62.5% of agricultural vehicles were an actual disturbance. Marine traffic became an actual disturbance 25% of the time, but with a sample count of only 4 times. Aircraft as well was an actual disturbance in 75% of cases, but the event was very rare (only 4 incidences this season).

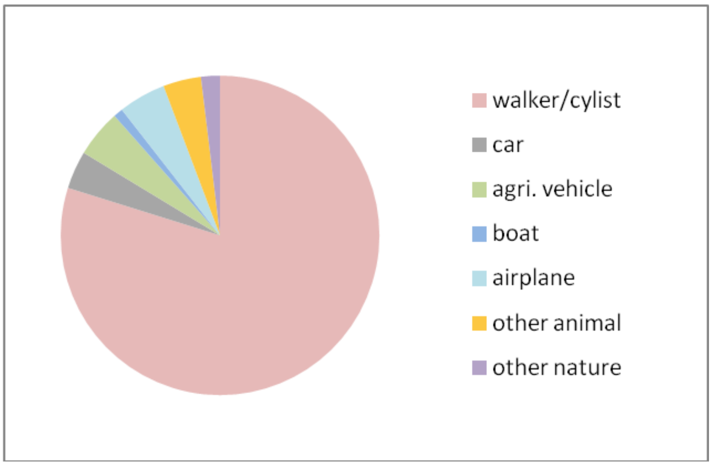


Figure 9: Occurrence of different categories of actual disturbance in 2012 (N=104)

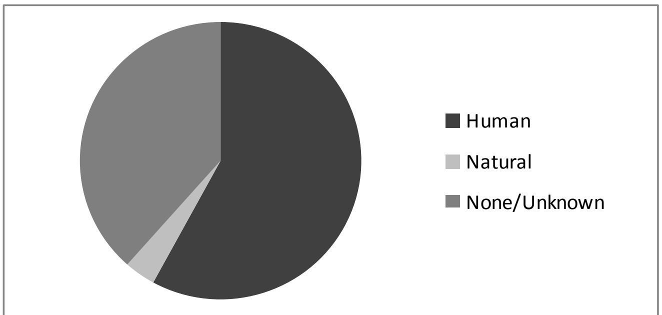


Figure 10: Distribution of response cause 2012

Significantly this year, within the data, other animals (in this case always sheep) caused a reaction 100% of the time. However, sheep were always nearby, and there were other occasions they were on the beach but no reaction was recorded. There seemed to be a certain distance limit with which they could approach without provoking a response. Although one could argue that sheep are present as a result of humans, for this report they are classed as a natural disturbance because they have been there a long time living alongside the seals, and there are no humans present the majority of the time the two encounter each other. Seagulls were the other animal noticed around a lot, and observed being a nuisance to the seals through pecking or chasing pups. Although there are no statistics for this, there were a number of pups brought in to the SRRC this season with eyes or bodies that had been pecked by seagulls.

In summary, 94.2% of actual disturbances caused by a tangible stimulus were due to humans, and only 5.8% as a result of natural disturbance.

When the control measurements were included in the data, it was found that out of all times a group of seals were surveyed, 54% of the time they would react within the 2 minute period- stimulus or not. Out of all occasions there was a response recorded this summer; 58% was as a result of a human disturbance, 3.6% because of a natural disturbance, and 38.5% had no obvious cause for the observer (figure 10).

3.2.3: Level/location of disturbance

The most severe type of disturbance reaction, and the most likely to cause further problems for the seal is reaction #4, movement into water (Renouf et al., 1983; Osinga et al., 2012). This was at a high in 2009 of 48.3%, almost half of all actual disturbances causing at least one seal to move into the water. This figure has fallen since then and this year's results showed that only 9.6% of actual disturbance events led to movement into water, figure 11. The actual numbers of occasions when seals were alerted enough to flee into the water were 19, 44, 14, 17, 28 and 10 respectively over the years.

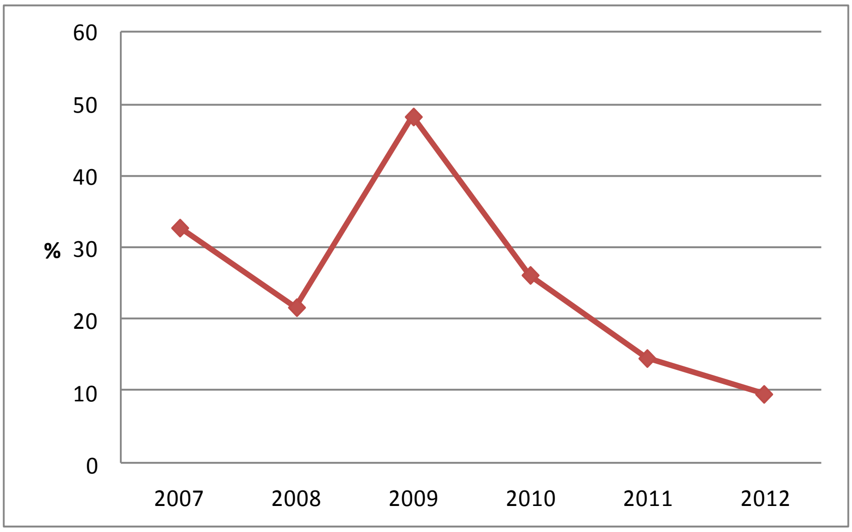


Figure 11: Percentage of actual disturbance provoking move to water

2012 is the lowest there has been in terms of actual quantity, and in the percentage occurrence from total disturbance. However, when looking at frequency, this year seals were scared into water on average once every 12.2 hours during their haul out, based on observations taken during the hours of low tide. This was lower in 2010, when they went to water every 14.8. The figure is still amongst the lowest though as last year seals went to water on average every 6 hours and a similar figure for 2008.

Looking at location of disturbance, it was hypothesised that the place most disturbing to seals on the WI would be the centre, followed by the left/right section (which for the purpose of analysis includes anywhere in left, right or zero areas), then a disturbance event using the platform, and finally no recorded disturbance- theoretically, this should mean no behavioural change in the group.

The raw disturbance data was collated and put into a table (table 5) which is shown in Appendix III. It demonstrates divided between potential disturbances sampled on the left or right, centre, behind the platform, or not at all; for each different category of response (0 No response; 1 Head up; 2 Commotion; 3 Movement towards water; 4 Movement into water); the average percentage of seals that showed these reactions in each day, and overall.

Broken down, table 6 shows the average reactions across all days for each area of disturbance. As mentioned earlier, left and right zones were put together as they were both equally far away from the seals, and the recorded disturbance was almost always in the L rather than R, as discussed further later on. Also, it should be noted that the different levels of response cannot be compared as one overall percentage as they are not exclusive. For example a seal can show several or all of the types of response for any one disturbance, or indeed without any tangible disturbance. These results are shown pictorially in figure 12.

Table 6: Average responses shown to a disturbance in different areas (%)

	No response 0	Heads up 1	Commotion 2	Movement towards water 3	Movement into water 4
Disturbance centre c	61.8	33.6	21.4	9.1	4.5
Disturbance left or right lr	50.4	44.4	16.3	6.5	0.6
Disturbance platform p	57.9	28.2	8.8	1.6	1.4
No visible disturbance	47.5	39	21.7	4.6	1.2

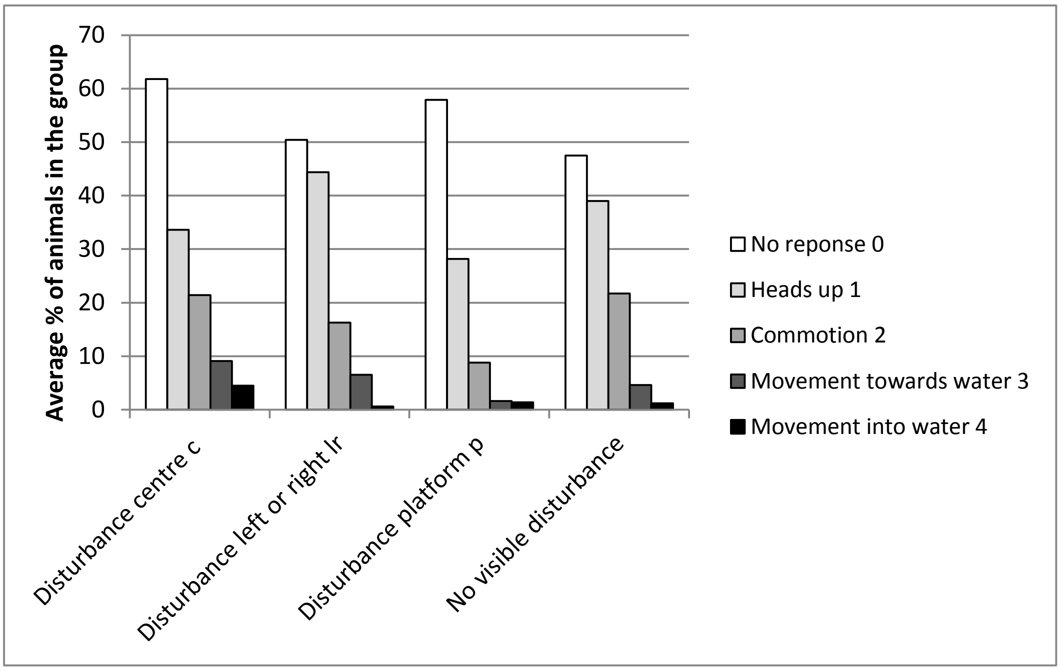


Figure 12: Average percentage responses shown for a disturbance in each area

Figure 13 consolidates the disturbance data, and just looks at an overview of the percentage of times when the seals show any reaction, and the percentage they don't, across all the areas.

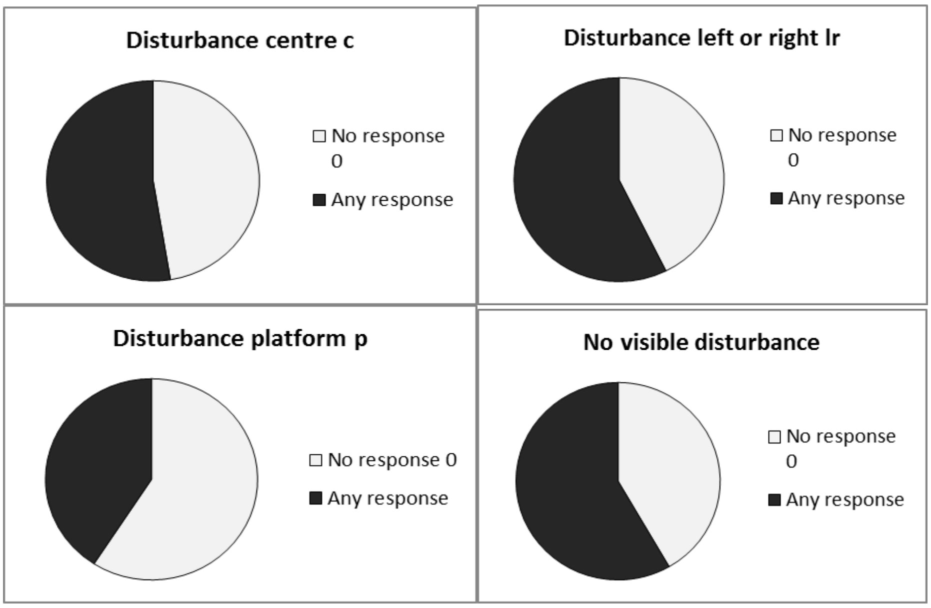


Figure 13: Proportions of seals responding and not

Moving a step further, figure 14 looks at all the areas together and summarises the mean percentage of animals that show some response in the presence of a stimulus, and those that show some response with no stimulus.

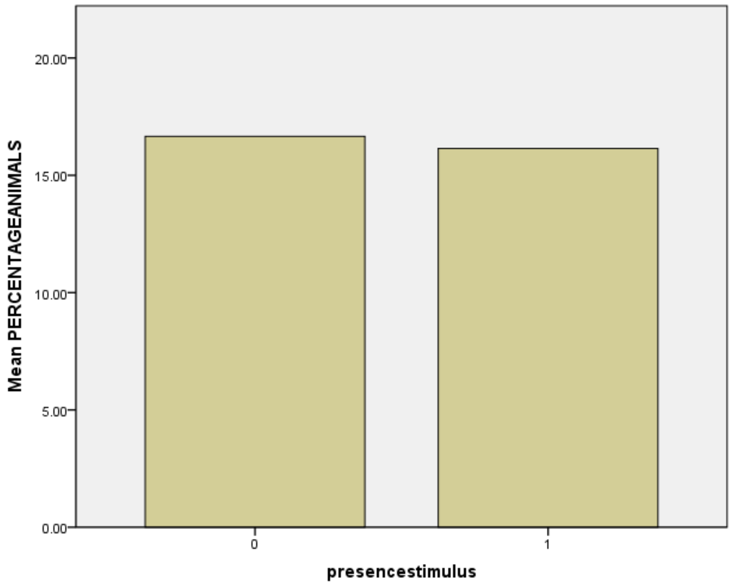


Figure 14: Mean animals showing a response with or without a disturbance event

Looking specifically at moves to water, as this has been identified as the most serious response, figure 15 shows the distribution of this response on average for a disturbance event across the zones.

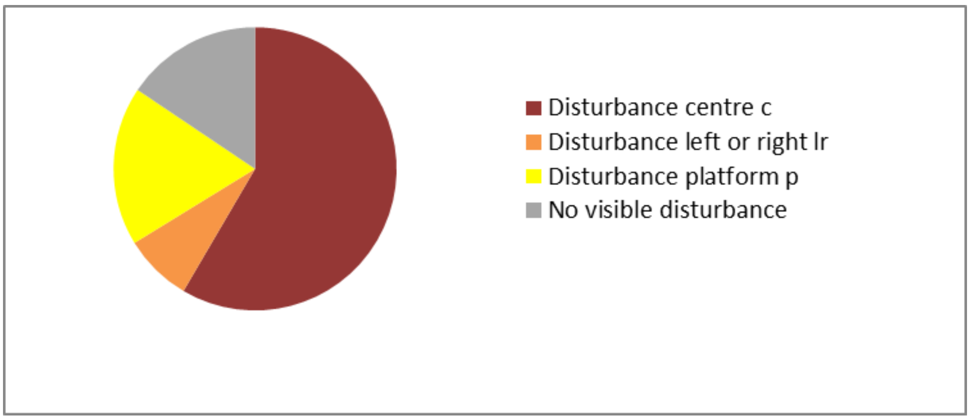


Figure 15: Average percentage of seals moving to water across the zones (N=10)

In the entire study, there were only 3 occasions out of the 10, when seals were made to flee into the water and were later observed hauling out again in the same place. On 12/06, 2 seals that had been involved in a fight amongst the group at the same time as some human presence, were seen hauling out again 4 minutes after they went to the water. On 13/07, one seal got into the water as a result of 4 walkers talking behind the platform, and returned 10 minutes after the disturbance had left, 23 minutes after it had fled to water. A large group of seals were alarmed into water on 25/07 by sheep on the beach and much later (presumably when the disturbance had passed) a section of the group returned to the sand.

3.2.4: Latency

Another factor measured was the time lapse between the onset of disturbance, until a response was seen amongst the sample seals. This gives an idea of the extremity of the disturbance (Finley and Greene, 1993). Table 7 gives the average latency (in seconds) for a disturbance (or when there was none but observations began), in each of the different areas. Latency 1 is the time between the disturbance appearing and response 1 (heads up) occurring for the first time within the group, latency 2 how many seconds from the start until response 2 (commotion), latency 3 for movement towards water, and latency 4 – movement into water.

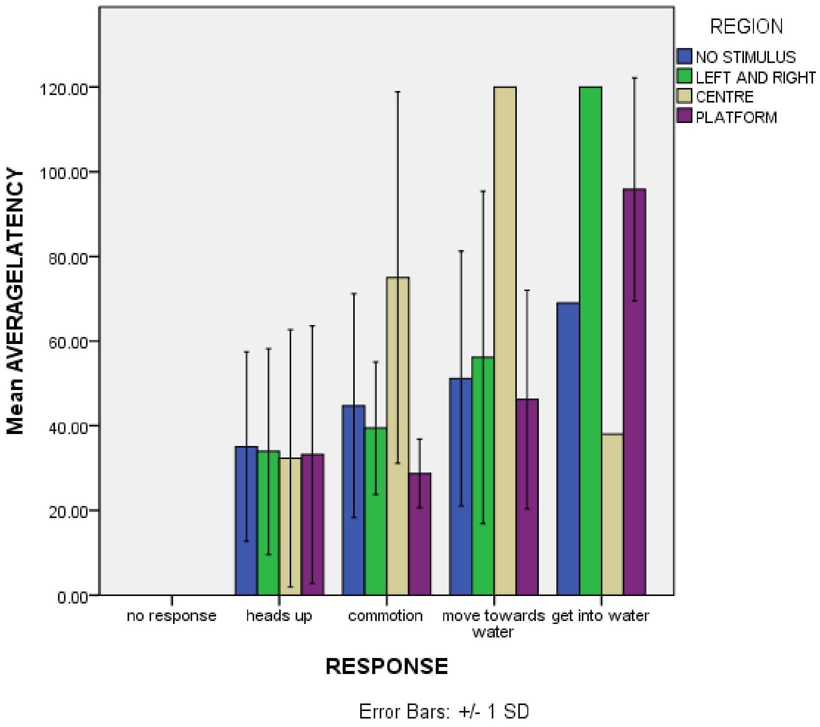
Table 7: Average latency (seconds) for different responses when the disturbance is in different areas

	Latency1	Latency2	Latency3	Latency4
	Mean	Mean	Mean	Mean
Novisibledisturbance	31	43	48	69
Sampledlr	36	44	50	120
Sampledc	31	64	120	38
Sampledp	30	31	50	100

In the cases where there is a response to a disturbance, Latency 1 is about half a minute, and not much variation depending on the location of the disturbance. On average the reaction is a second quicker when the disturbance is on the platform and the slowest at 36 seconds when on the left or right. Latency 2 is an average of 31 seconds for on the platform, but over a minute when the disturbance is seen in the centre. Latency 3 is shown on average at around 50 seconds for all the zones except the centre, where 2 minutes is the average latency. Latency 4 is seen on average after only 38 seconds when disturbance is in the centre, but nearly 2 minutes when on the platform, and also 2 minutes for the left or right. An overview is displayed in figure 16. Error bars are included in the diagram to ensure the data wasn't giving a skewed chart.

The average latency for seeing any response in the seals was 32 seconds. On 25/05, a seal reacted after 5 seconds to an agricultural vehicle in the area 0 left, and then after 2 seconds to 2 quiet walkers on the left side. On 30/05 a heads up response was seen after 5 seconds to 3 walkers talking at an average level on the left side, and again on 16/06 and 07/07 to 1 quieter walker. One of the quickest heads up response of 1 second was seen in 8 seals on WI R on 08/07 due to an agricultural vehicle working behind the platform. As well as this, all the seals on both sides of the WI were observed continuously putting their heads up throughout the time the vehicle was there. Interestingly this was mainly just the adult seals, most of the pups remained sleeping. On the same day at around 1215, light rain began. At 1311, the rain increased and this caused a large majority of the seals to look up/around. Dramatically increased rain and a thunder clap at 1336 caused a heads up after 5 seconds, and after 38 seconds, 2 seals had got into the water. The storm meant that observations were impossible for a short while, and when the observers came back out to the dyke again, there were only 5 seals left on the WI, where previously there had been 57.

Figure 16: Mean latency vs. response across different regions



Two walkers appeared to cause a heads up reaction after 3 seconds on 11/07, and 3 people having a conversation on the left side on 16/07 after 5 seconds. The other 1 second latency was on 29/07, where 2 walkers were chatting behind the platform. After 1 second, all the seals were putting their heads up, and continued to do so for the 6 minutes the walkers were there. The only time one of the other 3 responses was almost immediate, was on 27/05 when 5 walkers making a medium noise level on the platform, caused 1 seal to move towards the water after only 5 seconds.

Figure 16: Mean latency vs. response across different regions

Looking at the control observations, as expected, seals displayed all of the behaviours with differing frequency and latency. Although the observer could not see or hear potential disturbance at these times, there could have been other factors at play. For example on 25/05, seals displayed 2 heads up (100% of the group surveyed) during a control, but it was noted that there were seagulls very close by which could have affected the result. Again, on 07/06 during a control, a heads up was seen after only 2 seconds, and a commotion at 88 seconds. Later it was noticed that seagulls were in the area and had been bothering the seals.

One extreme reaction was noticed on 12/06 which involved 10/10 seals with heads up in 23 seconds, 4 commotions and movement towards water, and 2 seals actually entering the water by the time the 2 minutes were up. This appeared not to be due to the 2 quiet walkers present, but rather due to the adult seals having a fight amongst themselves.

Finally, latencies for all of the different responses were grouped together to give an average figure for how long it was before any response was seen. Figure 17 displays the results across all of the different zones and for when there is no stimulus, with error bars.

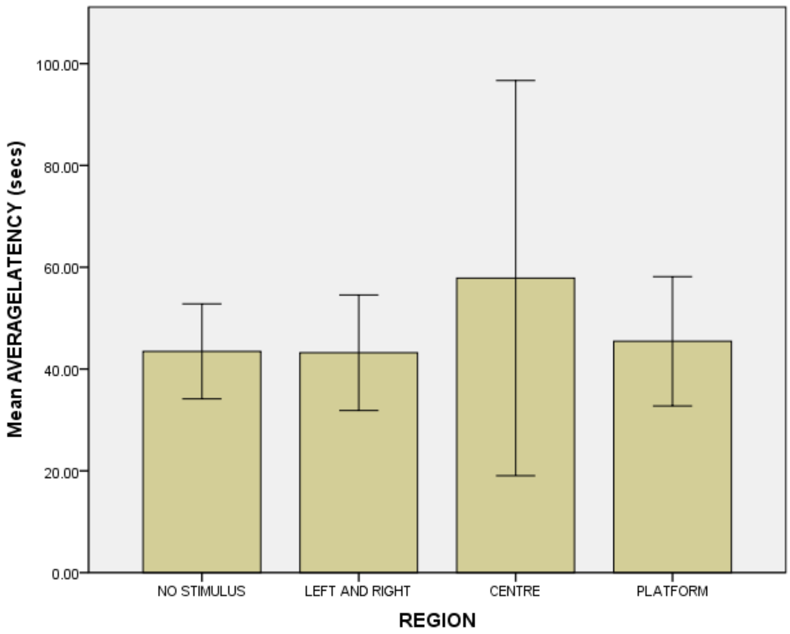


Figure 17: Mean latency for disturbance stimuli across different areas. For a description of zones, see figure 3.

It was also decided to test for the average latency before a heads up was seen, as usually that was the first indicator that a disturbance had been noticed. And then, as movement to water was the most extreme reaction, the same was done for that. Figures 18 and 19 demonstrate the results of this.

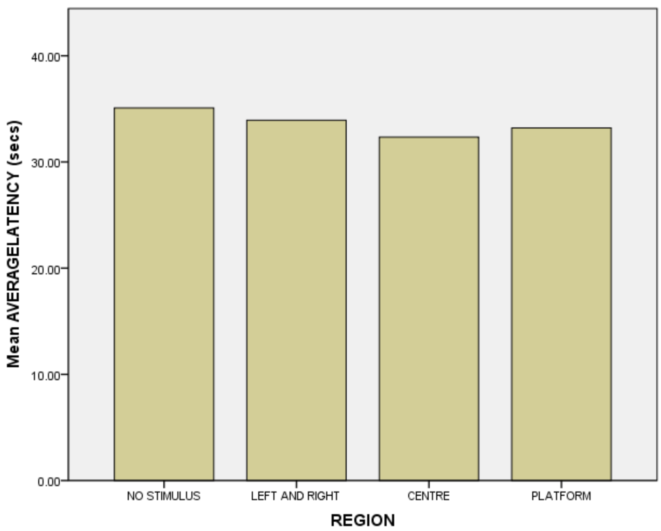


Figure 18: Mean latency for heads up response

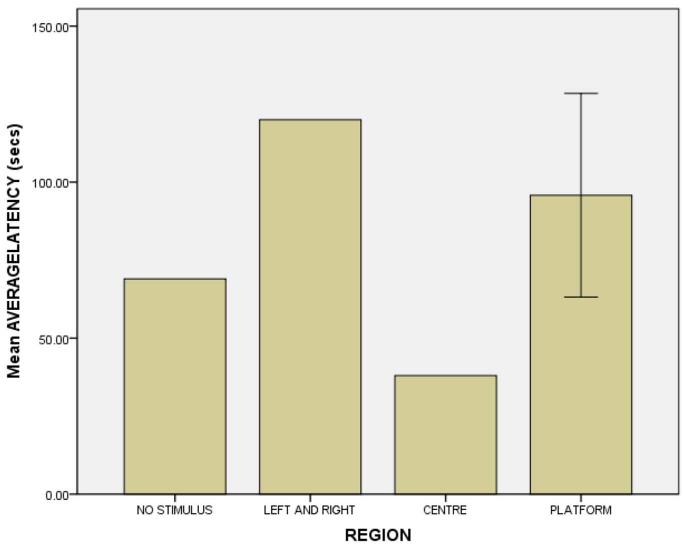


Figure 19: Mean latency for get into water response

3.3: Conditions

It is generally accepted from other studies that weather conditions can affect the haul-out behaviour of *P. vitulina* (Bakker and de Vries, 2007; Terhune and Brillant, 1996) On 25/05, the observation day started with a light rain, cloud and mist, and there were nearly 60 seals hauled out. Rain continued steadily for nearly 2 hours, before increasing noticeably at 1330. At the next count, seal numbers had gone down to 27, and they remained that low after the rain storm. This figure was not including sandbank 3D however, as the mist made it impossible to see. As already mentioned, on 08/07, heavy rain and a storm led to all but 5 seals leaving the sandbanks. The total figure fell from 112 to 5 in 1 hour, going down by 50% in just the first 15 minutes the rain started. However, on 10/06, a storm with hail stones, thunder, lightning and strong wind; produced no change in seal abundance on the sandbanks.

Figure 20- The pattern of average seal numbers on the sandbanks basically increased throughout the study period, beginning to rise steadily from day 8 (31/05) until day 15 when it peaked at 360 individuals. This was the 16/06. Average numbers then fell towards the end of the study, as pups became independent and mothers weren't nursing on the sandbanks as frequently.

Day 2 was a particularly rainy and windy day, with hailstone showers, so much so the observations were interrupted. Average abundance on this day was lower at only 14 seals. There was also a fall on day 8 of average numbers- conditions here were cold, overcast and rainy all day with patches of fog.

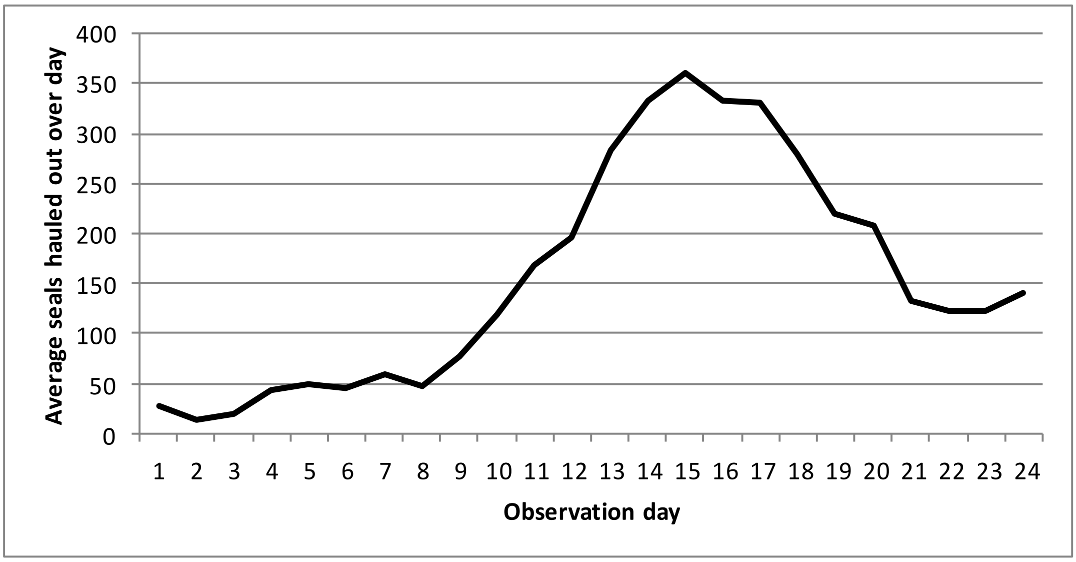


Figure 20: Average hauled out seal numbers over study period

The 11,13 and 16 of July (day 21-23) were all grey, windy and rainy and perhaps average abundance on the sandbanks was lower than expected. The last day of the study started off a lot brighter with some sun and average numbers had risen a little again. The trend seems to show a levelling off of seal numbers at the end of July, but after the study finished, it was noted that they continued to fall to almost nothing.

Of the behavioural responses with the shortest latency (5 seconds or under), across all categories of disturbance (including none detected); 75% of the time there was some wind, and 50% of the time that wind was medium to strong, including 1 case of high winds. 40% of these times the wind was coming from a N, W or SW direction, which would mean any sounds made on the land, would be carried out over the sandbanks.

This year there were 36 pups rescued from the Dollard area. It was decided to create a table (table 8 in Appendix V) which summarises the basic data on each seal, and includes notes on conditions of the day and previous day and any major disturbing events or circumstances, in order to assess all the factors present when *P. vitulina* pups were rescued from the Dollard area this season, and look at whether they contributed.

The first 4 pups (3 of which still with an umbilical cord, indicating they were at least younger than 7 days old, maybe less than 3 (Dierauf and Dougherty, 1983; Wipper, 1974, cited by Osinga et al., 2011) were found on 08/06. Earlier this day there was a storm of hail stones, thunder, lightning and wind, and a disturbance event of 21 people walking all over the Dollard and making a lot of noise, which resulted in seals on the WI lifting their heads within 7 seconds. The next day following these events, there were another 7 pups stranded. On 10/6 another 2 pups under 7 days old were found. The only notable factor was that there had been a strong wind that day, and that earlier on a couple of pups were observed alone in the area. The following day another 2 stranded.

On the 16/6 there were 6 pups found (5 of which with no umbilical cord, indicating they were older than 1 week, and at least older than 3 days (Dierauf and Dougherty, 1983; Wipper, 1974, cited by Osinga et al., 2011). 1 of these was probably significantly older based upon weight. While weather conditions had been very mild, one walker behind the platform had caused a heads up response within 5 seconds on the same day. The 20th and 23rd of June then had 1 pup stranding each, but as no observations had been carried out on those days there is no information available on conditions or disturbances. On the 25/06, 5 pups of over 1 week old were found alone, subsequent to a particularly overcast, wet, windy and cold day where 1 mother was seen with 3 pups at one time. It was around this time that groups of slightly larger pups had started to be observed sleeping on the beach for long periods of time without any adults around.

In July there were 8 pups brought in to the SRRC from the Dollard region. Information was unavailable for 3 of the seals but the other 5 were on days that followed bad weather and disturbance events. 1/07 had stormy, windy weather and rain; and the largest number of disturbances recorded this year- over 47 separate incidents, including sheep on the beach. All the seals in the group on the WI moved to water in response to the sheep, and the next day 3 pups were found orphaned. On 09/07 there was a storm with wind, heavy rain and thunder. Disturbances included: a dog, walkers causing continuous heads ups amongst the group on the WI, an agricultural vehicle behind the platform causing a very quick reaction, and responses to the storm which resulted in all but 5 seals moving to water from the WI. 1 adult seal was also seen with 4 pups at one time, and the following day there were 2 pups stranded.

The water test taken at the end of May on the approaching high tide, showed a pH of 8.0 and a kH of 12. NH_4/NH_3 levels were at 0.5mg, NO_2 <0.5mg, NO_3 <10mg, PO_4 1.0mg, Cu 0.0mg and Ca levels of 360mg p/l.

3.4: Results of socio-economic survey

On 09/09, a sample of 15 people using the land surrounding the Dollard were asked a series of 20 questions in order to get an idea of the opinions, level of knowledge and demographics of the public frequently using the area. A similar questionnaire was taken in the south west of the United Kingdom by Curtin et al., 2009, to gain opinions on tourism regarding *H. grypus*. Example survey sheets for this study are shown in Appendix IV.

20% of groups surveyed said they were out predominantly to see the seals, and a further 13.3% to see both seals and birds. The remaining reasons are shown in figure 21.

93% of people were aware that seals were in the area but only 20% of them knew which species of seal. In fact, 13% of them thought that they were Grey seals. Further, 66% of the people had no idea when the pupping season was. However, 86.7% said that they were interested in watching the seals, and another 6.7 'sort of' interested, with an average of 20 minutes suggested for the length of time spent watching the colony.

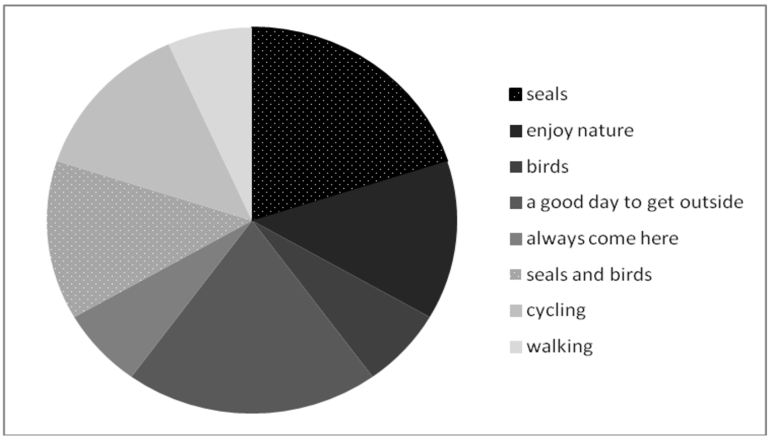


Figure 21: Reasons for visiting the Dollard

Of all the people surveyed, only 1 young woman and a group of 3 older walkers weren't aware of the viewing platform. After an explanation of its purpose, just the 3 older walkers stated that using the viewing platform wasn't important, and that they would walk everywhere they liked to view the seals. All of those surveyed agreed that it was important to remain quiet when in the vicinity of the seals, with just 2 groups being unsure of how important and citing such reasons as: it is dependent on wind direction, and that the seals keep their distance anyway.

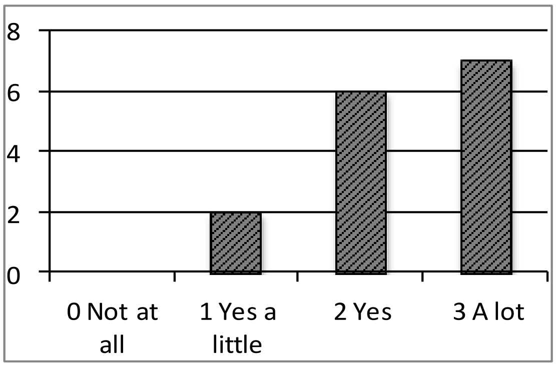


Figure 22: Opinions on liking seals

Although everybody asked said they liked seals (to what extent shown in figure 22), only 40% said they would be interested in learning more about the animals, many of the others saying that if they did they could use the internet.

40% had visited the visitor centre on site previously, and 87% had been to the SRRC before. Of the 2 couples that hadn't, 1 said they would consider going in the future, leaving just 1 who said they would not consider it. One of the couples interviewed already give donations to the SRRC.

On average, people on this Sunday had travelled for 38 minutes or 12.1 km to arrive at the area. Opinions were also given with suggestions for improvements to the area, including:

- Viewing platform longer to accommodate more people during busy times
- More holes in viewing platform for children
- Bigger holes in viewing platform to fit binoculars in
- Shorter walk to visitor centre/entrance gate
- Getting rid of windmills
- More cycle paths
- More signs giving advice and information on the seals

However, 53% of those surveyed said the area should remain the same as it is good how it is, or to allow nature a chance. One man liked the quietness of the area and the fact it wasn't too well known.

3.5: Incidental Observations

Sunday 10/06/2012

10:20: Arrive. 1 x *P. vitulina* pup on WI (L) – sleeping.
12:15: Pup crying. Went into the water and was circling and still crying. Looked weak and kept going underwater. Adult seal (presumably mother) arrives and they nuzzle, then swim away together.
12:30: 2 x adults are seen swimming alone in the middle of the water inlet, and 2 x pups are seen swimming alone at the mouth of the water inlet. In 1 or 2 minutes 2 mother and pups pairs (likely the ones observed) were seen hauling out together onto WI (L).

Thursday 14/06/2012

11:45: Pup observed completely alone at start of observations on sandbank 1B. At first it looked to be dead, but then was seen moving. Seagulls surrounding pup and pecking at him. Lenie 't Hart called but unable to help as too far out and tide going down. Continued to watch, pup moving a lot in the general direction of the water. Seagulls appeared to leave it after a while.
14:11: Pup seen showing commotion on the sand but after this was not seen again in the same place.
18:00: 1 x pup alone (unsure if it was the same one as before). The tide is rising and pup not really moving.
18:15: Researcher waded out. There were actually 2 x pups in the water although only 1 could be seen from shore- very small! Looking and moving towards researcher.
18:24: 2 x new mother/pup pairs appeared in the area, looking towards commotion and approaching. Researcher backed away and then adults came forward to take previous pups away.
18:33: Interaction finished as did observations for the day.

Sunday 24/06/2012

07:45: Today normal observations not carried out because of bad weather conditions. It was cloudy and dull with fairly persistent rain and a cold wind, making it very wet. The seals on WI were observed from the platform for one hour anyway, to look at behaviour.
WI (R) – right at the front closest to the beach, were 4 seals- a mother and 3 x pups.
08:00: 1 x pup slid into the water, leaving the mother to follow in after it (red-headed female). This left 2 x pups alone, though they looked to be reasonably large.
08:20: The remaining 2 x pups moved together for around a minute to the water's edge, where there was a steep slope in. The third pup was waiting at the bottom, already in the water (figure 23a).

Figure 23a: Two larger pups making their way to water after smaller pup

08:21: 1 of the pups slid down into the water, followed by the other. They seemed hesitant and took a while to do it. At this moment, the red-headed female swam over and watched as the pups got into the water, figure 23b. She then went towards them and greeted them, before her and all 3 pups swam away together, figure 23c.

Figure 23b: Red-headed female waiting with pup for 2 larger pups to enter water from sandbank

Figure 23c: Red-headed female with 3 x pups (1 small, 2 larger)

Thursday 28/06/2012

LOTS OF VOCALISATIONS TODAY- COULD HEAR A LOT OF NOISE FROM PUPS AND SOME FROM ADULT SEALS

12:52: 1 x pup emerges out of the sea, alone, onto sandbank 1A. It crawls across the mud and approaches a couple of different mothers to the right of it. It then goes off left and passes another couple of mothers and pups. It appears to be searching.
12:58: Pup gets back into the water and swims away.
14:44: WI (R) 21 x pups alone. Specifically, there were 20 pups in a group together, some were calling. A bit closer to the land was 1 x mother and pup pair. Finally, closest to the land was 1 x smaller pup alone. See figure 24.

Figure 24: Large group of pups, with one nursing female and pup at right hand side

16:15: The alone pup from the previous observation from WI (R) was seen alongside an adult with a reddish strip down its' back, highlighted in figure 25.
16:30: Most of the sandbanks had disappeared and the WI a lot smaller and closer to beach due to the tide coming up. Now many adults had returned out of the water and were lying alongside the big group of pups. Totals = Adults: 33, Pups: 44 (approx.).
16:45: WI (R) - Sheep on the beach causing an obvious disturbance to the colony, as very close to them. Didn't take disturbance observation as precise arrival time not known, but many seals seen with heads up watching, and some commotion ensued. See sequence in figure 26.

Figure 25: 'Alone' pup with reddish-strip backed adult

Figure 26a: Presence of sheep

Figure 26b: Effect on seals beginning

Friday 29/06/2012

12:15: WI (R) – 2 x adult mothers and 23 x big pups.
15:58: On right of group of sleeping large pups (which had been joined by 1 more adult), were now 2 x smaller pups alone. 1 dark, 1 white, see below figure 27a.

Figure 27a: 2 x alone pups

Figure 27b: Other pup approaching alone pup

16:04: Another pup hauls out (a bit bigger) and approaches alone white one, figure 27b. They remain together.
Constantly at the moment, seals and pups are hauling out and joining the group. A fair bit of whining is audible from the pups.
18:00: 1 x pup on WI (L), slightly away from group, slightly underwater; looked possibly dead. Observed until saw it move and lift head.
18:10: Pup approached by another pup that persistently nudged it with nose and flippers (figure 28) and encouraged it to shore. Pup did not seem to want to move, it just kept floating. Though it seemed okay, the other pup seemed concerned. No adults came near. Watched it move and swim a bit, it didn't appear to want to come to shore.

18:16: Eventually pup moved, then continued to float upside down off WI (R).
18:23: Stopped observations once decision was made pup didn't need rescuing.

Figure 28: Floating pup with other

Sunday 01/07/2012

Figure 29a+b: 01/07- Another example of sheep causing an entire group of seals to flee into the water. Copyright ©Lenie 't Hart 2012

Sunday 08/07/2012

13:25: 1 x mother seal with 4 x pups on WI (R). 2 x pups suckling at same time, whilst other 2 x pups trying to suckle. The mother did not do anything to stop any of the pups.

Wednesday 25/07/2012

15:06: High tide. Group of sheep on beach. Approx. 43 seals on right side. Again appeared to be disturbed, many fled into the water.
15:34: Seals remaining on right side had now moved to join group on left side.
15:50: Sheep moving again, initiating a mass movement into the water by the seals; beginning with heads up, looking around and commotion. Some seals were left on the edge of the water looking around, when the sheep moved closer. In the end no seals remained on the sand. Sequence in figure 30.
Later on (no exact time available) some of the seals returned to haul out again, figure 31.

Fig. 30a

Fig. 30b

Fig. 30c

Fig. 30d

Fig. 30e

Figure 30 (a-e): Sequence of seal response to sheep disturbance

Figure 31: Some of the group have returned

Sunday 29/07/2012

13:40: 1 x pup alone by beach on WI (R), to side of large group of large pups, figure 32.
16:52: Puppy gone to rejoin group. By high tide, adults had also reappeared.

Figure 32: Alone pup

4. Discussion

4.1: Abundance

2012's research in the Dollard, shows that the number of *P. vitulina* hauling out on the Dollard sandbanks, is still increasing every year. From a maximum of 380 adults and pups counted last year, this year's total was at 419. Despite any of the disturbances experienced in the area, it seems not to have prevented the group from using the sandbanks to haul-out while nursing their young. The first sightings of pups this year was very much in line with previous studies, and approximately 3/4 weeks later the abundance peaked and levelled off before falling again. This would be explained by the usual weaning time of around 24 days established by Boness and Bowen, 1996, and of three to four weeks, quoted by Wilson, 1999. The possibility of a dead premature pup in mid may, poses questions about disturbance as a contributor to miscarriage that are beyond the scope of this year's study.

In general, as the number of seals seen hauling out at the Dollard increases, as does the number of pups found abandoned in that area, with the exception of 2009 and this year. There were considerably less pups found in this region this year, but also overall (down from 224 to 145) which meant that the percentage from the Dollard was approximately the same. Overall, abandoned pup numbers have been on the increase every year, but last year's figure was particularly high for reasons unknown. The percentage figure for the Dollard in comparison to other areas has been higher the past two years than in any other time, except 2008. This can be looked at in two ways. 1) There has been a significant decrease in pups coming from the Dollard when just looking at last year, so this could indicate the platform is having a good impact. 2) On the other hand, when looking at all the years, overall the general trend in rescued pups both from the Dollard and elsewhere is increasing each year, and actually the percentage from the Dollard is at a quarter of all the pups from the season. Maybe human interference is still a problem and could further be reduced. It will be interesting to continue looking at this pattern in the coming years.

Each year, the SRRC carries out an aerial census of all seal colonies in the Wadden Sea area, getting a good estimate of total population. This season 5707 *P. vitulina* were counted at the time of survey on 25/07. Last year (2011) the numbers were 5472. Unfortunately, prior to this, the survey did not distinguish between *P. vitulina* and *H. grypus* so a count for these is unavailable.

4.2: Disturbance

4.2.1: Potential and actual

As with abundance, there are different ways the information found this year could be interpreted. For a start it is difficult to compare the number of disturbances because of differing overall observation hours. Total potential disturbances could be subject to some observer bias as to what classes as a disturbance, however to combat that this year, everything that occurred on top of, or to the seaward side of the dyke was classed as a potential disturbance, with the addition of any event that made a loud noise behind it. As can be seen, 2010's potential disturbance count was very high at 762. The observation hours were also the highest, but not significantly enough to explain the huge increase. Perhaps this was a very busy year for the area, or perhaps it had more to do with the researcher's definition of disturbance.

Looking at actual disturbances (those that were followed by some response in the seals) the highest was in 2008. This year's figure was half that, and only a little more than half of last years as well. But in order to compare them satisfactorily, it is better to look at the other column: percentage of potential disturbances that cause a response; as these take into account the differing observation hours. In 2008, nearly 70% of events caused some reaction amongst the seals, this indicates a bad year as although the number of potential disturbances wasn't that high, so many of them appeared to lead to a behavioural change. Results would indicate that in 2010, despite the high activity levels in the Dollard, the seals weren't affected that much. This year, actual disturbance was at 43.3% of potential. This means that nearly half of events cause seals to react. This is not what would have been hoped for with regards to the building of the platform. The hypothesis would have been the same number of potential disturbances, but a far lower percentage of actual disturbance. There is a possibility that in other years, not all potential disturbance was included in the count, so that the percentage of actual disturbance came out higher. Just looking at last year, it would seem the percentage has decreased a little, hopefully as the platform is used more properly. The other interesting parameter to look at is the frequency of actual disturbance. This shows that seals this year were disturbed just less than once an hour, which is less frequently than last year, but overall rather high.

As noted by Bakker and de Vries, 2007, it was more often the adult seals that showed the most disturbed behaviour, and in general pups tended to sleep right through it unless encouraged by a mother; both when they were still nursing, and once weaned. On 08/07, a group of 8 large pups remained sleeping throughout an agricultural vehicle working loudly behind the platform, and a few groups of walkers, whilst adults on the same sandbank (WI R) kept looking up and around persistently.

4.2.2: Type of disturbance

The building of the platform was designed primarily to reduce the impact of the disturbance from humans on foot, as there is less that can be done about the other categories. Results showed aircraft, boat or vehicle disturbance to be quite disturbing but there were only 23 occasions of these this year, compared to 213 of humans on foot or bicycle (79.8% of actual disturbance). However, only 39% of possible disturbance from humans on foot, became actual, in comparison to 88% last year. Thus, in 2012, 61% of disturbance events from humans on foot produced no response in the seals, whereas only 12% caused no response in 2011; suggesting that even though humans were present this year, they were not becoming a disturbance, possibly due to proper use of the platform. The other stimulus that this year proved to cause disturbance whenever it occurred, was sheep. Although sheep are present all the time on the dyke, there are no boundaries to prevent them walking down onto the beach and coming into close contact with the seals. This always caused a strong response on the WI. Seagulls and weather too, caused disturbance among the colony, but again, there is nothing that can be done to reduce this. Concentrating on overall figures, it is still far more important to reduce human impact as 94.2% of actual disturbance can be traced back to this.

4.2.3: Level/location of disturbance

Although it is not clear whether actual disturbance is falling that much when looking at overall numbers, maybe it is good to classify disturbance by the different levels of severity and look at this separately. Incidences where any seals from a group moved into the water have generally declined over the years, and this year particularly was down to only 10 witnessed occasions on record, with another couple observed outside of actual observation times but still noted. This was only 9.6% of actual disturbances. Even if seals are disturbed enough to look up and around at an event, the movement into water is arguably the best indicator of level of disturbance, and a reduction of this should, in theory reduce pup strandings. Again, looking at frequency, the figure was reduced to once every 12 hours from every 6 last year. This does correlate with less pups being found stranded. One factor that hasn't been taken into account yet, is the numbers of pups found dead each year. Of course this can be for numerous reasons, but it would follow that with less 'into the water' disturbance, there would be less pups found alone, alive or dead. In 2011, no pups were found dead at the Dollard, and only 5 found along the rest of the Dutch coastline (minus the island of Texel and mainland opposite). This year, 1 was found at the Dollard, with the possible sighting of another on sandbank 1C on 15/05. This was compared to 10 found dead across the rest of the country. This isn't the most useful comparison though, due to the fact that pup bodies can disappear in the sea, or be left in a location not visited by people, or the stranding network.

Overall, the mean percentage of animals that show reactions decreases as the severity of reaction increases, in the following order: no response, heads up, commotion, move towards water, get into water; showing a negative correlation with a high significance. It was common for seals to put their heads up during the observations, but much rarer that one would be driven all the way into water.

The results section demonstrates how reactions varied against a disturbance in each defined area. No response was shown on average in 50-60% of the group, but actually the highest percentage of this was shown in the central area, which was unexpected. The least amount of no response was seen in association to no stimulus. It is a consideration that control groups were influenced subconsciously by observers picking areas where there was some amount of commotion already, before carrying out the 2 minute observations.

A heads up response was shown the least when the disturbance was on the platform, generally just under 30% would show this behaviour. This would go along with the knowledge that the platform obscures the seals vision of the people behind it, including changes in light. There is less immediate heads up reaction because the seals are not seeing the people, whether or not later they become aware of their presence. “Seals react to large objects appearing on the skyline” (King, 1983) so this may be why. Commotion was also showed least behind the platform, and the most on the left or right areas- interestingly more so than the central area. It should be noted, however, that there were not that many incidences of disturbance in the centre (N=14, of which only 10 were sampled), so perhaps seals were not expecting to see people in this area. Due to new fences to ensure the platform was used as designed, it was more difficult for the public to ignore the signs and as such, wasn’t very common for them to walk over the central area. For this reason seals may have been looking out for commotion on the left or right sections more, and actually missed some of those in the central area. There were also observations in some cases of seals sleeping right through potential disturbance.

Movement towards water was actually shown by the biggest percentage after disturbance in the centre, and least when it was on the platform. This is in line with expectations, although it occurred with more frequency when there was no visible stimulus at all, suggesting that seals do generally move around quite a lot on the sand anyway. Finally, movement into water too was most observed for a disturbance on the centre, around 5% of the group. For all other disturbance zones it very rarely occurred. If the central area were not used at all (as is the design) it would mean that occasions where seals were caused to flee to water would be very low, thus hopefully reducing the occasions where mothers and their pups became separated, for all but natural cause. However, there will likely always be some people that ignore precautions and deliberately walk closer to the seals for a better view.

There was some response to a stimulus shown by the seals over 50% of the time in all areas (including when there was no disturbance), but with the exception of the platform. Here the percentage was lower. This would suggest the platform has reduced impact on the seals.

From 2012’s observations, it is apparent that once a seal has been made to flee to water, it is not usual for it to haul out again in the same location. Whether or not it chooses somewhere else is unknown at present, or whether it leaves the area altogether, leaving it easy to see how pups are lost.

4.2.4: Latency

In a similar way to how percentage of the group reacting decreases as severity of the behavioural response increases, so the average latency before a response increases as the response severity increases. The graph shows a positive correlation. This result is in line with expectations as, in general, the heads up would be the first sign that a noise or sight had been recognized, and the last would be moving into the water, as a last resort. The exception to this pattern is during a disturbance in the central area. The average latency for movement towards water is 2 full minutes, whereas seals would move into water after only 38 seconds. This can be explained in different ways. For example if a disturbance was pronounced enough, some of the steps of a reaction were skipped, i.e. the seals were on the edge of the water and immediately dived in without the precursor of moving towards the edge. This would indicate that the seal was unaware of the disturbance, and then suddenly surprised by it, and immediately fled. Indeed any anticipation, overview and predictability are also blocked by the platform, which results in surprise. This was noticed in observations, as when an event on the platform appeared to be noticed, the response was sudden. The other way this can be interpreted is that there were less occurrences of movement into water and more where the seals would begin moving to water, but not enter- either at all, or within the 2 minute cut off. After 2 minutes, observations were stopped, regardless of whether members of the group were still moving. This way of measuring could have brought the average up higher for latency 3 than latency 4.

Looking at the overviews for this category given by SPSS, the following observations can be made. It should be noted that these are worked out slightly differently to the previous averages purposefully, by leaving out of the calculations completely any occasion when disturbance occurred but behaviour wasn't recorded, in order to see if it changed the results. With no stimulus, again the latencies rise in an ordinal fashion according to the severity of the response. For a disturbance on the left or right, there is a similar pattern, with a much longer latency for getting into water. The heads up and commotion response do have a marginally lower average latency than the no stimulus category. For disturbances in the centre, the heads up reaction comes slightly quicker than all the rest of the areas, but much slower for commotion and move towards water. However, these still follow the overall pattern. The average latency for getting into water however, is considerably lower for stimuli in the centre zone than any other. Seals may not react overly quickly to a disturbance in the centre, but perhaps the cycle escalates quickly, and if they are going to enter the water, they do so more quickly than after a disturbance in the other categories. In other words, the severity of the response seems to increase more quickly. Looking at disturbances on the platform, a heads up is shown after an average latency length, but commotion is shown not only quicker than if the disturbance is in other areas, but also quicker than the heads up response. A move towards water, also, has a shorter average latency for a disturbance at the platform than anywhere else. This could be explained by the design of the platform itself. Because people using the platform will almost always be invisible to the seals, the disturbances as a result of these may be as a result of sound. When a seal can hear a noise from behind the platform, it is possible that it wouldn't be able to place it- a) because of the wooden barrier between the sound and the seal, and b) because it cannot see the disturbance. This may lead to the commotion/moving around behavior if the seal tries to work out what is going on. The get into water response does take longer on average than all the others though, perhaps as in the same way the seal cannot see any imminent danger increasing enough to send them into the water. The go to water response is longer only when the disturbance is on the left or right, when for example the perceived danger could be far enough away, compared to when it is directly in the centre.

Assuming that a short latency was an indicator of a more disturbing event, there were a few examples occurring this summer. Agricultural vehicles featured twice in a quick heads up responses, as would concur with data on percentage of seals responding. There were 8 incidences where walkers were the stimulus for responses in <5 seconds, however there seemed to be no obvious pattern to this. None of these walkers were in groups of any more than 5 people, none were making any more noise than a medium level conversation and most were on the left side, with 2 sets on the platform. It seems to be as in former years (Nussbaum and Selvaggi, 2008; Groothedde, 2010; Jenkins and Cimmino, 2011) that there is not always a particular trend to when and how much seals react. There are for sure other factors at play at the same time, which echoes the conclusions of Suryan and Harvey, 1999, and is an interesting finding which will be discussed later. Extreme weather was implemented in a mass movement to water on 08/07, with only 5 seals remaining, proving that bad weather can be a key factor in separation of mothers and pups. Geraci et al. (1999) reported that high mortality rates are often linked to severe weather.

It is useful to look at all latencies together as it gives the first moment any response occurs. The results of this are that in actual fact, there is not such a large difference across regions as hypothesized. The distribution is similar to the graph for percentage animals responding. There is no significant decrease (or increase) of latency whether or not there is a stimulus across any of the different zones. The graph actually demonstrates a higher average latency for disturbances in the centre zone, marginally higher on the platform and the same figure across the others. Error bars were included in this diagram in order to ensure the data wasn't giving a skewed chart, however, all the ranges are much the same, and longer latency for disturbances in the centre is the opposite of what could be expected. One reason for this could be the limited occasions this occurred. In addition, because of the new fences, reaching the centre section actually required climbing over a (deactivated) electric fence, or a gate. This meant that as occurrence was really quite low this year, it may not have been something seals on the WI really expected. As is seen in other animals, a frightening event can actually cause a 'freeze' response rather than a fight or flight one (Schmidt et al., 2008; Finley and Greene, 1993). This could explain the longer latency while they decided what to do in the unexpected situation. But in general, it does not seem to make a difference where the stimulus is (and even if there is a stimulus) to how many animals respond, and how quickly.

When looking at overviews that leave out any occasions there was a disturbance but behavioural changes weren't recorded, a heads up is shown after a vaguely longer time for no stimulus than with, and a central disturbance provoked slightly shorter latencies. But really there is not a substantial difference. For a moving into water reaction, the central area appeared to cause much shorter latencies, and the left and right sections much longer. No stimulus was in the middle as expected, and the platform seemed to vary considerably. This could be dependent upon whether or not the sample seal group could hear the disturbance on the platform or not. As this graph showed a lot of variation across the areas, a test of significance was carried out, however this concluded that based on the data the differences were not conclusive.

A different element was added to the data collected this year, in the form of control observations. It was decided that only including observations from when there was a tangible stimulus, could produce some very biased results. Indeed, this year, over half the times that a group of seals were observed for behaviour, they would show reactions – whether there was a disturbance or not. This added a whole new question about whether or not certain types of behavioural changes were the best measure of disturbance, as discussed further later. Analysis shows how the presence of a stimulus didn't produce any higher percentage of animals responding, than when there wasn't one. However there was only a limited occurrence (N=10) of into the water behaviour and this makes it hard to draw firm conclusions.

For the control observations it is worth mentioning again, that it is only within the scope of the observers to judge that there is no disturbance. This does not say that there was nothing there that was bothering the seals. As seen on a couple of occasions, seals were seen reacting to seagulls in the vicinity that were not always obvious from the observer location. Similarly, interactions between the seals themselves were hard to categorise as disturbance or not, but there were anecdotal observations of females moving her pup away from an area of sand, as a result of what appeared to be discomfort at the individuals around her. This was also seen in previous years (Bakker and de Vries, 2007; de Boer, 2009).

4.3: Conditions

In this year's study it seemed that weather conditions played a reasonably large part in seal behavior, and although lacking in data for inclement days due to difficulty in carrying out the observations, this section aims to get an overview of possible impacts and their severity.

Generally when looking at the results it appears that during heavy rain, cold temperatures, strong wind or fog; seal abundance on the sandbanks was lower than on calmer milder days. This was either seen on commencement of the observations, or later on as the weather increased in intensity. Thunderstorms certainly seemed to produce large movement into the water amongst the colony, with the exception of one day in mid June. This would indicate that the seals do not choose to stay hauled out during bad weather, and would prefer it to be warm and sunny. King (1983) states that pinnipeds have clear vision in bright light, but if light is poor, the image will not be clear. This could explain why they don't like bad weather such as greyness, drizzle, fog or rain, as then they can't see as well and feel more at risk from outside threats. They may prefer to be underwater where they can see well even in low light (Wartzok and Ketten, 1999, cited by Dierauf and Gulland, 2001). Reder et al. (2003) support this theory with the findings that *P. vitulina* in Svalbard haul out in the greatest numbers in favourable weather. It is easy to see how extreme events like thunder or lightning might affect the seals and this has been examined by Colegrove et al. (2005). Cold, wet weather may also be inefficient from an energy perspective, as heat is lost through the skin. All this would suggest that really bad conditions can disturb the seals daily haul-out rhythm.

It would follow that the weather could also be the deciding factor on whether or not a human reaction impacted on the seals. The most immediate responses (<5 seconds) were observed in windy conditions 75% of the time, perhaps explaining why sometimes seals would react strongly to a stimulus and other times not seem fazed at all, even at times to a potentially more disturbing event. If the wind was blowing in the direction of the sandbanks, almost half of the time seals displayed a short latency before responding to a stimulus, conceivably as they became aware of it faster. This shows that disturbance to a seal colony cannot be attributed to as simple categories as "human" or "environmental" as there always seems to be a combination of factors. Accordingly, Born et al. (1999) in a study in Greenland, found that the probability of Ringed seals (*Pusa hispida*) escaping into the water was related to time of day and wind chill. Unfortunately these natural disturbances cannot be controlled or reduced.

Looking across at all the *P. vitulina* pup strandings from the Dollard area this year, it becomes apparent that a vast number of them correlated with either a strong disturbance event or bad weather or both. Storms, strong winds or heavy rain on either the previous day, or the day in question, were implemented in 69% of strandings, out of those which weather was recorded for (N=21). A significant disturbance event was implemented in 61% of strandings.

Within 2 days (8/9 June) there were 11 orphaned pups following on from a large thunderstorm and a disturbance involving 21 walkers. 3 pups found on the 2nd July followed a storm, <46 human disturbances, and a disturbance from sheep resulting in mass movement into water. The 8th July saw a big storm with many disturbance events which could be classed as major, including all but 5 seals on the WI moving back into the water. The following day 2 stranded pups were found. It seems likely that had this happened earlier in the pupping season when there were younger, smaller and weaker offspring, this figure could have been higher. In fact, there was no occasion when observations had been taken, that there was no bad weather or disturbance recorded either on the day or the previous day to when the pups were found. It seems definite that stormy weather and wind really can be a large cause of pups becoming separated from their mothers as often it was the next morning that solitary pups were spotted on the beach. This tallies with the findings of Boness et al. (1992) that a high proportion of 35 separations observed in Canada; occurred during the same day as, or within 1 day following a storm.

At the beginning of the season, pups found were often still with an umbilical cord meaning that they were less than 7 days old (Dierauf and Dougherty, 1983) and could easily have been separated from their mother in rough seas. However, the results do also indicate that significant disturbance events can indeed play a part too. It is easy to see how any event that causes a number of seals to flee into the water, could mean that a mother becomes separated from her pup, either in the chaos in the water, or if the pup remains on land and the mother does not return immediately, or cannot find her offspring when she does. It does actually appear though, that disturbance events resulting in less extreme responses than actually getting into water, were also commonly observed on the day of, or day prior to pup strandings. It is unclear exactly what it would be in those incidences that causes the separation, and of course it could simply be coincidental; but the possibility remains that it has some impact. Perhaps the stress level is higher in the seals on those days and this contributes, or perhaps much later than the disturbance occurs, they do decide to move into the water and this increases the likelihood of becoming separated from each other.

The evaluation of the water sample shows that most parameters were well within the acceptable levels for an estuarine environment. pH was between the expected levels on the day sampled, however this would need to be monitored on a more long term basis to establish whether fluctuations were occurring (Waterwatch Australia, 2007). Ammonia levels too, were within a desirable range (Eddy, 2005). However, phosphate levels were actually fairly high, which can be an indicator of pollution and may cause poor health of marine ecosystems (Smith and Longmore, 1980). Overall it would be beneficial to continue this monitoring long term.

4.4: Socio-economic factors

The overriding conclusion rising from the survey was that one third of people cited seals as one of (or even the only) reason that they had come to visit the Dollard. There is no statistical data for previous years, but it is believed that prior to the building of the platform, the seals were not a main reason people came to the area. It has, in the past, been a predominantly bird watching area. This would suggest that the presence of seals in the area is now more widely recognized, and that people's interest is increasing. This is a positive thing, but could also lead to more disturbances in the area in response to the higher visitor numbers. This is another reason why it may be vital to increase protective measures and educational material, before such intensive use affects the colony more negatively.

Furthermore, although a fantastic figure of 93% of people knew that seals were found in the area, not many knew any more information than that. This confirms the need for more educational material at the WI and if possible in the visitor centre, not only for general facts on the species, but also the importance of quiet and minimal disturbance.

All but 1 group surveyed agreed that the platform was important, and all but 2 groups were sure that being quiet was vital. This and the fact that all asked liked seals, and the majority were interested in watching them, shows that there is a positive attitude to the seals in the area. This should therefore be a great basis in which to promote awareness of correct behavior around the seals, and a responsible approach to the use of the area.

4.5: Incidental Observations

A number of interesting episodes were observed during the study, and although they are somewhat anecdotal and lacking in numerical data, they are still worth discussing.

Firstly, on at least 2 occasions, a mother was spotted with more than one pup in her company, and contrary to previous years (Bakker and de Vries, 2007; Nussbaum and Selvaggi, 2008) didn't seem to be rejecting them. Boness and Bowen (1996) write that pinniped species almost always give birth to only 1 pup, and the mothers in question this year were seen allowing more than that 1 to suckle at the same time. Equally, during the incidental observations, an adult female was seen waiting for 2 pups other than her original one to get into the water before swimming away in a group. This subject was touched upon in Nussbaum and Selvaggi, 2008, but leaves the opportunity for much more study into the phenomenon of adoption, and how much it occurs within *P. vitulina* of the Wadden Sea. Burns et al. (1972) wrote that among Phocids, most species other than the Weddell seal (*Leptonychotes weddellii*) are prone to it after being "easily disrupted by human disturbance" and correspondingly Burns et al. (1972), Riedman and le Boeuf (1982), Bones et al. (1992) and Fogden (1971) reported the ice-inhabiting Harbour seal (*Phoca vitulina largha*), Northern Elephant seal (*Mirounga angustirostris*), Hawaiian Monk seal (*Monachus schauinslandi*) and Grey seal (*H. Grypus*) respectively, fostering other pups than their own. Strikingly, the *H. Grypus* found at a minimally disturbed beach, exclusively suckled their own, but where disturbed or in crowded conditions, showed tendencies to foster.

Although Renouf and Diemand (1984) reported that lost pups attempting to sneak milk from females other than their mothers are rarely successful, there is evidence for the behaviour occurring during studies on other populations of the species found by Boness et al. (1992). Ten percent of a sample of 76 paint-marked female harbour seals fostered pups for some portion of the lactation period. They surmised that fostering appeared to be associated with young females and those having lost their own pup, and that it appears to be common in the Phocidae family. It argues that because experience enhances maternal performance, it could be beneficial for a young female to help care for another's young and also report a study where Bishop (1967) found 2 incidences of a lone female permitting a lost pup to suckle and then treating the pup as its own.

As a side note, on days the observers spotted an adult accompanied by more than one seal, it was often the next day that there were pups found alone at the Dollard. This seems to show the first stage of a lost pup, trying to attach itself to another mother, and being unable to remain with her thus becoming stranded the next day. Pups were seen on a few notable occasions actively searching for a lost mother, either calling or silent, and both crawling over the sandbanks approaching other females and swimming up and down the area in the water. Evans and Bastian (1969) and Renouf (1984) previously said that a distinctive call from the pup brings the mother to it in instances of separation, but conversely, Boness and Bowen (1996) state that odour is the most important factor in reuniting pairs as mothers do not have unique calls they use. There was one day in particular where the noise of pups and some adults vocalising was extremely audible. It is not known whether the previous day was bad in terms of weather or disturbances, but it seemed that many were looking for each other. As none were found to need rescue over the following days, it is presumed that these may have mostly been nearly weaned, hungry pups waiting on the beach for the mothers. It would seem that the mother returns to the last location she saw her pup and then moves along the area sniffing for it (Boness and Bowen, 1996) so by this logic, pups staying where they were left seems to be the most effective way of ensuring reunion. Wilson (1974) also found that the mother was usually the one to re-establish contact after a pair lost/left each other, although Renouf (1984) did find that pups were also capable of recognising their mother. Groothedde (2010) and Jenkins and Cimmino (2011) witnessed reunions between mothers and their pups in the Dollard, proving that it can resolve itself at times.

This leads on to the topic of pups that lost their own mother, and it is interesting to look further into the reasons why this happens, and how frequently it resolves itself. On the 10^{th} of June, 1 pup was observed alone on the WI sleeping. After 2 hours it began to cry and move around presumably looking for its mother. After some time the presumed mother appeared, nuzzled the pup and swam away with it. This implies that potentially, a mother does at times leave her young on the beach for short periods, in order to feed, or prepare the offspring for weaning. Geraci and Lounsbury (2005) assert that Harbour seal pups are a particular species likely to be left on the beach while their mothers forage. Similarly, Boness and Bowen (1996) write that as the female pinniped is solely responsible for the upbringing of their progeny, she must have access to enough nutrition to produce all the milk needed for nursing. Foraging and nursing must be separate with rearing young on land, and so those species of the Phocidae family evolved to undertake a fasting and foraging cycle during a relatively short lactation period. *P. vitulina* is 1 species among others that favour this strategy due to their small size and probable inability to support all of lactation using only stored energy reserves. Boness and Bowen recorded dives taken by a lactating female *P. vitulina* commencing only 6 days after parturition. They witnessed evidence of feeding during these trips which lasted up to 7 hours, and depths recorded of up to 50m. An average of 7 further trips were then made during the weaning period. Likewise, Wilson (1974) wrote that a mother may leave her youngster alone starting from 2 weeks of age, lasting for longer and longer periods in preparation for weaning; although stating that there was evidence the actual event is rather sudden. In a separate study of Scottish *P. vitulina,* there were similar findings. Mothers were reported missing from the nursing site at various times, but only for short times. Interestingly, *P. vitulina* body mass and percentage body fat at parturition was found to be much lower than that of other phocids, building evidence for the case that these individuals need to continue foraging during nursing. However, it was noted that more research would be needed to establish if this behaviour was the normal, or adapted by certain populations only. In 2010, several pups were observed becoming separated from a parent after slipping down the steep edges of a sandbank and not being able to climb back up (Groothedde, 2010) but this was not noticed in 2012.

It does seem to be even more probable that after a certain age, larger pups just weaned or close to it, are left on the beach in groups with others at a similar stage while the mother goes off to forage. Indeed Wilson (1974) said that during a study on *P. vitulina* off the coast of Scotland, from 14/07 onwards pups were observed socialising with others of their own age, and on all days away from their mothers for some time. There was a progressive increase in time spent at a distance from each other. Boness et al. (1992) also found that *P. vitulina* adults at Sable Island routinely make foraging trips to sea during mid to late lactation. This year, it appeared to be the case consistently towards the end of the study period. Large numbers of pups would be sleeping on the WI for entire days, and it wasn't until later in the day, or when the tide was coming up, that the adults would return and join the young. After weaning, Wilson (1999) testifies that pups begin to cluster together in groups even more, and start to learn to feed independently. The conclusion was reached this summer that by this stage the pups were capable of survival and did not need assistance from the SRRC.

4.6: Limitations

Weather was of a significant impact to the study this year, as many of the observation days were wet or very overcast. In the case of medium to heavy rain, the telescope became too steamed up to use, and as the observation spot was so exposed, there was no way of sheltering from it. In addition, areas of sandbank 3 frequently became invisible due to mist just before heavy rain showers and thus there are pieces of data missing or incomplete. On a couple of occasions, high winds accompanied the bad weather, and this also made observations impossible as the telescope shook too much to focus. In total there were 8 observation days that had to either be cancelled or cut very short due to inclement weather conditions.

With regards to abundance, it is certainly not possible to see every single seal that is on the further away sandbanks, therefore every count is a minimum number of seals, and there may well be more. For example, sandbank 1C slopes downwards so much that seals on the further side are not visible at the lowest tides but start to appear as the tide rises, causing a sharp rise in abundance, even though they were present the whole time. Also, pups are sometimes hidden by adults, and in the cases where they are not visible during the count, they were not counted. Therefore, all totals are minimums.

With the disturbance observations, location of the researchers may have meant a certain bias. Looking through the results, it seems that most potential disturbances happened on the left or zero left side, and very few on the right. This could have been because most visitors came through the pedestrian entrance further down the road to the left, but it could also have been because the right side was harder to see for the observers. This is the location always used previously, but a suggestion would be that it might be better to sit in the centre closest to the water inlet so that vision extends equidistant to the right and left. Furthermore, there is no guarantee that when an observation is recorded as “no stimulus” there has not been a stimulus that is undetectable to the observers. Seals feasibly see, hear and smell differently to humans, and are also in a different location to the observers. Vision is obviously an important faculty to the pinniped due to their large eyes. Although above the surface there is evidence they can only see well in bright light, underwater they have good vision even in low light (Wartzok and Ketten, 1999, cited by Dierauf and Gulland, 2001). Hearing is their most developed sense (Evans and Raga, 2001) and it is necessary for sound to be received both above and below water. Sound travels better through water than air, and King (1983) suggests that seals hear exceptionally well underwater, and many hear at least as well as humans on land. Pinnipeds also rely a substantial amount on the olfactory sense when out of water, not least for bonds with their offspring. (Riedman, 1990) indicates that this can be very acute, and in many species can detect the presence of humans hundreds of feet away. On the strength of these evidences, it is fair to assume that a seal could be aware of more and different dangers or disturbances than a human observer. We have to assume they have reacted for nothing, but this may not be the case.

Looking at the wider picture, observations were usually conducted 3 days a week during approximately 7 hours, leaving many times when the observers were not there. Thus, data is only a sample of the season and many events will have been missed on other days; which does leave a fair bit of missing information.

It is likely that the presence of the observers in some way affected the seals. To minimise this as much as possible, the researchers always sat below the top level of the dyke so they wouldn’t be visible to the seals, and kept any noise to a very low level. It was hoped the colony would become accustomed their presence and limit the influence this may have had on their behaviour.

5. Conclusions

5.1: Stress in marine mammals

The important factor in this study is to measure stress levels in *P. vitulina*, associated with anthropogenic disturbance. Guyton and Hall (1996) state that stress can be defined as "a threat to homeostasis, a term used to indicate maintenance of static or constant conditions in the internal environment". In order to assess this, a measure of stress has to be found for the species, which previously has been behaviour. However, this may not be giving the most reliable results for extent of disturbance and it is interesting to investigate alternative methods of monitoring.

In 1946, Selye defined a three stage stress response: an alarm reaction, a stage of resistance, and a stage of exhaustion. In general the first sign of stress is the flight response, followed by the fight response if unsuccessful. However there is a third possibility, the 'freeze' response, where the individual fails to move and appears to play dead (Schmidt et al., 2008). This has been observed by Finley and Greene (1993) in Narwhals in response to ice-breaking ships, off the coast of Canada. Other investigations carried out with dolphins subjected to noise and presence of an unfamiliar object showed that some displayed stress by distancing themselves from the disturbance, and excessive activity such as "tail-slapping, head-slapping, hyperactive swimming and thrashing" whilst in others it was a lack of activity that signalled anxiety (Norris and Dohl, 1978, cited by Dierauf and Gulland, 2001).

With frequent or repetitive exposure to a stressor, chronic stress may develop, meaning that animals are exposed to raised levels of the chemicals associated with stress in the body. Long term, one consequence of this can be habituation, development of passiveness, and a reduction in response to the stressing event. In terms of the group at the Dollard, it can be that they are habituated to most of the disturbances occurring around them, or that they are entering a freeze response. Either way, in addition to conceivably increasing the likelihood of mothers and their pups becoming separated, and cutting down the time for milk intake; chronic stress can also be responsible for "impaired growth and reproduction, frequent infection, and pathological changes in organs" (Dierauf and Gulland, 2001).

During stressful situations, animals undergo various internal changes, which result in "notable physiological consequences" as documented by Fair and Becker (2000). Chemical changes in the body include a release of the hormone cortisol. Its primary functions are to increase blood sugar, suppress the immune system and mobilise fat; and it can be used as an indicator of stress (Johnson, 2002). One effective way of measuring this parameter currently is through either blood, saliva or faeces (Sea Research Foundation, 2011). There is also recent evidence that hair samples could be an indicator of cortisol, and more relevantly, of "long term exposure" to it (European Society of Endocrinology, 2011).

Existing data shows reported levels of cortisol vary in wild *P. vitulina* seasonally, according to daily cycles, and dependent upon stage of life. Juveniles have been measured between 3-8.6µg/dl, while adult females between 8-16µ. Prepartum females have also been measured at between 6-16.4µg/dl, but postpartum that figure rises to 39.2µg/dl (Dierauf and Gulland, 2001). This would suggest that the nursing mothers at the Dollard are already under considerable stress, without the addition of outside disturbance.

The other concern is that if these stressful events were to continue over lengthy periods of a seals life, the result could be a reduction in the function of the immune system and increased probability of illness. In chronically stressed humans, the immune system is compromised and viral or bacterial disease often develops (Fair and Becker, 2000). The same article reports that laboratory studies on animals have discovered that overstimulation of the stress response can produce biochemical toxicity, trauma, and fatigue.

5.2: Disturbance

Richardson et al. (1995) cited by Born et al. (1999) testified that disturbance in any form, can induce stress. As has been discussed, this stress can manifest itself in many different ways, and may or may not result in abnormal behavioural trends in the presence of disturbance events.

Palpable reactions to disturbance have been reported to include cessation of feeding, resting, or social interaction, and onset of alertness or avoidance behaviour. Baker (1986) testified that close approach by vessels, people and low flying aircraft had caused panic, injuries and even death in Harbour seals. Reijnders (1981) also pointed to evidence in his study of the area that disturbance may not play a minor role in infant mortality. Quite clearly any behaviour that causes a seal to move location can at least be implicated in disrupting social bonds, as well as being energetically disadvantageous. However, Terhune and Brillant (1996) considered the possibility that it is common for *P. vitulina* to move into water and between haul out sites during the course of a day. This has certainly been observed in 2012 at the Dollard as sandbanks appear and disappear with tide fluctuation, but also in previous years- both in published literature and in research carried out by the SRRC (Richardson et al., 1995; Terhune and Brillant, 1996; Bakker and de Vries, 2007; Nussbaum and Selvaggi, 2008; Jenkins and Cimmino, 2011). In 2008 however, it was not seen during the first 2 weeks of parenthood. Sullivan (1982) also wrote that pups especially have to move about in response to tidal fluctuations and waves, and Wilson (1974) found that haul out time is likely a combination of tidal and diurnal rhythms.

There was very little occurrence this year of an entire sandbank of seals rushing to water, and even large scale responses were limited to agricultural commotion, aircraft, sheep or storms. This seems to be a new development as seals have been known to take a cue from other members of the group in the past, Terhune and Brillant (1996). There was always plenty of movement and shifting taking place, but usually only shown by a low percentage of the group. It would not be surprising if this were animals at the edge of the group, as they are at the greatest risk of predation and may be the most vigilant, Terhune and Brillant (1996).

When looking at an overview of the results this year, and analysing the data further using SPSS, it becomes apparent that the findings are not significant enough to conclude that disturbing events are causing a significant behavioural change in the *P. vitulina* hauling out in the Dollard region. It actually seems that certain types of responses shown to disturbance may not differ radically or consistently from those shown normally. Previous studies have not included a control measurement and without this there is not enough information to reliably predict when a potential disturbance will become an actual one. Perhaps certain behaviours (such as heads up) measured after a certain period of time, are not an adequate measure of disturbance, as all the different areas show roughly the same response, and certainly do not disprove the null hypothesis. Observers should therefore consider to only include direct responses (e.g. within 30 seconds) after a potential disturbing event. It should however also be taken into consideration that there may be different reactions of seals to an approaching disturbance (e.g. pedestrians walking on the dyke towards the centre zone, or disturbances being masked by the platform for a while) versus a sudden disturbance (pedestrians appearing on top of dyke in the centre zone). A delay in response is likely to occur for approaching and masked disturbances and in these cases a response may occur after 30 seconds. Groothedde (2010) did also speculate from her study that behaviour might not indicate the full amount of stress seals were experiencing.

There is one theory to the results this year, which takes into account that in previous years there may have been more and stronger reactions to disturbance. This is that over the years of hauling out on the sandbanks close to recreational land, the seals have become habituated to human presence and activity, meaning that the severe reactions experienced in the past have become less. This has been observed in *L. Weddellii* by van Polanen Petel et al. (2008) and *P. vitulina* by Bigg (1989) cited by Richardson et al. (1995). It was also theorised by Suryan and Harvey (1999). There was very little example this year of seals fleeing to water on the stimulus of a human disturbance, even when not behind the platform. Do the seals now wait once a potential disturbance event occurs, to see if it comes closer or becomes more of a threat, before moving to water? On the 13/07, farmers herding sheep onto trailers made a lot of noise and commotion; and only a few seals from the group were watching, there was no movement. It could be suggested they might become used to a type of disturbance that they encounter frequently, such as this. It is well documented (Suryan and Harvey, 1999; Curtin et al., 2009) that a violent reaction such as fleeing is costly in terms of energy, something that females do not have to spare whilst nursing young. Perhaps delaying the reaction, with the chance the disturbance passes, is an effective way of saving energy. It could be that there is an element of learnt behaviour within the colony, that disturbances that happen frequently begin to have less impact. For this reason, it should be concluded that although behavioural response to disturbance is relatively low this year, there are other indicators of distress which need to be taken into account. Movement of seals appears to be down to a combination of external factors and an issue that came up a lot was how much impact weather conditions and the presence of other animals can have on the seals.

In summary therefore, with the strength of these results, it is not reasonable to assume events are the primary factor in disturbance amongst the seals. However, the data has shown that were all disturbances outside the platform eliminated, there would be a further drop in behavioural response. Accordingly, although often only the adult seals seemed to react, it would certainly be worth ensuring that all disturbance is kept to a minimum as far as possible during the crucial pup weaning time of May and June. Views and opinions of visitors to the area seem to suggest that on the whole, they would be willing to cooperate with this.

5.3: Separation, orphaning and adoption

The majority of literature studied, declared that female *P.vitulina* were regularly seen to leave their pups for short periods of time in order to forage and feed in the sea. Previous research indicated that this began as early as 2 weeks after birth, and would increase in frequency and duration throughout the season. Sullivan (1982) found adults spent 69.3% of time hauled out sleeping, while pups tended to spend more time on land; indicating that some of that time they would be unaccompanied. In accordance, there were a number of occasions in the Dollard this year that pups were thought to be alone, and would later be rejoined by an adult. This could well be a normal occurrence, but it can be hard to differentiate times when this is the case, and when the pair have become permanently separated. It does seem though, that as weaning time approaches and the pups are of a certain weight, they can safely be left alone or in groups with their peers.

The Water Inlet area is unique for hauling out in that even at high tide, parts of it remain exposed. This may relate to behavioural decisions of mother seals as they will not be washed off this area at any time. It is hypothesised that females, particularly late in lactation, may temporarily leave pups here while foraging at sea. Further study into this phenomenon is needed.

Boness et al. (1992) found that smaller (supposedly younger) females were significantly more likely to become separated from their pups than were larger (presumably older) females at a figure of 73% compared with 33%. From the population in Canada studied, 53% of the closely followed females became separated from their young at least once during lactation. The risk is that they do not become reunited. If events that cause seals to flush into the water can be responsible for the separation of mother and pup pairs, then it makes sense that heavy disturbance has an impact. Renouf (1984) did notice mothers monitoring their youngsters' movements particularly closely after being flushed into the sea by disturbance, but in the Dollard, this was not observed.

Aside from the obvious effect, it has also been proven that exposing seals to stress can have a profound effect on their health and wellbeing, meaning that in time they may not perform as well as parents, and potentially compromising the physical condition of the offspring. On top of the times when human noise and disturbance scared seals into the water this year, incidents of environmental disturbance could well have contributed to pups becoming lost. The effects of bad weather on a colony is well documented and can easily lead to separation, and this is conducive with findings this year where pups were found abandoned and in need of rescue most frequently after a storm.

Lastly, adoption seems to be a note-worthy possibility when looking at a combination of evidence this year and past reviews on the subject. There are suggestions that fostering could have biological benefits for the donor (Boness et al., 1992) and it has been observed on a considerable number of occasions. This is a subject that is valuable for further enquiry, and may mean that pups that lose their mother could go on to adapt and survive through help from another individual.

5.4: Does the platform work?

When looking at last year's results for correct use of the platform (i.e. the person stood behind it) there was an almost 100% rate of no response from the seals. This year's 'platform' zone is the equivalent parameter, but did not end up with the same success rate. Disturbance behind the platform this year still provoked some response from the seals, thus effectively, the platform does not eliminate negative effects on the colony altogether. However, overall, the severity of responses and the number of potential disturbances that become actual ones, were lessened, and that may in part be due to the improvements in place that now discourage the public from using the platform incorrectly. As established by the results, there were very few occasions this year when a disturbance behind the platform resulted in an extreme response in the seals. This doesn't mean that they are not aware of this presence, or affected by it in some way, but in general terms 2012 seems to have demonstrated less severe disturbances overall. Certainly when taking the area's history into account, the situation is more controlled, and this can be attributable to the viewing platform. When used as it was designed, people behind it are hidden from the seals. Sound could still be a problem, especially when the wind was blowing in the direction of the seal group, and perhaps this also depends on the kind of noise or the pitch of a person's voice, and the only way to address this is through education. Additionally this year, the installation of the fence increased the correct usage of the platform, meaning that it is now much harder for any person to stand in front, or to the side of the wood. As a result, most incidences of this have stopped.

Because of the very existence of the platform, and perhaps helped by the signs, people are more likely to be quieter when standing behind it. It's being there seems to make them stop and think about how their presence might affect the seals and therefore just in terms of a reminder to remain quiet, it helps. Furthermore, it seems to have helped highlight the importance of the area for the seals, and in turn raise awareness on the species amongst the general public. However, the platform seems also to have the negative effect of causing an even more severe reaction should it be misused.

6. Recommendations

6.1: The Dollard area

There are a few suggestions for development and improvement of the Dollard that have come about. These are borne from experience, and take into account the views of those individuals using the area. They are as follows:

- A better fence around the platform. It either needs to be harder to climb under or over, or the electric fence could be switched on
- Much better information signs at the platform, explaining a bit about the breeding season and the need for quiet
- More coherent signs in other places, providing a guide to better inform people on how to approach the colony. There should be one on the gate at the entrance to the protected area, giving plenty of warning of the presence of pups
- It might be beneficial for the visitor centre behind the dyke to provide information on the seals and the pupping season, as well as just on the birds. This means that people would be more educated on the issues before they even started to walk in the area
- Leaflets could be available at the SRRC, in order to create links between the two places and encourage responsible use of the Dollard
- In a similar vein, a media campaign could be undertaken prior to the pupping season each year, in order to raise awareness and help protect the Harbour seal
- Perhaps it is worth the Landschap containing the sheep a little during breeding season and not allowing them to roam the beaches freely, based on the number of disturbances witnessed
- There may be scope to build a sound barrier on top and to the backside of the viewing platform, perhaps using a sound-absorbing material to reduce the noise that reaches the colony

6.2: Further study

Generally, the new method worked well. It would be very helpful to have an extra telescope another time in order that the observer noting behavioural changes could see in a bit more detail than the binoculars allowed, and a camera with a better zoom capability for capturing noteworthy events. The abundance count often took the full 15 minutes to complete and on days when there were many disturbances to record, it would also have been useful to have a third person to help recording reactions to them.

In light of the investigations, the question remains whether or not measuring behaviour is an accurate test of disturbance levels in *P. vitulina*. Perhaps there are other methods with which to investigate. For example, even if in the past seals have been reacting to disturbance by fleeing into the water, it is well known that over time animals can become habituated to a stimulus (van Polanen Petel et al., 2008; Suryan and Harvey, 1999) and therefore the obvious response may be lessened. This does not however, imply that the animal is less interrupted by the event. It could be that it has learned there is no need to move, or may in fact have modified its behaviour to 'freeze' when the stimulus occurs. One more accurate test would be to measure cortisol levels in the faeces of the animals. It would also be useful for comparison to carry out some observations on seals already in the SRRC.

During a couple of night visits to the Dollard, it was observed that at high tide there were many seals on the WI, right up on the beach close to the platform. Not only this, but a lot of activity was reported amongst the group. Due to insufficient night vision equipment, researchers this year were unable to effectively observe at this time, but with the correct cameras, this might be a fascinating sideline. Being so close to the dyke increased the possibility of disturbance but equally perhaps the colony preferred the quieter time. Not a great deal is known about nocturnal behaviour in *P. vitulina* (Norris, 2007) but a study by Acevedo-Gutiérrez and Cendejas-Zarelli (2011) on the species in Washington; found that higher numbers were hauling out at night than during the day. This was close to an urban area with high levels of human activity. Perhaps this is normal, or perhaps it has shifted as a result of too much disturbance during daylight hours. Thus does sleep during the day time hold greater importance? A good starting point would be looking at sleep and activity cycles within the SRRC. Additionally, it would be good to observe at different times of day than just low tide, as again, much action was noted around high tide when seals congregated on the WI.

Terhune and Brillant (1996) conducted a study on *P. vitulina* where they looked at how vigilance on a haul out decreases in relation to the length of time spent out of water, taking into account the position and spacing of seals within a sandbank in relation to group size. This could well be applied at the Dollard to help explore reasons why seals are minimally responsive to disturbances at certain times, but in other moments will react strongly, and whether response does diminish over time.

Following on from the circumstances where seals were separated from their mothers, it would be very valuable to look further into possible lengths of time females in the Dollard would leave their young and whether there was a real possibility of them returning and locating their offspring again. Using recognition software, it might be possible to identify individual members of the colony easier, and monitor them throughout pupping so that separations could be recorded, and any incidence of adoption be confirmed.

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APPENDIX I:

Sample survey sheets used

Conditions Monitoring Sheet: Dollard 2012

Day/Date: ____________/________/________ L Tide: : cm

Observer(s): ______________________________ H Tide: : cm

Time hh/mm	Wind Speed (MPS)	Wind Direction	Cloud Cover /8	Temperature °C	Weather Conditions

* Record conditions hourly throughout duration of observation period

Seal Abundance Sheet: Dollard 2012

Day/ Date: ______________ Observer(s) __________ Start Time: ______________ End Time: ________________

Time Interval (mins)	Water Inlet				Sandbank 1								Sandbank 2		Sandbank 3								Sandbank 4		**TOTALS**		
	Left		Right		A		B		C		D				A		B		C		D						
	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	All
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Potential Disturbances Sheet: Dollard 2012

Day/ Date: ________/___/______

Observer (s): _______________

Type	No.	Area: Time Entered / Time Exited												Sand-bank (near)	Total seals on bank	Seal sample size	Reaction of seals (numbers) in following 2 mins									Haul out again (Y/N)	Time
		0L		L		C		R		0R		Platform															
		Enter	Exit	Enter	Exit	Enter	Exit	Enter	Exit	Enter	Exit	Enter	Exit				No reaction	Heads up	1st time	Commotion	1st time	Move to water	1st time	Get in water	1st time		

Disturbance Type Categories: w* = walker c* = cyclist h* = horse m = motorbike c = car a = agricultural vehicle la = low flying aircraft ma = military aircraft (**+H** = only heard but loud) sb = small (quiet) boat sp = speed boat sh = ship os = another seal R = sudden heavy rain S = storm N = no apparent stimuli O = other (specify)

* Follow type with noise category: 1 = silent/very discreet 2 = ambient/average 3 = loud/shouting/running etc.

APPENDIX II:

Detailed protocol for use in carrying out the observations in future years

Dollard Protocol

The following are detailed instructions and guidelines for carrying out the annual research into the Harbour seal colony in the Dollard Estuary during pupping season, as revised in 2012.

The study is to begin mid May to make sure researchers are in place for when the first pups arrive, and will continue until the end of July until after weaning, when it becomes more difficult to distinguish pups from adults due to their size. A minimum of two researchers need to be present for three observation sessions per week, at least one on a weekday and one on a weekend if possible. Observations must commence four hours before low tide and end three hours after, therefore tide times must be checked to ensure daylight for the entire duration.
The researchers are situated on the dyke around 100m left of the observation screen, just to the right of the public fence. The observers and their equipment must be just lower down from the apex of the dyke, away from the water, thus ensuring they cannot be seen by the seals.

Conditions Monitoring:

On commencement of the observation session the conditions are to be recorded, and once every hour thereafter. The instrument used to record these is the 'Speedtech WindMate'. Recordings must be taken from the position on the dyke with arm held in the air. Use 'compass' setting for wind direction, 'wind speed (av)' for average wind speed, in metres per second (Mps), and 'temp' setting for temperature in °C. Wait for the reading to stop changing for a few seconds to get the average - try to shelter the instrument from direct sunlight and wind to get an accurate reading. Record cloud cover out of 8 for the amount of the sky covered by clouds, and write a description of the weather at that moment, for example rain or sunshine.

Abundance Counts:

The seal counts must be done for four different sandbanks and the water inlet, split into different lettered areas, as seen on the diagram. It needs to be carried out every fifteen minutes, using a telescope and a counter. Binoculars can be used for the seals on the water inlet. Seals seen in the water are not to be counted.

Disturbance Recordings:

A possible disturbance for the purpose of this study is interpreted as anything that occurs within view of the seals, or above a reasonable noise level. The categories below explain how to fill in the table.
Type:
Walkers (w): Any people appearing on top or on the front side of the dyke, where they can be seen by the seals. This needs to be followed with a rating from 1- 3 for noise level. This can be 1) silent or discreet, 2) ambient or average, or 3) loud, for example shouting or running.
Cyclists (c): Any cyclist on the top or on the front side of the dyke, where they can be seen by the seals. Again followed by the 1- 3 noise level rating.
Horse (h): Any horse rider on the top or on the front side of the dyke, where they can be seen by the seals. Again followed by the 1- 3 noise level rating.
Motorbike (m): A motorbike on the top or on the front side of the dyke, where it can be seen by the seals; or behind the dyke but particularly loud. If not seen but heard, a **+H** should be added after the symbol.
Car (car): Any car or other small motor vehicle on the top or on the front side of the dyke, where it can be seen by the seals; or behind the dyke but particularly loud. **+H** added if heard but not seen.
Agricultural vehicle (a): Any agricultural vehicle (tractor, van, lorry, grass cutter, etc.) on the top or on the front side of the dyke, where it can be seen by the seals, or behind the dyke but particularly loud. **+H** added if heard but not seen.
Low flying aircraft (la): Any aircraft (helicopters, propeller airplanes) flying over the sandbanks at a lower height than a passenger jet, or making an excessive noise. **+H** added if heard but not seen.
Military aircraft (ma): Any military (jet) aircraft flying over the sandbanks, at a high speed and/or making a large amount of noise. **+H** added if heard but not seen.
Small boat (sb): Any small (<10m) boat without an overly loud engine, passing in the water between the study boundaries to the left and right, and as far away as sand bank 3.

Speed boat (sp): A speed boat, making a large amount of noise, passing in the water between the study boundaries to the left and right, and as far away as sand bank 3. Also recorded (with **+H**) if outside the specified zone but making very detectable noise or waves.
Ship (sh): Any boat, or cargo ship (>10m) passing in the water between the study boundaries to the left and right, and as far away as sand bank 3. Also recorded (with **+H**) if outside the specified zone but making loud and persistent sound.
Another seal (s): Excessive or persistent pursuing by another seal can be classed in this category.
Rain (R): Sudden, heavy rain may be enough to disturb seals and can therefore be recorded if it is significant.
Storm (S): Thunder and/or lightning.
No apparent stimuli (N): Used for recording reactions of seals, when the observer can detect no obvious cause. Is always recorded when carrying out controls of seal behaviour.
Other (O): Anything else not covered above. Must specify.

No:
This column is for recording the number of the particular stimulus, i.e. how many walkers, how many cars etc.

Area: Time Entered/ Time Exited:
The observation area in front of the dyke is split into six sections.
The platform (platform) - for when the disturbance is behind the platform, theoretically minimising the impact on the seals.
Central area (C) – this includes a roughly 200m long piece of beach and dyke between the two closest fences, technically out of bounds to the general public.
Left side (L) – from the left end of the central area extending left to where the path bends round out of sight.
Right side (R) – from the right end of the central area to the far fence and where the bank starts to extend out into the bay
Zero left (0L) – from the end of the left side to anything further left as far as the eye can see.
Zero right (0R) – from the end of the right side to anything further right as far as the eye can see.
These zones then extend out parallel to the water and sand bank area, allowing for disturbances at sea to be categorised. After sand bank three is where the observation area stops. See map.
When a potential disturbance enters one of the areas, the event is recorded, with an exact time of entering and exiting. It is therefore possible for a disturbance moving across the area to enter and exit all of the zones, and each time needs to be recorded accurately.

Sand bank (near):
Each time a potential disturbance is recorded, an immediate snapshot observation of the seal's behaviour is taken to record any reactions that might have happened. Every time one is spotted, a researcher should immediately select a number of seals to watch (the closest ones to the disturbance if possible which will usually be the WI) and watch solidly for two minutes, recording the behaviours. If disturbances overlap it will not be possible to always do two minutes as soon as the stimulus happens, and due to wanting to test for reactions it cannot be done late. Therefore if there are "disturbances" that occur simultaneously, the first will allow a two minute observation, and the others will just be recorded, until the two minutes are up and the next one comes along. It is important, however, to record all potential disturbances, because even though immediate reactions may not be looked at, there may be something to note in the time surrounding a group of stimuli. This also gives an overall picture of the number and type of disturbances over each season. There is no assumption here that the disturbance has **directly caused** any reactions captured, and for this reason, where there is time, it is useful to carry out 'control' two minute observations on a half hourly basis. A moment is picked where there are no obvious disturbance stimuli, and seal behaviour monitored and recorded for two minutes the same as when a disturbance has just happened.
For every disturbance achievable though, the two minute observation period should be carried out. This particular column is to record the sand bank and area that is being observed, this should also be the nearest to the disturbance and will usually be the water inlet as long as there are seals there. This is because they are the most prone to be disturbed by activities on land, and the easiest to watch accurately.

Total seals on sand bank:
Looking at the closest sand bank to the disturbance, this is for the total number of adult and juvenile seals seen (if a lot, the latest figure from the abundance count can be used).

Seal sample size:
This column is for the number of seals (adult and juvenile) that have been selected from the chosen sand bank to be observed for the two minutes. It can be difficult to have a view of all the seals on a sand bank at a time and therefore not always possible to watch them all. This information therefore gives an idea of the percentage of seals that have been sampled.

Reaction of seals (numbers) in following 2 minutes:
The selected group of seals must be watched continuously for two minutes from the start of the disturbance. It must be recorded every time one of the following behaviours is recorded from a different seal:
Heads up – Seal lifts head in the air, to either a small or large degree
Commotion – Seal shifts about rotating or lifting body but does not actually locomote in any direction, or slaps fore flippers in a defensive manner. This category **does not** include lifting of the hind flippers, rolling onto back or going into the 'banana' position
Move to water – Seal locomotes towards water, but does not actually enter the water with any part
Get in water – Any part of seal enters the water

1st time:
The 1st time column for each behaviour is for the time (mm:ss) from 00:00 to 02:00 when the behaviour is first displayed by an individual. After the first time is recorded, it is not necessary to record the other times that specific behaviour occurs in the two minute period. When the two minutes are up, the total number of seals in the group that showed none of the above reactions are recorded under the 'No reaction' category.

Haul out again (Y/N) – time:
If a seal(s) enters the water during the two minute period, it needs to be noted whether at a later time the seal hauls out onto the sand bank again. Researchers can watch out for this during abundance counts and if it occurs, note the time.

APPENDIX III:

Average occurrence of each response across different disturbance zones, per day

Table 5: Mean average occurrence of each response across different disturbance zones, per day

Zone	No visible disturbance					Disturbance lr					Disturbance c					Disturbance pl				
Response	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
Day																				
1	50.7	42.6	2.5	4.2	.0	70.0	30.0	25.0	.0	.0						87.4	12.6	.0	.0	.0
2																				
3	44.8	44.1	18.5	3.7	.0	78.8	18.2	19.7	6.1	.0	100.0	.0	.0	.0	.0					
4	50.9	40.4	13.2	5.9	.0	.0	100.0	.0	20.0	.0	41.7	58.3	58.3	.0	.0					
5	45.3	27.4	26.0	2.6	.0	66.7	30.6	1.1	.0	.0										
6	45.8	44.6	29.5	22.2	16.7	44.0	18.0	11.0	8.1	.0						72.7	1.0	1.0	1.0	.0
7	71.3	21.7	12.9	4.1	.0	80.7	13.9	8.2	2.8	.0										
8	8.3	79.2	54.2	.0	.0	100.0	.0	.0	.0	.0										
9	60.3	22.6	1.6	2.8	.0	33.3	33.3	41.7	.0	.0										
10	37.1	59.2	30.8	6.3	.0															
11	20.0	20.0	60.0	.0	.0	50.0	50.0	.0	.0	.0						50.0	50.0	.0	.0	.0
12	66.7	33.3	.0	.0	.0															
13	71.4	28.6	14.3	.0	.0	35.0	65.0	20.0	20.0	10.0										
14	36.8	57.9	12.6	2.6	.0	50.0	50.0	.0	.0	.0						73.2	26.8	7.4	1.7	1.7
15																41.4	53.6	39.3	.0	.0
16						89.4	10.6	.0	.0	.0										
17	56.0	24.0	28.0	12.0	.0	50.0	50.0	12.5	.0	.0	87.5	12.5	.0	.0	.0	87.4	11.4	5.8	3.5	3.5
18																				
19						28.6	71.4	28.6	14.3	.0						63.8	18.9	18.4	3.2	2.1
20											18.2	63.6	27.3	36.4	18.2	74.3	22.8	5.6	.0	.0
21																81.8	18.2	.0	.0	.0
22						30.0	70.0	10.0	.0	.0						.0	100.0	50.0	25.0	25.0
23						.0	100.0	83.3	33.3	.0										
24																4.8	95.2	19.4	8.3	8.3
TOTAL	**47.5**	**39**	**21.7**	**4.6**	**1.2**	**50.4**	**44.4**	**16.3**	**6.5**	**0.6**	**61.8**	**33.6**	**21.4**	**9.1**	**4.5**	**57.9**	**28.2**	**8.8**	**1.6**	**1.4**

APPENDIX IV:

Example survey questions - Harbour seals in the Dollard 2012

Harbour seals in the Dollard 2012

Survey Questions

1. What is the purpose of your visit today?

……..

2. How many people are in your group? …………………………………………………

3. What are the ages of your group?

....

4. How often do you visit this area? ………………………………………………………………………………………

5. Do you know there are seals here? Y...... N...... Do you know what kind of seals?...

6. Do you know when the pupping season for the seals here is?..

7. Are you interested in watching the seals? Y......... N.........

8. If yes, how long would you spend watching them?...

9. Have you seen seals in the wild before? Y......... N.........

10. Are you aware of the viewing platform? Y......... N.........

11. Do you think it is important to use the platform, or would you look at the seals from further down the dyke? Y......... N......... Would view from……………………………………………………………………..

12. Do you think it is important to remain quiet when the seals are here? Y......... N.........

13. If you've been here before, what kinds of things have you seen the seals doing?..

14. How do you think this area could be improved? …………………………………………………………………………… ………

15. Have you been to the visitor centre today? Y......... N.........

16. Would you be interested in learning more information about the seals here? Y......... N.........

17. Do you like seals? 0 (No)............ 1 (A little)............ 2 (Yes)............ 3 (A lot)............

18. How far did you come today?..

……

19. Have you ever visited the Zeehondencreche Lenie 't Hart, in Pieterburen? Y......... N.........

20. If no, do you think you will in the future? Y......... N.........

OTHER COMMENTS: ………

APPENDIX V:

Conditions surrounding pup strandings at the Dollard

Table 8- Conditions surrounding pup strandings at the Dollard

Date	Previous day					Current day					Stranded Pups	Weight (kg)	U. cord	Location
	Conditions	Average temp (°C)	Average wind speed (mps)	Significant event	Pups alone?	Conditions	Average temp (°C)	Average wind speed (mps)	Significant event	Pups alone?				
8/6	cold, overcast, breezy	16.7	2.8	no	no	storm, hail, thunder, lightning, wind	21.6	3	21xloud walkers c/l/pl heads up in 0.07s	no	4	10,6	Y	P van R
8/6												9,0	Y	P van R
8/6												9,4	Y	P van R
8/6												12,2	N	P van R
9/6	storm, hail, thunder, lightning, wind	21.6	3	21xloud walkers c/l/pl heads up in 0.07s	no	unknown	unknown	unknown	unknown	unknown	7	14,1	Y	P van R
9/6												11,9	N	P van R
9/6												12,0	Y	P van R
9/6												9,7	Y	P van R
9/6												10,0	Y	P van R
9/6												9,9	Y	P van R
9/6												8,8	N	P van R
10/6	unknown	unknown	unknown	unknown	unknown	strong wind, cool	17.7	4.9	no	1, later 2	2	10,0	Y	P van R
10/6												12,2	Y	P van R
11/6	strong wind, cool	17.7	4.9	no	1, later 2	unknown	unknown	unknown	unknown	unknown	2	8,7	N	P van R
11/6												11,5	Y	P van R
16/6	unknown	unknown	unknown	unknown	unknown	breezy, mild	21.4	5.7	1xwalker pl heads up in 0.05s	no	6	9,2	Y	WI
16/6												17,0	N	WI
16/6												11,8	N	WI
16/6												11,0	N	WI
16/6												14,0	N	WI
16/6												10,0	N	WI
20/6	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	1	8,6	N	WI
23/6	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	1	8,3	N	S of beach
25/6	Bad. Persistent rain, cloud, cold wind	unknown	unknown	unknown	1 adult + 3 pups	unknown	unknown	unknown	unknown	unknown	5	11,4	N	WI
25/6												13,6	N	WI
25/6												9,7	N	WI
25/6												9,6	N	WI
25/6												11,1	N	WI

2/7	stormy sky, strong wind, rain	20.1	>6.6	>46+Sheep on WI-all to water	no	unknown	unknown	unknown	unknown	unknown	3	12,7	N	WI
2/7												13,6	N	WI
2/7												15,2	N	WI
3/7	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	1	7,5	N	WI
5/7	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	2	12,1	N	WI
5/7												11,7	N	WI
9/7	Storm, rain, wind	22.3	3.7	*	1 adult + 4 pups	unknown	unknown	unknown	unknown	unknown	2	16,2	N	WI
9/7												10,2	N	WI
	*1xdog pl 5headsup / 7xwalkers pl heads up numerous times / agri. veh pl heads up in 0.01s / heavy rain many heads up / thunder 2 seals to water in 0.38 / storm-just 5 seals remaining after												P v R = Punt van Reide	