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Common Seals (Phoca vitulina) in the Dollard

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Research into the distribution and abundance, disturbances and mother pup bonds of common seals (*Phoca vitulina*) in the Dollard, The Netherlands.

Zeehondencrèche Lenie 't Hart. Seal Rehabilitation and Research Centre (SRRC). Pieterburen, The Netherlands

In memory of

Renske Hekman

1981 - 2011

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1. Introduction:

Two species of pinnipeds are indigenous to the Wadden Sea namely, the common seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*). This research paper focuses on the common seal, also known as the harbour seal (*Phoca vitulina*), on popular haul out sites within the northeast section of the of the Wadden Sea in the Netherlands; the Dollard estuary.

The Dollard estuary is an important haul out site for a population of common seals, which inhabit the coastal waters of the Dutch Wadden Sea. Due to the exposure of sandbanks by tidal movements; the Dollard is a core breeding and nursing area for common seals (*Phoca vitulina*) (Ries, 1999). During late spring through to summer, common seals use the sandbanks in the Dollard to haul out, give birth and lactate (Hewer, 1974). Mating also occurs after the birth season from July to September (Haaften van, 1983). This birth season coincides with the peak in the recreational use of the area.

A number of these sandbanks are located within close proximity to agricultural, urban and industrial areas. Due to the development around this area, the common seals are potentially exposed to anthropogenic disturbances. Disturbances on common seals during the pupping season can potentially interfere with the natural abundance, distribution, and behaviour of seals hauling out on the exposed sandbanks within the Dollard. During the pupping season mother seals and pups are constantly alert and nervous (Newby, 1973).

The coastal area directly surrounding the Dollard estuary and an artificial wetland connected to the study site is a popular area for local and migratory birds. This, along with the seals, attracts large numbers of visitors to the area, potentially leaving an impact on the seals in the study site.

Yearly observational research and monitoring has taken place at the Dollard by the Seal Rehabilitation and Research Centre (SRRC) in Pieterburen to determine distribution and abundance, seal behaviours, and actual and potential disturbances on the local common seal population since 2007 (Bakker, 2007, Selvaggi, 2008, de Boer, 2009) .

The main objective of this paper is to continue the ongoing research into the indigenous population of common seals (*Phoca vitulina*) within the Dollard Estuary. The aims of this research are as follows:

i. To determine the distribution and abundance of common seals in the Dollard
ii. To observe actual and potential disturbances on common seals in the Dollard
iii. To observe the bond between mother and pups in the Dollard

In addition to the above, information was gathered on the recently installed observation platform that was developed to view common seals in the Dollard. The observation platform was installed to reduce/ prevent potential and actual disturbances on seals hauling out on the sandbanks. The main areas of interest include the use and effectiveness of the observation platform for viewing common seals and the effect on common seal behaviour.

1.1 The Seal Rehabilitation and Research Centre (SRRC)

This research was carried out by the Seal Rehabilitation and Research Centre (SRRC, also commonly referred to as Zeehondèncreche Lenie 't Hart.

The SRRC was founded in 1971 and is located in Pieterburen in the northern section of the province of Groningen. Over the past 40 years the SRRC has grown into a fully functioning rehabilitation hospital, which currently (08/09/2011) holds 212 seals (including common seals, *Phoca vitulina* and grey seals, *Halichoerus grypus*).

The SRRC is responsible for the first aid, medical treatment, care and rehabilitation of injured, ill or orphaned pinnipeds. The SRRC follows established protocols and has an ISO 9001-2000 quality certificate. All seals admitted to the centre are released back into the wild. The SRRC has contributed greatly to the ongoing survival of pinniped populations within the Netherlands and around the world.

Aside from seal care, the SRRC functions as a research facility allowing the ongoing study into various aspects of pinnipeds. Post-mortem analysis is carried out on all deceased seals taken to the centre to determine its cause of death. Advanced virological, toxicological and genetic analysis is also undertaken.

The SRRC cooperates with numerous research and educational institutes within the Netherlands and globally to ensure methods and practices are current, effective and efficient. Public education about pinnipeds, threats and conservation is also provided onsite in the informative and interactive visitor centre.

2. Materials and Method

2.1 Research Area: The Dollard and Punt van Reide

The study site selected for this research was chosen due to a large number of common seals hauling out on exposed tidal sandbanks. These sandbanks are located within the Dollard estuary of the Eems situated in the northeast section of the province of Groningen, 53°17'1.39" N, 7°05'05.44", a natural boundary between The Netherlands and Germany (Figure 1). The Dollard area covers approximately 100km^2. A peninsula "Punt van Reide" separates the Eems and the Dollard.

Punt van Reide (46 ha) is a restricted area. The restricted area is protected by article 17 of the nature conservation law, article 461 and is managed by the local Groninger Landschap. From the 15th May to the 1st of September the waters around this area are restricted to fishing and recreational activities. This also coincides with the birth of common seal pups and the period in which they are weaned. A section of the Dollard waters are also protected under the Natura-2000 legislation. This area is referred to as Kerkeriet and includes the sandbanks observed for this research. This limits access to these waters from 15th May to the 1st of September and air traffic above the Dollard to a height of 450m (1500 feet) or above.

Tides, river deposits, weather conditions and man made structures influence the geographical morphology and the ecosystem of the area. The composition, size and position of the sandbanks vary quite considerably. Sandbanks generally composed of sand, mud or a mixture of both including suspended organics and debris.

The Dollard estuary is part of the Eems River within the Dutch Wadden Sea. This particular estuary is one of few estuaries still connected to the Wadden Sea without interference from dykes, sluices and locks. Nutrient rich waters created by the mixing of marine and fresh water allow a rich biodiversity of marine, brackish and freshwater species to co-inhabit. This and the presence of exposed sandbanks create a unique environment for a growing population of common seals to inhabit. Since the first observations and aerial surveys were conducted by the SRRC in the Dollard back in 1993, the population has steadily increased, despite a sudden decline in 2002 from the Morbilli virus.

In 2001, a water inlet was installed to allow water to pass through the dyke into an artificially constructed wetland. This wetland was built to accommodate a large biodiversity of migratory birds. The Dollard has recorded the largest colony of avocets (*Recurvirostra avosetts*) in North West Europe (www.waddenvereniging.nl). In the process of installing the water inlet a new haul out site was subsequently created along the water stream to the inlet. This produced a haul out site perpendicular to the dyke. The location of the haul out site makes the seals prone to human disturbances from the dyke area, as the dyke is often used as a recreational area.

Several sandbanks are located in the southwest of the Dollard, which were used for this particular study (Figure 2). This area of the Dollard is surrounded by agricultural development whilst to the northern area of the Dollard is dominated by a large industrial zone known as Emden (Germany). Eemshaven, located at the entrance of the Eems was in the process of building large energy factories. Due to the location of these agricultural and industrial developments, seals hauling out on these sandbanks are potentially exposed to numerous disturbances, which are discussed in a following section, 2.3.

Observations were conducted from the top of the dyke 115 meters north of the water inlet on the landside of the dyke. This site was selected to prevent the observers from disturbing the seals and to allow a clear view of all sandbanks within the study area. This site was also the selected site in previous observations and research.

Figure 1: Areal image of the northern section of the Netherlands and the Dollard estuary. (Courtesy of Google Earth 2011)

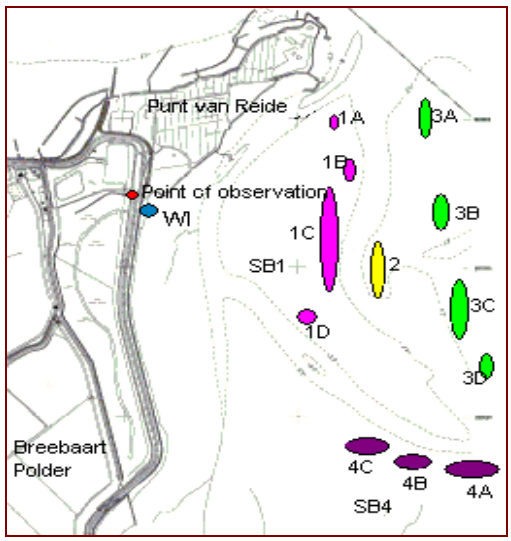


Figure 2: Map of the Dollard estuary and haul out sites.

2.2 Research Species: The common seal (*Phoca vitulina*)

Two species of seals are indigenous to the Dutch Wadden Sea, the common seal and the grey seal. Other species may occasionally be recorded in the Dutch Wadden Sea: the ringed seal (*Pusa hispida*), the harp seal (*Pagophilus groenlandicus*), the bearded seal (*Erignathus barbatus*) and the hooded seal (*Cystophora cristata*) ('t Hart, 2007). This research paper focuses on the common seal, also known as the harbour seal.

The common seal is the most abundant species of pinniped found in the Dutch Wadden Sea. The current colony of common seals in the Dollard is 235 (25/06/2010).

Male common seals grow to approximately 1.4 – 1.8 metres and weigh approximately 170 kilograms (King, 1983). Female common seals are slightly smaller growing to 1.2 – 1.6 metres and weighing approximately 105 kilograms. Their body and flippers are short, with a proportionately large, rounded head. As with other true seals, there is no earflap, or pinna. Common seal fur varies quite considerably between individuals but in general is brown, tan, or grey with a lighter ventral surface. Some seals can be heavily spotted.

During the months of May through to September common seals haul out to give birth, lactate and moult (Hewer, 1974) on intertidal sand banks exposed with the descending tide. After a 9-month gestation period a female seal will give birth to a pup measuring approximately 70 to 80 centimetres in length and weighing approximately 8 to 10 kilograms (King, 1983). Females suckle their pup for 3 to 4 weeks. The milk from a seal contains a high fat composition ranging over 43 %, depending on the species (Wagemann. R, 1988). This fatty milk allows the pup to triple in size in their first month of life. After 3 to 4 weeks the pup is weaned weighing in at approximately 30 kilograms. Shortly after the female has weaned her pup she is reproductively receptive. Mating generally occurs from July to September (Haaften, 1983). Males are sexually mature at 5 to 6 years of age, females at 2 to 5 years of age. Courtship and mating occurs in the water but little is known.

The daily consumption of fish is approximately 5 kilograms per day for an adult seal (Havinga, 1933). 29 known species of fish, which include herring, sole and flounder form part of the seals diet (King, 1983). It has been noted that seals can swim upwards of 45 kilometers in search of food and can stay submerged for up to 30 minutes (King, 1983 and Havinga 1933)

On land, the seal's vision is reduced. They do however detect movement and may be frightened easily by vertical moving objects (Lenie 't Hart, per. Comm. 28th of May 2007). This makes them highly sensitive to disturbances caused by human activities and was a key point taken into consideration whilst under taking the observations.

Figure 3: Common seals at the SRRC (Zeehondencreche), Pieterburen. The Netherlands.

2.3 Research Method

This research paper is a continuation of previous observations and research conducted over the past 4 years, starting in 2007 (Bakker and De Vries). The observational data collected for this report was carried out from the 27th May to the 13th of July, which included a total of 24 observation days (Table 1). In order to keep the data continuous from previous years, the same research methods were applied.

Observations were carried out by the authors of this report. Observations were conducted via telescope and binoculars. In regards to mother pup bonds and partially for distribution and abundance, natural sight and hearing was also used. Observations started 4 hours after high tide until 3 hours after low tide. Observations would typically last for 7hrs (see Appendix A).

Observations were conducted from the top of the dyke 115 meters north of the water inlet on the landside of the dyke. This site was selected to prevent the observers from disturbing the seals and to allow observers to clearly see all sandbanks within the study area. This site was also the selected site in previous observations and research. The total area observed, covered an area approximately 9 km^2.

In total, 5 sand banks were selected for the study. These sand banks can be seen in Figure 2. Due to the size of sandbanks 1, 3 and 4, they were further divided into sections e.g. 1A, 1B, 1C, 1D, 3A, 3B, 3C, 3D, 4A, 4B and 4C.

Table 1: Days of observation 2011

May-11

Mon	Tues	Wed	Thurs	Fri	Sat	Sun
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Jun-11

Mon	Tues	Wed	Thurs	Fri	Sat	Sun
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Jul-11

Mon	Tues	Wed	Thurs	Fri	Sat	Sun
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Observation day

2.3.1 Distribution and abundance of common seals in the Dollard

A focal point to this study is to gain a better understanding of the population of common seals in the Dollard and to compare them to previous years research. These comparisons will be used to see any trends in population growth or decline within the Dollard estuary.

To determine an estimate figure or the total number of common seals on the sandbanks outlined in the previous section, the seals were counted at regular 15-minute intervals. The first count began 4 hours before low tide until 3 hours after low tide. Observations would typically last for 7 hours (see Appendix A).

Adult seals and pups were counted separately. This was done by size differentiation. Pups were noticeably smaller then their mothers, other adults and sub adults. During the later part of the study the differentiation between pups and weaned pups was difficult, as they appeared similar in size. Seals swimming in the water were not counted and rarely occurred with low tide.

The seals were not only counted as a whole but it was also noted which sand banks the seals were using to haul out. These sand banks can be seen in Figure 2.

From the selected observation point, the seals were counted via binoculars and telescope. Due to the distance between the observation point and sandbanks 1,2,3,4 the telescope was required for the population and distribution counts. Binoculars and natural sight was used to observe seals located on the water inlet banks.

2.3.2 Disturbances on common seals in the Dollard

Due to the location of the Dollard estuary in regards to industrial, agricultural and urban developments, potential and actual disturbances were examined. Disturbances were classified as one of the following two:

a. Potential Disturbance: corresponds to a disturbance that had no effect on the seals on the haul out sites in question

b. Actual Disturbance: refers to events that had an effect on the seals on the haul out sites in question. All effects were included, from heads up to entering the water

Table 2 outlines the disturbances associated with the Dollard estuary. These disturbances were also used in the previous studies. Actual disturbances on the seals were recorded and classified into 5 categories. These categories/effects can be seen in Table 3. The same categories defined by Bakker and de Vries, 2007 was used.

The same methods were applied each year to allow a continuous flow of data. The observers remained hidden from the seals to avoid creating a disturbance. Each actual and potential disturbance was noted, and the following parameters were recorded: date, time, event and recorded effect. Due to the distance and reduced visibility of sand banks 3 and 4 it may have been possible that some events were not recorded. The calculated level of disturbances should, therefore be considered as a minimum.

Table 2: Definition of the different types of disturbances on common seals, 2011.

Disturbance	**Description**
Pedestrians (people)	Any person(s) in the area visible to the seals or walking behind the dyke.
Cyclist	All persons that came on top of the dyke via bicycle.
Car	All kinds of cars, excluding farmers.
Agricultural Vehicle	All kinds of agricultural vehicles. This includes utility vehicles, quad bikes, tractors, grass mowers and vehicles with trailers.
Boat	All kinds of small watercraft within the study site. This excludes cargo vessels and ferries.
Ship	All kinds of large watercraft within the study site. This includes cargo vessels and ferries.
Airplane	Light aircraft – propeller aircraft.
Jet Fighter	Fast moving military aircraft.
Farmer	Herding sheep with or without cattle dog. Attending to maintenance on property.
Other	Any other disturbance not categorised in the above events.

Table 3: Definition of the various effects of disturbances on common seals, 2011.

Recorded effect on the seals	Description
No Effect	No effect on the seals in the study site.
Heads up	Seals raise head and/or look toward the disturbance.
Commotion	Heads up, movement and restlessness of the seals.
Move towards water	Seal(s) move(s) towards the water but do(es) not enter the water.
Enter water	Seal(s) enter(s) the water.

2.3.3 Mother and pup bonds in common seals in the Dollard.

As mentioned previously, the Dollard is a very popular area for common seals to haul out. With the construction of the water inlet in 2001 a new haul out sight was created for the seals. The water inlet runs perpendicular to the dyke meaning that seals on this particular sandbank are close to the land and subjected to potential disturbances. A wooden observation platform was constructed on top of the dyke, directly over the inlet connection between the Dollard estuary and the artificial wetland, to prevent people from disturbing the seals.

The researchers stood behind the observation platform to observe the bonds between the mother and pup seals. From here, the researchers remained hidden from the seals and thus provided the perfect observation view of the water inlet area. The other sandbanks are too far away to observe the behaviour of the seals in detail. For Sandbanks 2, 3, and 4, only resting, active, nuzzling and suckling behaviour was recorded every 15 minutes. For the water inlet, behaviour was observed continuously due to the observers close proximity and ease of sight.

Natural sight, binoculars, pictures and movies were used to collect data and make observations. A Canon EOS 550 camera with 75-300 lens was used to take the pictures and movies. Mother and pup behaviour was recorded on data sheets as well (see Appendix A).

Due to the position and composition of the water inlet, it is the first sandbank to emerge during low tide and the last to be submerged during high tide. Here, seals were mostly present before high tide and when the tide started to descend.

2.3.4 The use and effectiveness of the observation platform for viewing common seals in the Dollard.

In 2001, a water inlet was installed to allow water to pass through the dyke into an artificially constructed wetland. This wetland was built to accommodate a large biodiversity of migratory birds. In the process of installing the water inlet, a new haul out site was subsequently created. This produced a haul out site perpendicular to the dyke and potential disturbances.

To prevent disturbances on the seals hauling out on the water inlet, an observation platform was constructed in early 2011 to provide a barrier to prevent seals from seeing visitors standing on top of the dyke (Figure 4 and Figure 5). The observation platform was installed by the Groninger Landschap. The observation platform was constructed to allow people to stand behind a wooden barrier and peer through peepholes. It was also constructed to allow people to stand in front of the wooden panels with the assumption that the seals would not be able to see the silhouettes of the visitors against the wooden panels.

In addition to the previous research aims, this report will look into the effectiveness of the observation platform. The observers will monitor the use of the observation platform and the effect on seal behaviour. This was done visually and audibly. The observers recorded every use of the observation platform, looking closely at the position of the visitors using the platform and the response of the seals in the nearby water inlet.

After initial observations the observers noticed that there were four main categories of use:

1. People who stood behind the wooden panels and remained hidden from the seals.
2. People who stood in front of the wooden panels, on the concrete platform
3. People who stood beside the observation platform.
4. People who did not use the observation platform (i.e. pedestrians on top of the dyke or near waters edge).

Based on these initial observations the use of the observation platform was categorized by the above. The recorded effect on seal behaviour was the same as outlined in section 2.3.2 Table 3.

Figure 4: Observation platform at the Dollard water inlet. View facing the Dollard estuary.

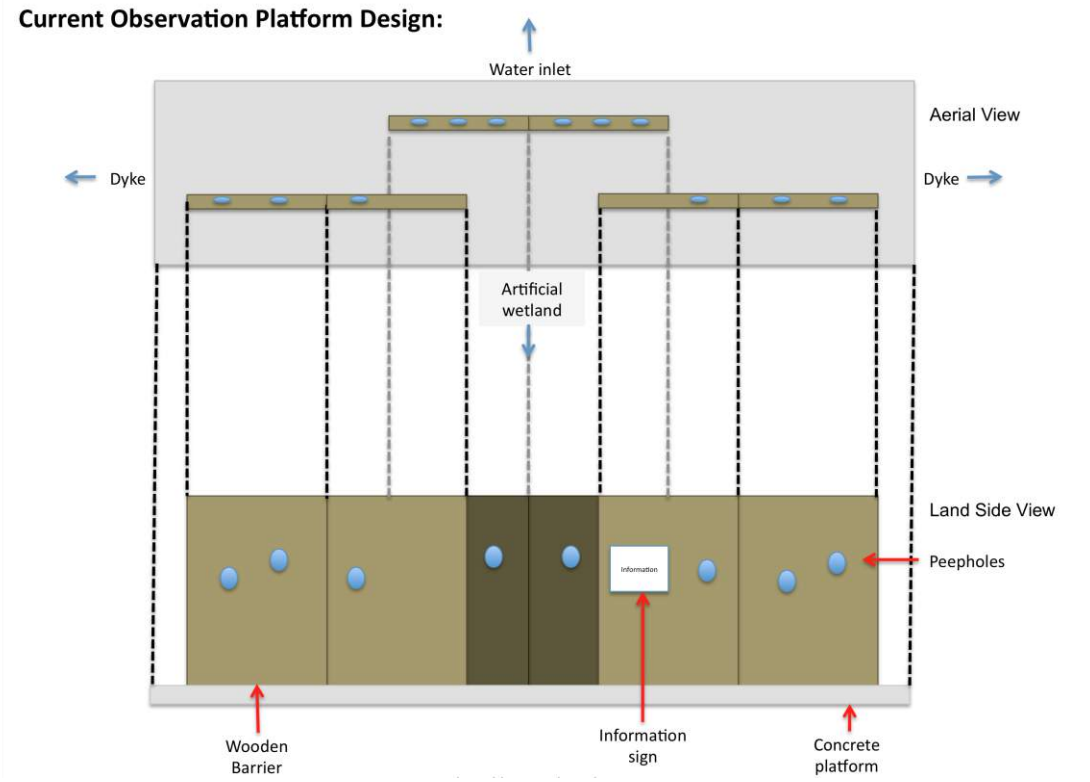


Figure 5: The current design of the observation platform at the Dollard.

3.3.5 Water Quality Parameters

The Dollard estuary is subjected large movements of marine and fresh water. The integration of these nutrient rich waters creates a unique estuary, home to numerous species of animals. Seals living in the Dollard estuary are influenced by the quality of the water, as these waters provide a home and a food source for the species. Agricultural, urban and industrial developments can potentially influence the quality of the water, thus creating an environment less suitable for the species of animals inhabiting the area.

Weekly water quality samples were taken during the observation period and the following parameters were recorded: Temperature, pH, KH, Ca, NO_2, NO_3, NH_2/NH_3, Ca and Cu. To record the water quality parameters a Sera Aqua-test box was used. The water samples were taken at the end of the observation period (3 hours after low tide). The water quality samples were collected from the water inlet directly in front of the inlet pipe connecting the artificial wetland to the Dollard estuary. The wetland side of the water inlet was chosen to prevent a disturbance to the seals hauling out on the water inlet sandbanks. Two other samples were taken for comparison. One sample was collected close to the Dollard estuary in an industrial area known as Delfzijl. The other water sample was taken from an area not influenced by industrial development, Lauwersmeer. These sights were selected to see whether there was a difference in water quality from a heavily industrialised area and a non-industrialised area.

3. Results and Analysis

This section of the report included the results of the analysis based on the research questions outlined in the Materials and Method. The data was analysed using Microsoft excel 2008.

Due to the nature of the study some of the observations were not suitable for quantitative analysis. However these observations do contribute to the greater understanding of the behaviour of seals in the Dollard estuary and therefore have been included in the following sub paragraphs.

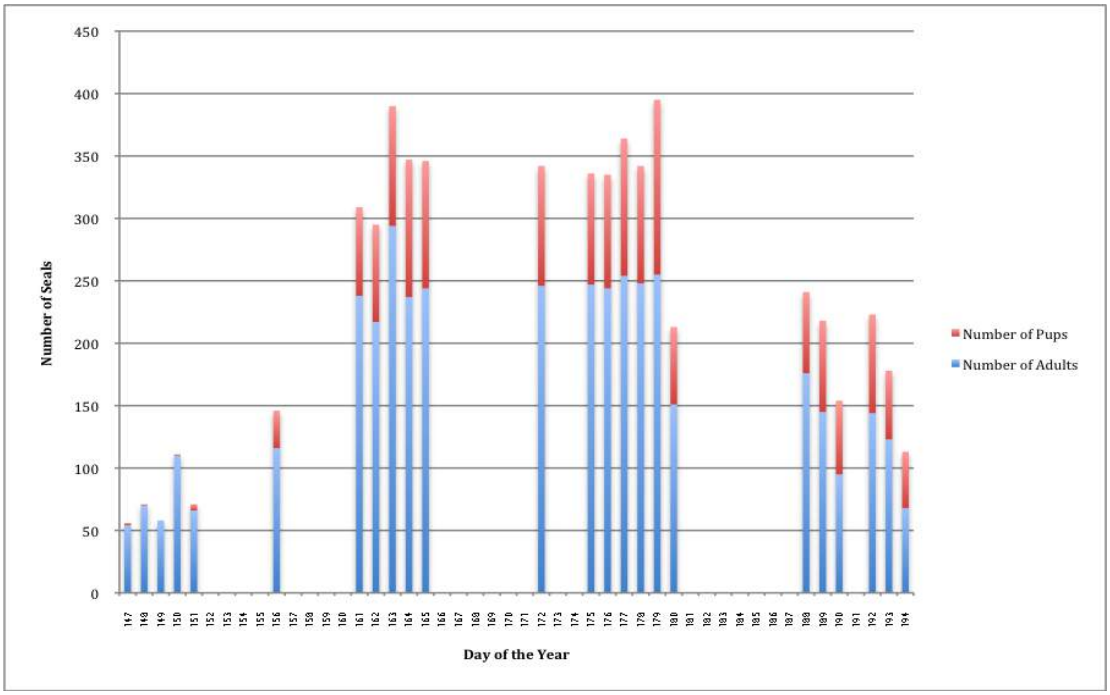
3.1 Distribution and abundance of common seals in the Dollard

This chapter of the report is separated into two subparagraphs. The first subparagraph in this chapter 3.1.1 contains the analysis of the distribution and abundance of common seals on sandbanks/haul out sites in the Dollard and the second subparagraph, 3.1.2 the analysis of the movements of common seals on haul out sites in the Dollard.

3.1.1 Distribution and abundance of common seals on sandbanks/haul out sites in the Dollard

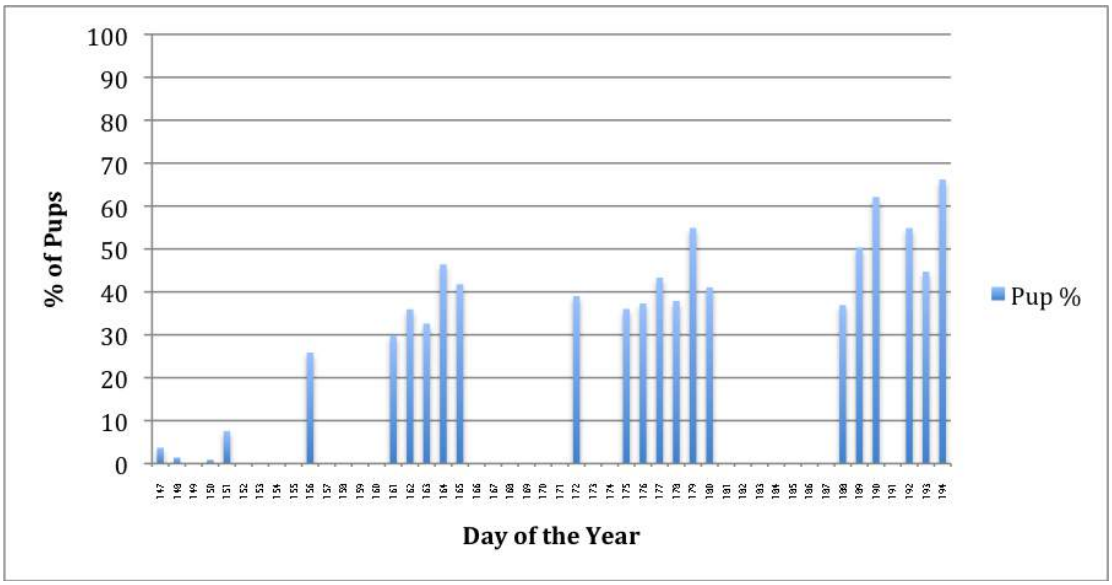
During the observation period between day 147 (27/05/2011) to day 193 (13/07/2011), a maximum of 294 adults (day 163, 12/06/2011) and maximum of 140 pups (day 179, 28/06/2011) were observed in the Dollard estuary within the study site. On day 179 (28/06/2011) the highest number of seals (combined adults and pups) were sighted, with 395 present within the study site. The number of seals fluctuates over the observation days, and was highest at low tide.

The first pups were observed on day 147 (27/05/2011) and the number of pups steadily increased during the observation period. During day 161 (10/06/2011) to day 174 (28/06/2011) there was a peak in the total seal (adults and pups) numbers within the study site.



Graph 1: Total number of adult and pup common seals in the Dollard estuary from day 147 - 194 (27/05/2011 - 13/07/2011).

The percentage of pups in comparison to the total number of seals was highest from day 164 (13/06/2011) to the end of the observation period, day 194 (13/07/2011) (Graph 2). This coincides with the natural pupping season, with pup percentages reaching their highest at the end of the observation period.

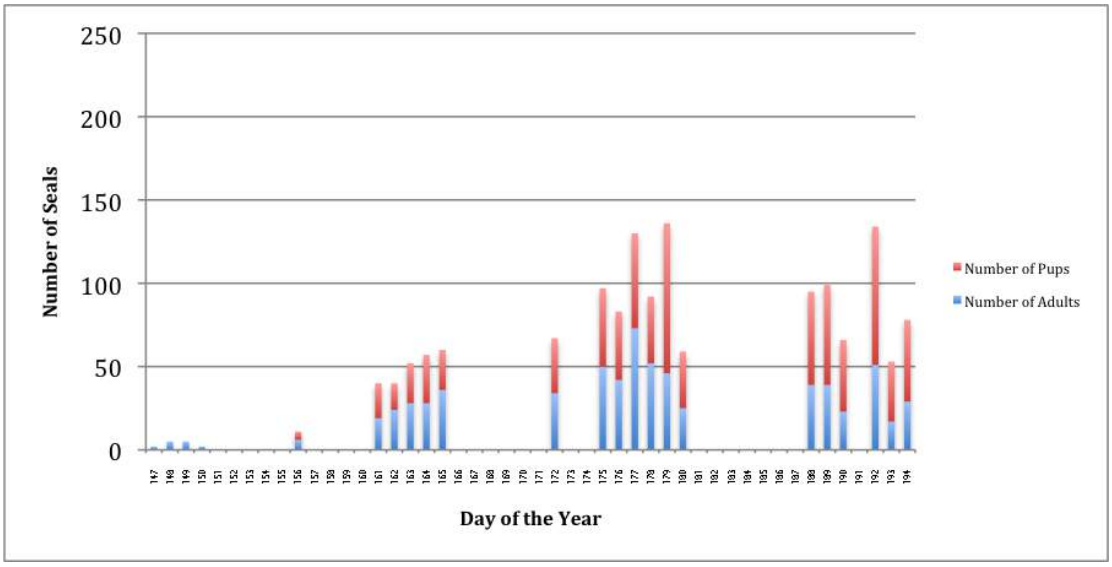


Graph 2: Percentage of pups on the total number of seals in the Dollard estuary Day 147 - 194 (27/05/2011 - 13/07/2011).

Water Inlet:

The water inlet is the closest haul out site to the observation point (Figure 1). It also contained the highest percentage of pups compared to adult seals. Seals hauled out on both sides of the water inlet with considerably higher seal numbers from mid to late observations (Graph 3). Day 179 (28/06/2011) had the highest combined (adult and pup) total of 136 seals. The water inlet was the only sandbank that did not decrease significantly in abundance within the final observation days.

The water inlet is the first haul out site exposed on a descending tide and the last haul out site submerged on an incoming tide, thus providing a longer period of time for seals to haul out. Seals were seen closer to the dyke when the tide was higher and as the tide descended seals would move further away from the dyke closer to the main water channels. At low tide it was noted that the gradient of the slope of the water inlet closer to the dyke was very steep. This made it extremely difficult for seals especially pups, to haul out of the water.



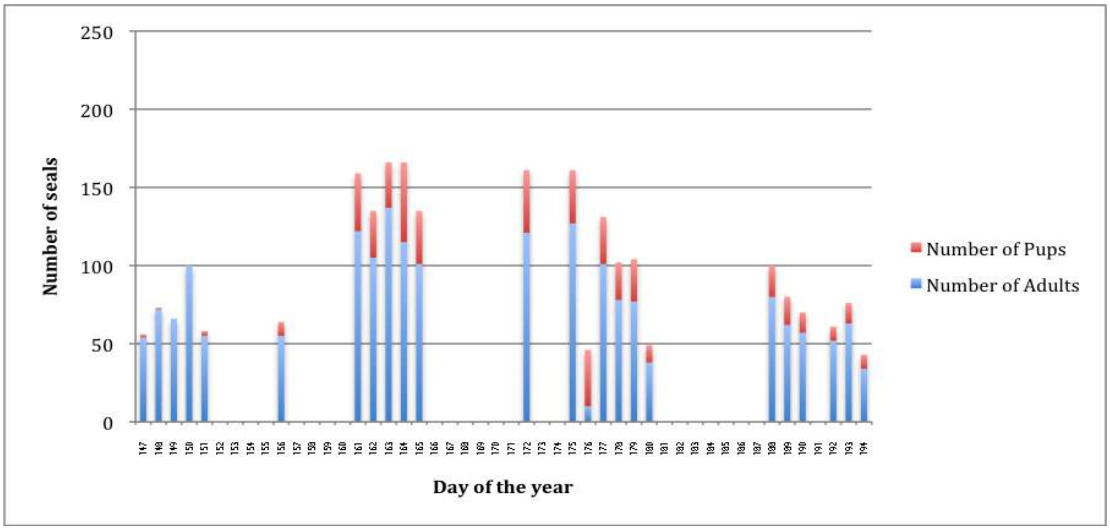
Graph 3: Total number of mother and pup seals hauling out on the water inlet in the Dollard estuary Day 147 - 194 (27/05/2011 - 13/07/2011).

Sandbank 1:

During the observation period there was a constant abundance of seals on sandbank 1 (Graph 4). The initial part of the observations showed very few pups present, however by day 161 (10/06/2011) there was a peak in pup numbers, which remained steady until day 179 (28/06/2011) before there was a slight decline. This also corresponded with a decline in adults present.

The very first pup was sighted on day 147 (27/05/2011), and from this moment on, the number of pups increased as with that of the adult seals. By day 180 (29/06/2011) pup numbers decreased as with that of the adult seals.

There was a significant decrease in total seal numbers on day 176 (25/06/2011). On this particular day poor weather conditions (strong winds, cloudy with rain) were experienced. This reduced seal abundance was also seen on the water inlet and sandbank 3 (Graphs 3 and 6).

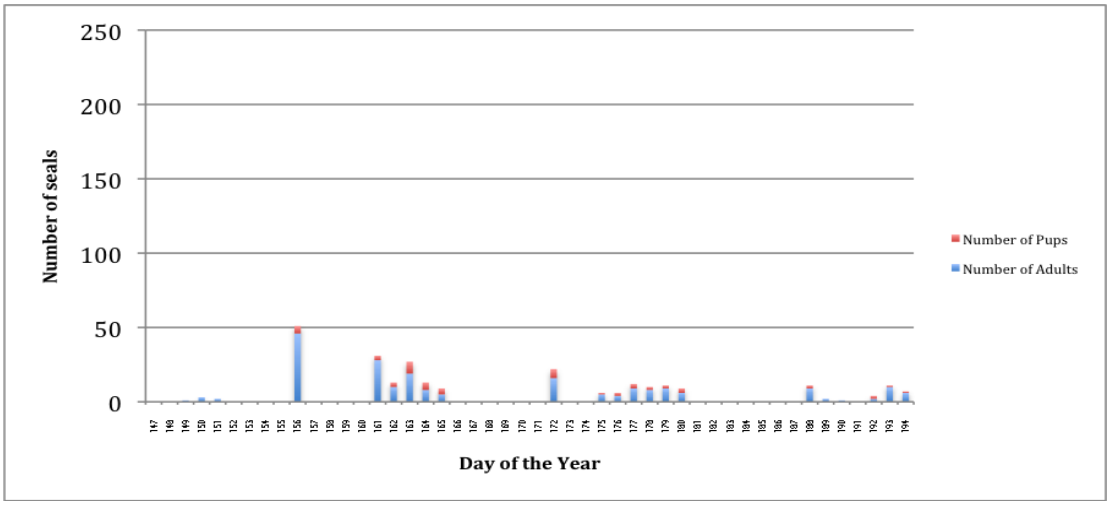


Graph 4: Total number of adult and pup seals on Sandbank 1 n the Dollard estuary Day 147 - 194 (27/05/2011 - 13/07/2011).

Sandbank 2:

Sandbank 2 is the smallest of all sandbanks. It is also the last sandbank exposed on a descending tide and the first sandbank submerged on an incoming tide. Therefore the time available for seals to haul out on is considerably less then that of the other sandbanks (Graph 2).

The first pups sighted on sandbank 2 was on day 156 (05/06/2011), this coincided with a significant peak in adults present on the sandbank. Throughout the observation period very few seals (adults and pups) were present on the sandbank compared to the remaining sandbanks.

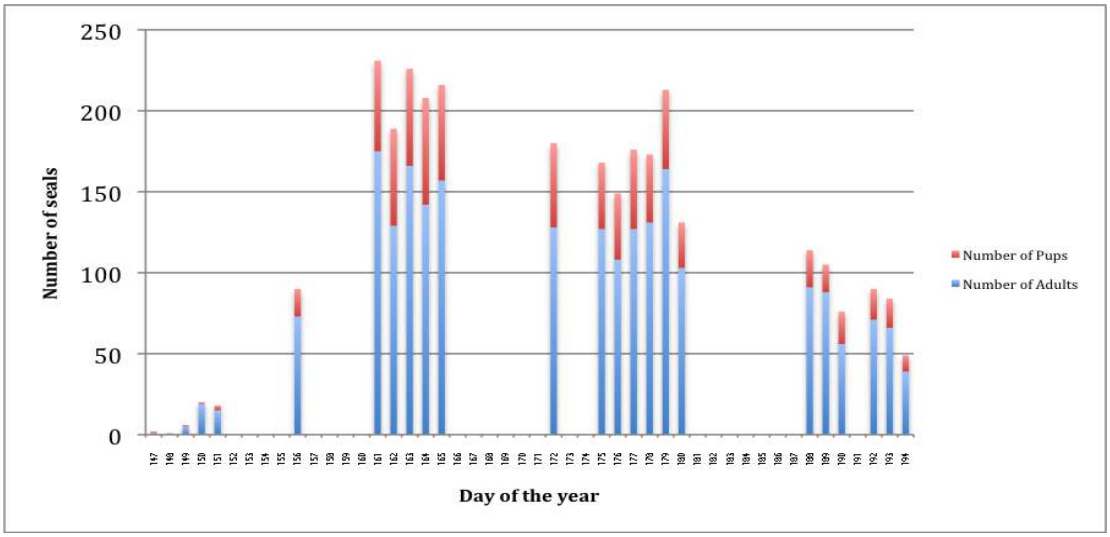


Graph 5: Total number of mother and pup seals hauling out on the sandbank 2 in the Dollard estuary Day 147 - 194 (27/05/2011 - 13/07/2011).

Sandbank 3:

Sandbank 3 is the largest of all sandbanks; it also contained this highest total abundance of seals (Graph 6). Due to the size of sandbank 3 and its position from the observation point, observational calculations may not reflex true abundance number due to poor visibility (especially during poor weather conditions). Therefore number recorded should be taken as a minimum.

There was a significant increase in total seal abundance on day 161 (10/06/2011) and this remains constantly high to day 179 (28/06/2011). During this period there was also a higher number of pups. The number of pups decreases as with adult abundance from day 180 (29/06/2011) to day 194 (13/07/2011).

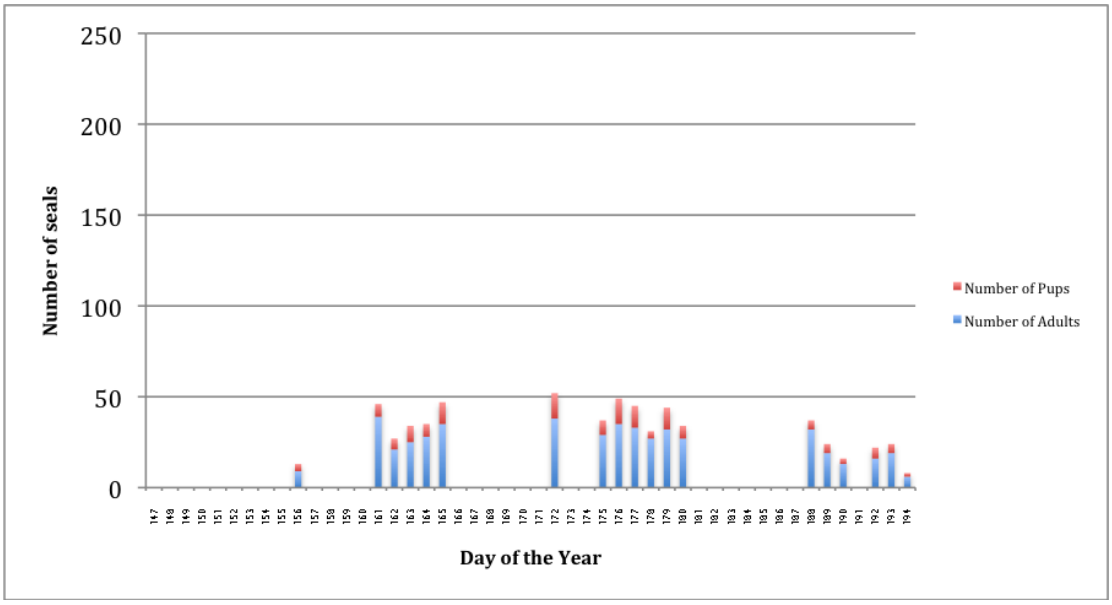


Graph 6: Total number of mother and pup seals hauling out on the sandbank 3 in the Dollard estuary Day 147 - 194 (27/05/2011 - 13/07/2011).

Sandbank 4:

Sandbank 4 is located quite a distance from the observation point; similarly to sandbank 3. Therefore observational calculations may not reflex true abundance number due to poor visibility (especially during poor weather conditions). Therefore number recorded should be taken as a minimum.

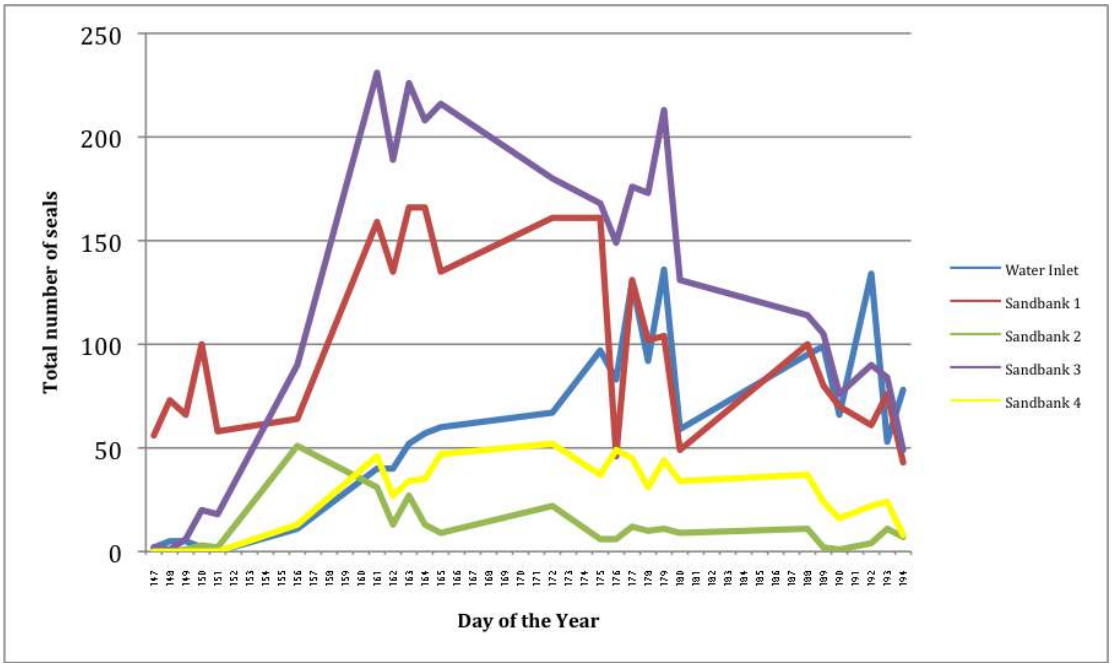
Sandbank 4 was utilized later then the other sandbanks with the first seal hauling out on day 156 (05/06/2011) (Graph 7). There was a significant increase in total seal numbers on day 161 (10/06/2011) to day 180 (29/06/2011), with a steady decline in adult and pups there after.



Graph 7: Total number of mother and pup seals hauling out on the sandbank 4 in the Dollard estuary Day 147 - 194 (27/05/2011 - 13/07/2011).

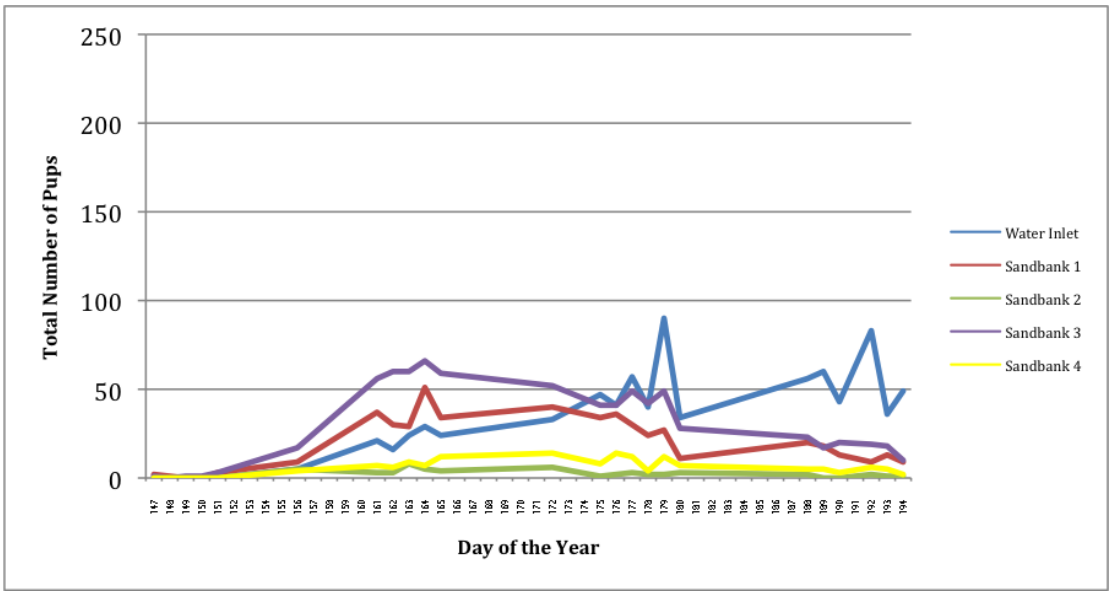
3.1.2 Movements of common seals on haul out sites in the Dollard

During the observation period it was also noted which sandbanks seals hauled out on (Figure 2). By comparing the sandbanks, we can see a distinctive pattern into favoured haul out sites. Graph 8, displays the total number of seals (adults and pups) on each one of the observed sandbanks. At the beginning of the observation period the highest number of seals were sighted on sandbank 1, whilst the remaining sandbanks had significantly less seals. By day 156 (05/06/2011) there was a significant peak in seal numbers. This was noted on all sandbanks but was considerably greater in sandbanks 1 and 3.

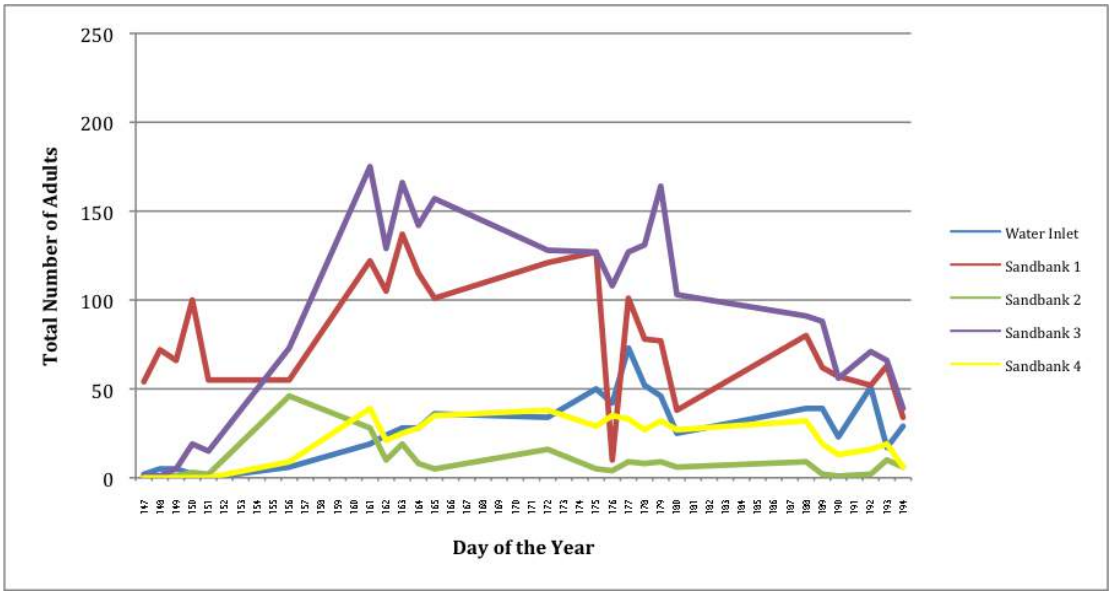


Graph 8: Total number of seal (adults and pups) on each of the studied sandbanks in the Dollard estuary from day 147 - 194 (27/05/2011 - 13/07/2011).

With further analysis of haul out sites we can gain a greater understanding of favoured birth sites. It was noted that on day 161 (10/06/2011) there was a significant increase in pups present on the haul out sites (Graph 9). It was also noted that there was an increase in adult seals that arrived to the sandbanks at the same period of time (Graph 10). Sandbanks 1 and 3 had a higher total number of pups present in the beginning of the observation period, however this declined over time, whilst the water inlet increased in pup numbers. The water inlet had higher sightings of pups compared to the remaining sandbanks.



Graph 9: The total number of pup on each of the studied sandbanks in the Dollard estuary from day 147 – 194 (27/05/2011 – 13/07/2011)



Graph: 10: The total number of adult seals on each of the studied sandbanks in the Dollard estuary from day 147 – 194 (27/05/2011 – 13/07/2011)

4.1 Disturbances on common seals in the Dollard

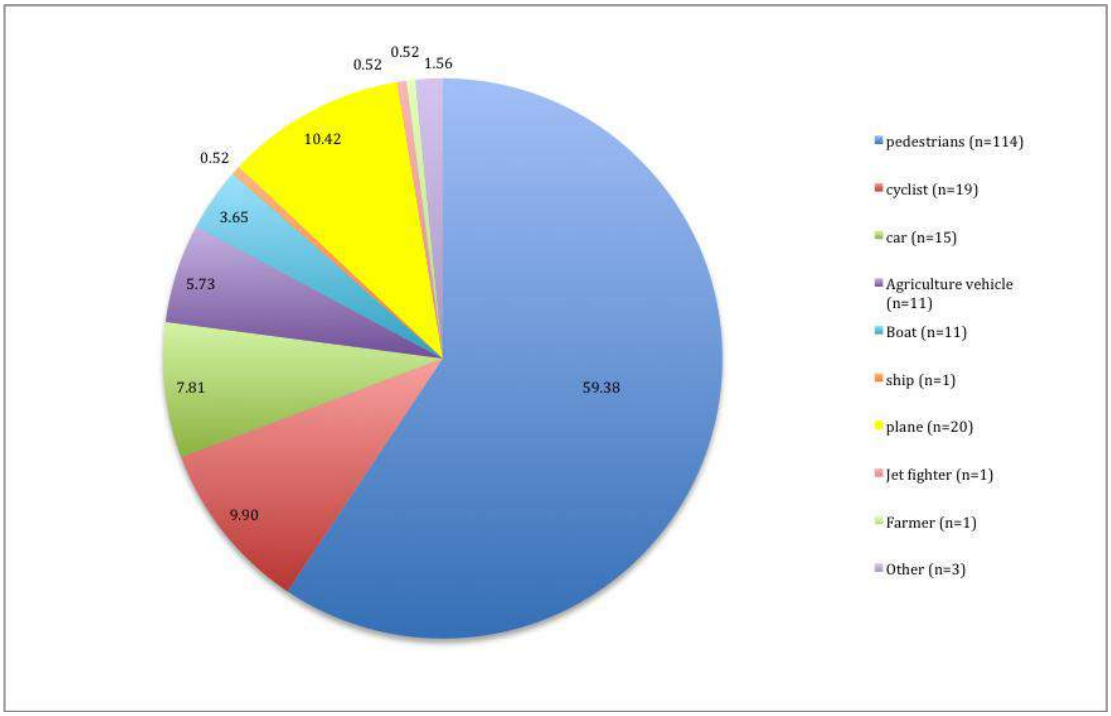
This chapter of the report is separated into two subparagraphs. The first subparagraph in this chapter 4.1.1 contains the analysis of the disturbances of common seals on sandbanks/haul out sites in the Dollard and the second subparagraph, 4.1.2 the analysis of the consequences caused by disturbances to common seals on haul out sites in the Dollard.

4.1.1 Disturbances on common seals in the Dollard and their effect

Actual disturbances

Actual disturbances can lead to a number of distinctive behaviours on seals hauling out within the Dollard estuary. These behaviours or "effects" are outlined in Section 2.3.2, Table 3. In total, 401 disturbances were recorded, 192 of which were actual disturbances, during observation days 147 to 194 (27/05/2011 - 13/07/2011).

192 out of 401 (47.88%) of all disturbances lead to an actual disturbance and change in seal behaviour. The actual disturbances were recorded as one of the following events; pedestrians, cyclist, car, agriculture vehicle, boat, plane, jet fighter, farmer and other. Of these events, pedestrians were the biggest disturbance causing 114 out of 192 (59.38%) of all actual disturbances on seal behaviour. It was noted that pedestrian disturbances were more likely to affect the water inlet then the remaining sandbanks. Small aircraft "planes" followed in second with 10.42% of actual disturbances. Cyclists (9.89%), cars (7.81%), agricultural vehicles (5.72%), boats (3.6%) and others (1.56%) followed this. Ships, Jetfighters and farmers caused the least amount of actual disturbances each with 0.52%. The analysis shows that ships, jetfighters and farmers have a low percentage of actual effects on seals. However, it must be taken into consideration the low sample size of these events (1/1 = 100% impact).

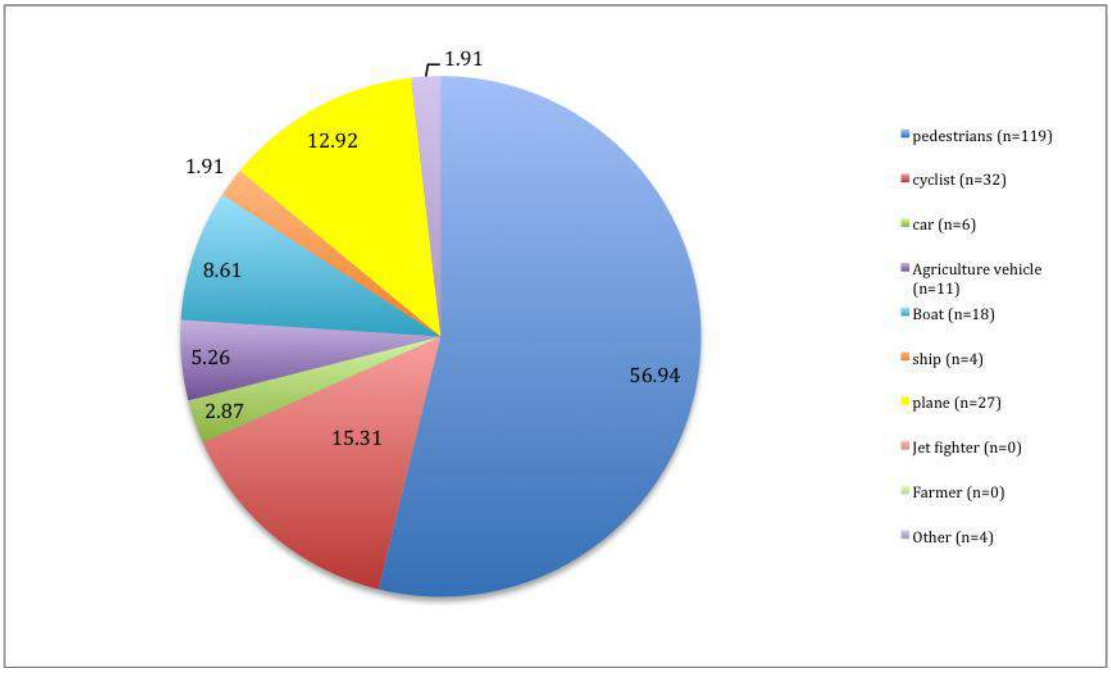


Graph 11: *The percentage of actual disturbances on common seals in the Dollard estuary from day 147 – 194 (27/05/2011 – 13/07/2011). (n=192).*

Potential Disturbances

Not all disturbances created had an affect on the seals in the study sites. These disturbances known as "potential disturbances" were recorded as not having an affect on the seal behaviour, however they have the potential to create an effect on seal behaviour. The potential disturbances were recorded in the same method as actual disturbances as outlined in Section 2.3.2, Table 2.

As noted with the actual disturbances, pedestrians were most likely to cause a disturbance (119/209), followed by cyclists (32/209), planes (27/209), boats (18/209), agricultural vehicles (11/209), cars (6/209), ships (4/209) and others (4/209). Jet fighters and farmers recorded 0/209 however in the case when they were present (1/1) had a 100% actual effect on seal behaviour.



Graph 12: *The percentage of potential disturbances on common seals in the Dollard estuary from day 147 – 194 (27/05/2011 – 13/07/2011). (n=209).*

4.1.2 Disturbances and consequences

Disturbances on seals at the Dollard estuary can lead to a number of effects on seal behaviour. These effects are outlined in Section 2.3.2, Table 3. The first consequence of these disturbances will generally lead to a heads up followed by commotion amongst the seals, this will be followed by movements towards the water before actually entering the water to avoid the disturbance.

487 actual and potential effects were recorded from day 147 to 194 (27/05/2011 - 13/07/2011), 209 (42.94%) of which had no effect on the seals. It was also noted that some seals had more than one response to a disturbance especially if the disturbance was prolonged. The most serious response was recorded.

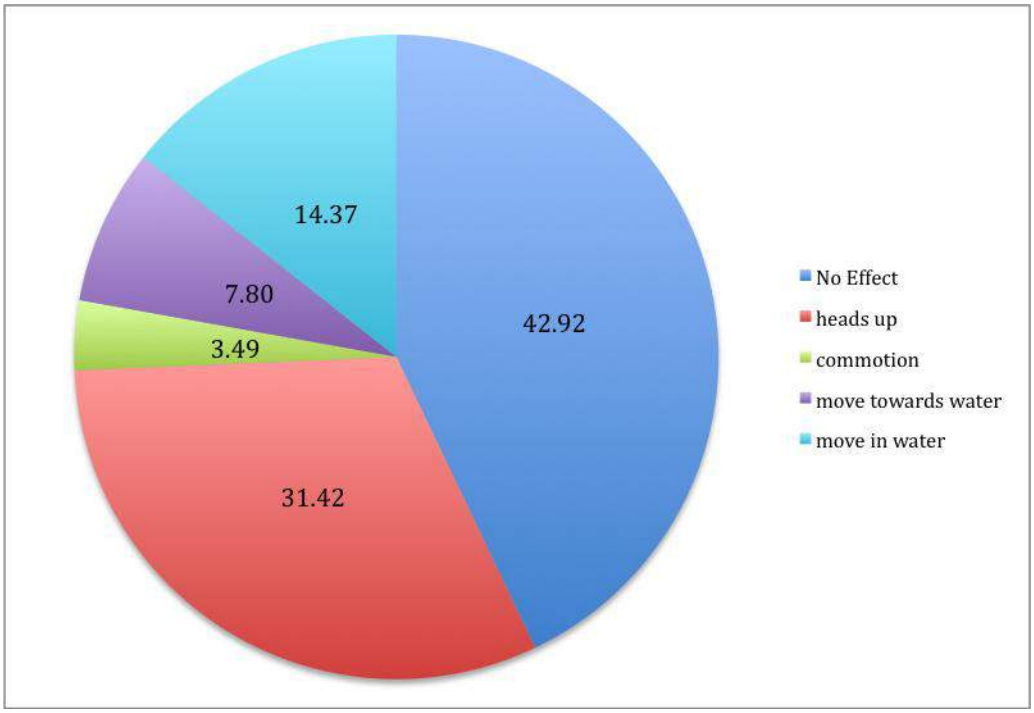
31.42% of seals raised their heads to a disturbance whilst 14.37% entered the water to avoid a disturbance. In total, 57.06% of seals responded negatively to a disturbance cause by one of the events outlined in Section 2.3.2, Table 2.

Observations in the field also showed that pups were not as easily disturbed as the adults, especially mothers. This raised an issue of whether a disturbance could lead to a mother and

pup becoming separated, leaving the pup orphaned. Pups were more prone to staying on the sandbanks or water inlet, even when a disturbance occurred. A number of these observations are discussed in Section 3.3, Mother and pup bonds in common seals in the Dollard.

In many cases when a mother was alerted to a disturbance, she would respond first followed by the pup. The response from the pup may not be directly caused by the disturbance, instead the response maybe triggered by the reaction of the mother.

It was also noted during observations that the seal's response to an event varied considerably. Sometimes seals responded to an event that occurred and at other times a similar event triggered no response from the seal. Observations also showed that seals respond to the actions of other seals. If one or more seals reacted to a disturbance, this sometimes triggered a response to the remaining seals on the sandbank.



Graph 13: *The effects of disturbances on common seals in the Dollard estuary from day 147 – 194 (27/05/2011 – 13/07/2011).*

3.3 Mother and pup bonds in common seals in the Dollard.

3.3.1 Mother and pup behaviors on haul out sites in the Dollard

During the months of May to September, common seals in the Dollard give birth to a single pup, however multiple pups have been recorded. Pups usually stay with their mothers for 3 to 4 weeks and after that period they are weaned and ultimately abandoned by their mothers. Behavioral observations were observed during the lactation period whilst the pup was still with their mothers. The mother and pup pairs usually stay on the sandbanks during low tide and swim away during high tide when the sandbanks are submerged.

Pups were observed alone on the sandbanks. This may have been caused by a disturbance or due to cyclic movements. During the observation period it was noted that mothers could return to collect orphaned/abandoned pups after a disturbance/separation. The reuniting of mother and pup pairs would often occur immediately after the disturbance/separation or within the following 1 to 2 hours.

During haul out, the mothers and pups spend most of their time resting on the exposed sandbanks. Whilst resting, the mother frequently nuzzles with the pup to ensure that it is hers and to strengthen their bond (Figure 6).

Figure 6: Mother and pup nuzzling in the Dollard estuary.

Tidal movements often lead to the movement of the seal pairs from one sandbank to another. This movement is commonly referred to as tidal cyclic movements. During times of movements, the mother initially enters the water vocalizing or using body movements to encourage the pup to follow. Pups can be reluctant at times and in these observed cases the mother would use louder vocalization, vigorous body movements or even return back to the sandbank to collect the pup.

Once the mother and pup have entered the water surrounding the sandbanks, continuous body contact is observed. Even in the water, the pup stays continuously in touch with its mother's body, by holding on to her back. Suckling usually occurs after moving on the sandbank when the tides expose the sandbanks. Suckling generally lasted no longer than one minute (Figure 7).

Figure 7: Pup suckling milk from the mother in the Dollard estuary.

To allow the pup to suckle, the mum usually rolls on to her side exposing her stomach and mammary glands. If the pup is unable to locate the mammary glands, the mother would move position so that her teats are in front of the pup, allowing it to suckle. Abandoned pups may try to suckle from other adults and even from other pups (Figure 8). Newly weaned pups were observed attempting to suckle from other adults and pups as well.

Figure 8: Pup suckling from another pup in the Dollard estuary.

Mothers are very protective of their of their offspring and will defend the space around the pup. The mildest form of defensive threat for a mother with her pup, when a adult seal approaches, is fore-flipper waving (Figure 9).

Figure 9: Fore flipper waving behaviour of a common seal in the Dollard estuary.

More intense defensive threats involve vocalizations such as growling, snorting accompanied by lunging, and fore flipper waving or slapping. During some observations mothers showed a more aggressive behavior by trying to bite the other seal (Figure 10).

Figure 10: Adult seal trying to bite an unrelated pup in the Dollard estuary.

Abandoned/orphaned pups were observed approaching unrelated mothers and their pups in an attempt to try and suckle. In most cases the mother would nuzzle the unrelated pup to assess whether the pup it hers. Mothers generally show an aggressive behaviour to unrelated pups that try to suckle from them. These behaviours often include fore flipper waving and biting.

Disturbing events taking place on the dyke and are likely to lead to the separation of mother and pup. When adults are disturbed they enter the water and swim away. Pups do not always respond immediately to the disturbance. Mothers will return and encourage the pup to follow, generally directly after the disturbance has occurred, however, it was observed that some pups were not reunited with their mothers. In case of mother-pup separation, mother seals don't make any noticeable sounds compared to the pups, which are very vocal when separated from their mothers. Pups that were separated from their mother were heard vocalizing for hours after the separation occurred, or until the mother had returned.

Approximately 3 to 4 weeks after birth, the pups do not need to rely on their mothers anymore and are able to hunt for themselves. Weaned pups rest in groups for most of the time on the shore (Figure 11). They seem to be less disturbed by people or any other kind of disturbance that occurs on the dyke. The weaned pups usually stay in the water inlet near the dyke even when the tide is low without moving to the farthest side of the sandbank like adults do. Tidal cyclic movements of adults seals was observed frequently on the water inlet with seals moving further away from the dyke with the descending tide.

Figure 11: Group of weaned pups resting together on the water inlet in the Dollard estuary.

This year (2011) researchers were able to observe a particularly spotted adult female who had appeared to have lost her pup. She approached numerous the pups in the water inlet, even if they were associated with another female. The spotted female would often nuzzle the pups and encourage them to follow her into the water. Once she had encouraged the pup into the water she was seen swimming away, leaving the pup alone. She performed this behaviour for several days. This female was never seen suckling a pup.

During the observation period a number of pups were orphaned. A majority of these separations of mother and pups were caused by the disturbances occurring on the dyke. The initial behaviour expressed by the mother is restlessness followed by the intensive search for the pup. The abandoned pup shows restlessness as well and usually vocalizes loudly for a long period of time.

3.3.2 Case studies of mother and pup behaviour in the Dollard

Unfortunately, it's not possible to identify all the individual seals in the Dollard estuary from the observation point. However, there were some exceptions. Some individual seals show distinctive marks or colourations that allow researchers to follow them partially or for the entire period of study.

During observations a number of seals were recognized frequently using the water inlet. Two adult females in particular, one with a wound around her neck (Figure 12) and the other one with a particular red colour on her head (Figure 13) were frequently observed during the observation period.

The mother with the neck wound and red headed mother were seen on the 30/05/2011 and 31/06/2011 respectively for the first time with their pups. Both mothers were still seen with their pup on the last day of observation (13/07/2011).

Figure 12. "Neck wound" mother with her pup in the Dollard estuary.

Figure 13. "Red head" mother with her pup in the Dollard estuary.

3.4 The use and effectiveness of the observation platform for viewing common seals in the Dollard

Early 2011 an observation platform was installed on top of the dyke to prevent visitors to the area from creating an actual disturbance. Details of this observation platform can be found in section 2.3.4. This section looks at the effectiveness of the observation platform and the effects of the potential and actual disturbances caused by people using the observation platform.

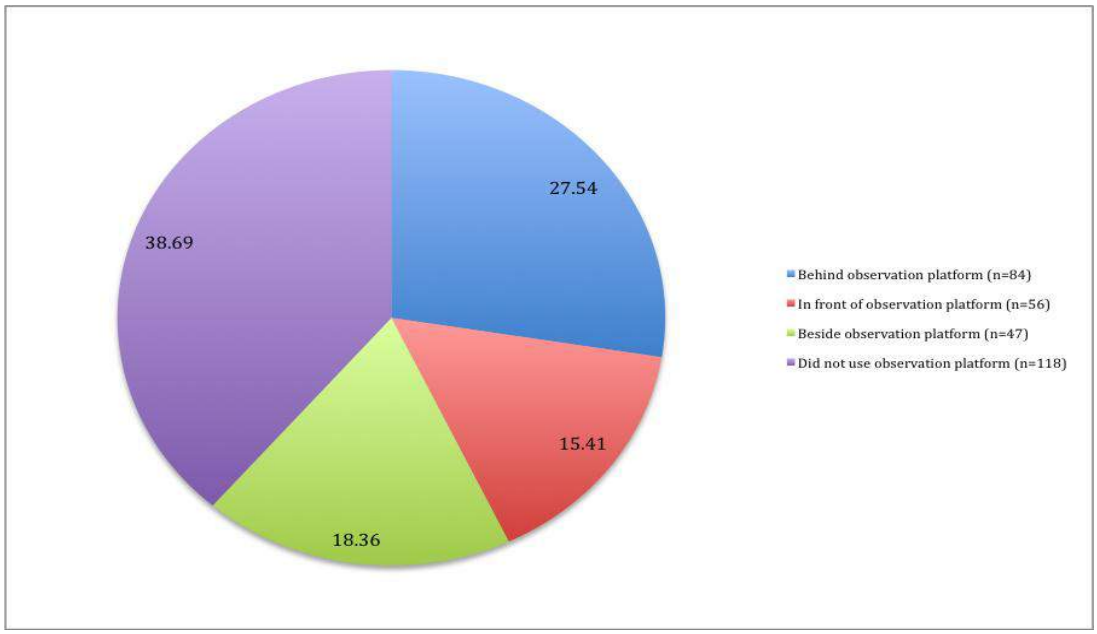
In total, the observation platform was used on 305 occasions. To look at the effectiveness of this observation platform an analysis was done to look at whether people using the observation platform had an effect on the behaviour of the seals, primarily on the water inlet. The remaining sandbanks are located further away from the dyke and are generally not disturbed by events on the dyke.

Initial observations showed that there were four categories to the use of the observation platform: people who stood behind the observation platform, people who stood in front of the observation platform on the concrete platform, people who stood beside the observation platform and people who did not use the observation platform.

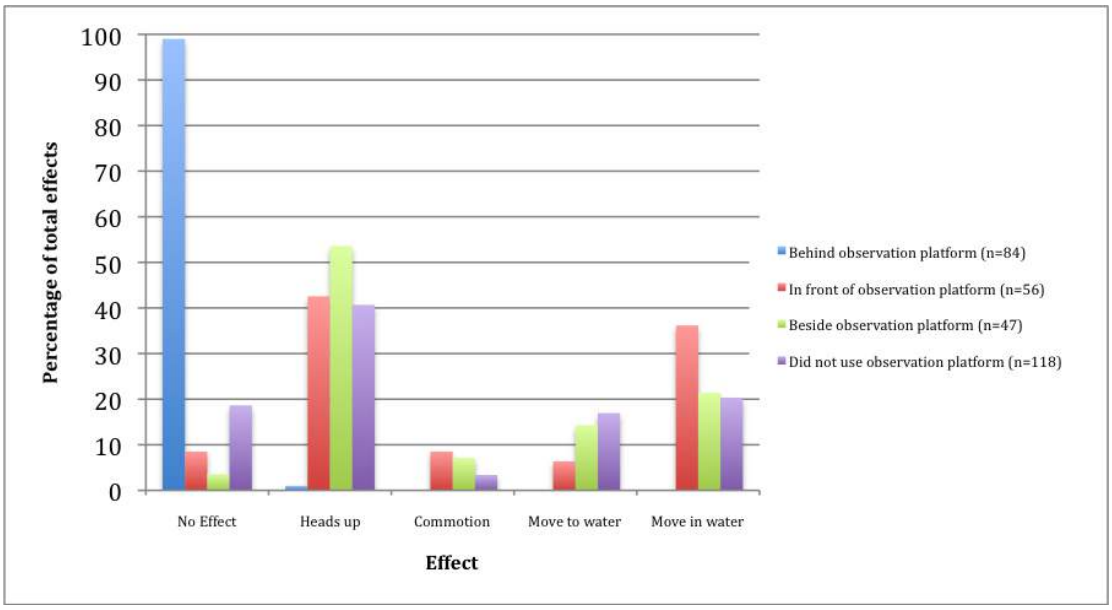
During the observation period it was shown that 27.54% of people stood behind the observation platform (Graph 14). It was shown that 99% of people who used the observation platform that way had no effect on seal behaviour (Graph 15).

It was also found that standing in front of the observation platform or beside the observation platform also caused a high disturbance to the seals, 91.49% and 96.43% respectively. People standing in front or beside the observation platform cause very high percentages of disturbances. It must be noted that the sample size was much less of that compared to people standing behind the observation platform and people who did not use the observation platform. A total of 38.69% of people did not use the observation platform at all, this lead to a disturbance of 81.36% on seal behaviour.

Observations showed that seals hauling out on the water inlet closer to the dyke (+/- 50 meters) were more likely to be disturbed by the use of the observation platform compared to the seals hauling out at the end of the water inlet near the water channel.



Graph 14: The percentage of use of the observation platform in the Dollard estuary from day 147 – 194 (27/05/2011 – 13/07/2011).



Graph 15: *Percentages of the effects of the observation platform in the Dollard estuary from day 147 – 194 (27/05/2011 – 13/07/2011). (Please note that the combined x axis is equal to 100% for each of the categories).*

3.5 Water quality parameters

Water quality is a good indication of the health of an ecosystem. Samples taken at the Dollard estuary during the observation period were compared to Delfzijl and Lauwersmeer. By comparing the different locations we are able to see whether the Dollard estuary's water quality is influenced by the industrial development in the area.

The water parameter that had the most varied results between sample sites was PO_4. The Dollard estuaries samples varied between 0.5mg/l and 1mg/l and Delfzijl 1mg/l. Lauwrsmeer however, recorded 0.1mg/l (Figure 14).

Water quality tests from all of the sample sights indicate that there was 0mg/l of NH_2/NH_3 and Cu. Very little difference was noted in pH with values ranging between 8.5pH to 9pH. The amount of Ca in the Dollard area was slightly lower (180-240mg/l) then that in both Delfzijl and Lauwersmeer (260mg/l) (see appendix). The KH values in the Dollard estuary varied from 5 to 8, Lauwersmeer 6 whilst Delfzijl had the highest reading of 9. NO_2 varied between 0mg/l and 0.5mg/l in the Dollard estuary, with Lauwersmeer recording 0mg/l and Delfzijl 0.5mg/l (see Appendix). NO_3 varied between 0mgl/l and 10gm/l at the Dollard estuary whilst both Delfzijl and Lauwersmeer recorded 0gm/l (see Appendix). The temperature of the water was relatively constant throughout the observation period and at Delfzijl and Lauwersmeers with recordings between 22.1`C and 22.4`C (see Appendix).

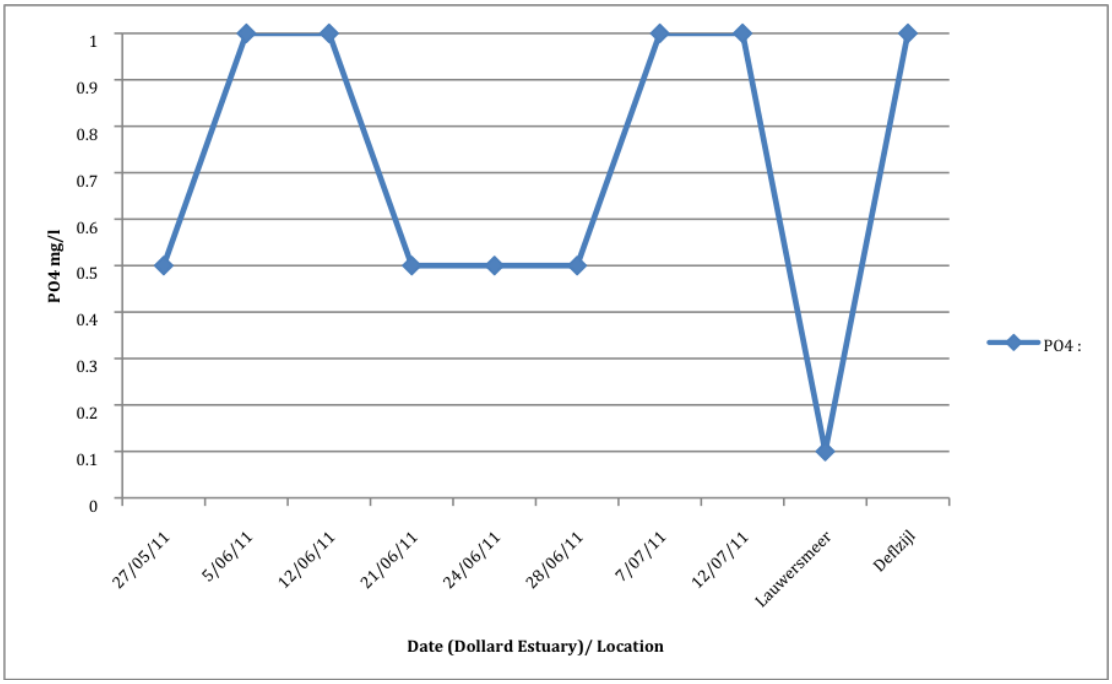


Figure 14: Total amount of PO_4 (mg/l) in water samples taken from the Dollard estuary, Delfzijl and Lauwersmeer.

4. Discussion

This chapter will discuss the research aims in regards to the results analysed in the previous section. With respect to the research method, it must be noted that there were a number of variables that may have influenced the results of this report.

Distribution and abundance counts count may have been influenced by the environmental conditions. It was noted that due to the presence of rain, visibility on some of the sandbanks, especially sandbanks 3 and 4, was impaired. Rain reduced visibility and impaired vision through the lens of the binoculars and telescope. The presence of cloud cover reduced light and therefore reduced visibility of the area. High wind conditions trembled the telescope reducing the ability to focus. It was also noted that weather conditions in 2011 were considered quite poor compared to previous years. On sunny days the photospheric oscillations made observing sandbanks 3 and 4 difficult.

Other variables to take into consideration are related to the behaviour of seals and their position on the sandbanks. Seals generally haul out on sandbanks in groups. The larger the group of seals, the more difficult it was to distinguish between individuals. Seals may be situated behind one another, in close proximity to each other, or behind the sand ridge of the sandbank. When pups were present they are easily hidden behind a mother or adult resting on the same sandbank. During the final observation days it became quite difficult to distinguish between yearlings and newly weaned pups, as they were very similar in size and appearance.

Observers were present during the observational period and therefore must also be considered a potential disturbance if not directly, but indirectly. The observers behaved in a manner not to disturb the seals, however their presence at the Dollard may have influenced the behaviour of visitors to the area. The presence of the observers may have encouraged the curiosity of visitors, resulting in people approaching the observers to ask questions, and thus increasing the chance of disturbances. The observers may have also influenced the behaviour of the visitors to the area resulting in more cautious behaviour.

4.1 Distribution and abundance of common seals in the Dollard

The first study of the distribution and abundance of common seals in the Dollard was carried out in 1993 with a maximum of 77 seals (Selvaggi 2001). Since then, the population of common seals in the Dollard estuary has increased, with 395 seals observed on day 179, 2011 (28/06/2011). Seasonally the number of seals present in the Dollard estuary varies with a higher population numbers present during the birth season.

Females use the sandbanks in the Dollard estuary to give birth, lactate and haul out (Pauli & Terhune, 1987, Thompson, 1993, Riess 1999, Wilson, 1978). It was also noted that males were present during the birth season. Incidentally a few males were observed hauling out on sandbanks as well as displaying visually and acoustically throughout the observational period. These demonstrated behaviours became more abundant during the later part of the study.

Certain sandbanks appear more favourable then others. Sandbank 1 and sandbank 3 had higher total seal abundance at the beginning of the observational period and both declined as the observations progressed. Contrary, the water inlet was least abundant at the beginning of the observational period, becoming more popular towards the end. The water inlet also had a higher pup to adult ratio.

When looking at the location and composition of the sandbanks we may be able to understand more about the movement and use of the sandbanks in the Dollard. According to Pauli & Terhune, 1987, seals prefer to haul out on steep sided rocks at the beginning of a low tide and then move to a lower profiled gradient on a descending tide. This was demonstrated in the water inlet. Although the Dollard's sandbanks lack rocky substrates, the gradient of the slope varies from the individual sandbanks. The water inlet has a steep slope profile closer to the dyke. As you move along the sandbank toward the water channel and sandbank 1, the gradient of the slope decreases. It was observed that seals preferred the steep gradient slopes when the tide was high and moved to the end of the sandbank on a descending tide. This movement maybe influenced by the ability of a seal to exit the water on a high gradient slope.

In contrast to the other sandbanks the water inlet had the highest presence of (abandoned) orphaned pups. This may have been due to the geographic location of the area as the water inlet was the last haul out site to be submerged on an incoming tide. The water inlet was also the first exposed on a descending time, thus providing an area where the pups can rest for a longer period of time. Pups may have also been carried with the incoming tide to the water inlet. It is unclear whether there is an increased separation risk between mother and pup in the area or that abandoned/orphaned pups move towards this area. Mother and pups close to the mainland where the presence of varying disturbances is greater, have a higher chance of separation.

Very few seals utilised sandbank 2 and sandbank 4. These sandbanks were considerably smaller and had a reduced exposure time than the remaining sandbanks. Therefore sandbank 2 and 4 were not a significant haul out site for females to give birth and lactate.

During this study it was possible to follow some individual common seals movements between banks. Depending on the movement of the tides and composition of the sandbank, it also found cyclic movement of larger groups of seals. This has been described by Thompson 1993 who describes cyclic movements in association with the availability of haul out sites due to tidal movements and the characteristic of the sandbanks. In estuary areas, where tides influence the availability of haul out sites, the haul out pattern follows the tidal cycles (Pauli & Terhune, 1987, Thompson, 2005). To understand cyclic movements of common seals in the Dollard, future research is required.

4.2 Disturbances on common seals in the Dollard

Most actual disturbances occurred in the water inlet. Due to the location and nature of the water inlet, the water inlet was more prone to disturbances from the land. It was also much

easier to observe seal behaviour on the water inlet as it is in close proximity to the observation area. Observations also showed that the degree of response to a disturbance varied, with the same event not always triggering the same kind of response. Furthermore, the awareness of a disturbance is also different to that of a seal. For instance, seals are less aware of airborne sounds than a human (<10KHz) (Richardson, 1995).

More than half of all actual disturbances were due to land disturbances caused by pedestrians. This has also been noted in previous Dollard studies and in other locations around the world. Common seals in Glacier Bay, Alaska (Lewis, 2000) showed a similar response to the presence of pedestrians. To a lesser extent, seals in the Dollard were also affected by cyclists (9.90%) and aerial events (10.42%).

Observations showed that the distance and nature of the disturbance, especially in regards to pedestrians, triggered different responses. Pedestrians at a distance less then 50 meters from the nearest seal often led to a response, 50 to 100 meters frequently triggered a response and pedestrians greater then 100 meters rarely invoked a response from a seal. Studies outside of the Dollard have shown that boats are the main cause of disturbance to common seals (Suryan, 1999. Johnson, 2007. Hennery, 2001). Observations in the Dollard however, show that boats had a minimal impact (3.65%) on the seals. This is more then likely a result of the haul out sites being located in a protected area (Natura-2000 legislation), which limits boat access between May 15th to 1st September.

In total, more than half of seals responded negatively to a disturbance within the Dollard estuary. The disturbance events this year are greater then that of previous years, indicating an increase in human activities in the area.

Observations demonstrate that the seal's response to an event varied considerably. Sometimes the seals would respond to an event that occurred and at other times a similar event triggered no or little response from the seal. The discrepancy of effects that have been triggered by an event has been demonstrated in this research and previous research at the Dollard. Terhune and Almon (1983) (in Suryan, 1999) reported that the response to a disturbance was different from group to group. Previous studies on seals also showed that "different levels of tolerance among age, sex, or reproductive status" influenced seals reactions, and they differ "within and among regions" (Suryan, 1999). Responses to disturbances may also be related to wind direction, however future research is required.

An increase in human activities in the area can severely impact the seals during the birth and moulting season (Suryan, 1999). Newby (1973) (in Suryan, 1999) noted that a female common seals with a pup show a tendency to be "constantly nervous and alert". It has also been shown that seals are more likely to be disturbed at a pupping site (Suryan, 1999).

These disturbances can potentially lead to the separation of a pup from its mother. This is likely to occur when the mother enters the water to escape the disturbance. Observations at the Dollard show that mother and pup pairs are first to respond to a disturbance. During the course of this study, numerous disturbances lead to a simultaneous widespread panic of mother and pup pairs, thus increasing the chance of separation. Not all pups were reunited with their mothers and were subsequently rescued and cared for at the SRRC. Mother and pup pairs who are frequently disturbed are exposed to negative energetic consequences. Pups have less time to nurse and rest during a disturbance (Drescher, 1979 and Reijnders, 1981). This may increase the mortality within a population.

Observations show that abandoned pups are never taken care of by other mothers in the Dollard estuary. Pups have been observed attempting and on rare occasions suckling from another mother but very quickly are turned away when the adult realises it is not their pup.

This research looks at the varying events and effects on common seals in the Dollard estuary. To understand the true nature of the effects on common seals, more research is required to understand the long-term outcome of these events. Previous studies have shown that only 39% of all disturbances encountered a full recovery (Suryan, 1999). Selvaggi (2001) found that 75% of seals that left a sandbank at the Dollard did not return during the same tide from

a disturbance. Some seals were more tolerant to a disturbance, whilst others left and did not return. Suryan (1999) also noticed that a seal, which stayed or returned after a disturbance, was less likely to be effected by a new event. This would be an interesting aspect to measure in future research at the Dollard.

The protective measurements of the Punt van Reide and the construction of an observation platform are taken into account as positive measures to protect and limit disturbances to the seals hauling out in the area. However, 114/192 of actual disturbances, and 119/209 of potential disturbances can be contributed to “pedestrians”, is a concern and warrants for further investigation.

4.2 Mother and pup bonds in commons seals in the Dollard

Mother seals and their pups have a strong bond, maintained by physical contact. This bond appears stronger in the period immediately after birth where the interactions are numerous. The most common behaviour, which was observed, was resting. Nuzzling occurred quite often as well. Suckling was not seen very often and when it occurred it did not last for more than 1 minute, in the cases observed. In the weeks following birth, interactions remain but become less frequent. After approximately 4 weeks the pup is weaned and eventually the mother will leave the pup.

Many orphaned pups were sighted during the observation period of this study. The separation of mother and pup was predominantly caused by a human disturbance, namely pedestrians. These anthropogenic disturbances cause the mothers to enter the water rapidly without the pup. It was observed that pups where least likely to be affected by a disturbance than an adult. In most cases mothers came back to their pups, but, if the disturbance was prolonged, it was unlikely that the mother and pup would reunite.

A total number of 44 pups were rescued from the Dollard area and taken to the Seal Rehabilitation and Research Centre Zeehondencreche Lenie't Hart during the observation period 27/05/2011 to the 13/07/2011. During the observation period the maximum number of pups observed was 140. This result indicates a conservative figure of 24% (44/(140+44)) of the total pup population within the Dollard estuary. The first pup rescued from this site arrived at the SRRC the 04/06/2011 and the last one was brought in on the 12/07/2011.

4.4 The use and effectiveness of the observation platform for viewing common seals in the Dollard.

During the observational period less than one third of visitors used the observation platform. Of this, 99% of people who stood behind the wooden panels on the observation platform did not create a disturbance to the seals hauling out in the water inlet. This figure indicates that the best way to view common seals in the wild is to stand behind the observation panels on the platform and to use the peepholes provided.

Based on previous observations in other areas it was expected that the wooden panels would prevent the seals from seeing the silhouettes of people standing in front of the observation platform. It was previously noted in Lenie ‘t Hart, pers. Comm. 28th of May 2007, “that vertical moving objects easily frighten the seals hauling out in the Dollard”. Our results concluded that vertical moving objects such as the silhouettes of pedestrians (43 out of 47) standing in front of the observation panels actually created a disturbance to the seals in the water inlet.

People standing beside (54/56) or not using the observation platform (96/118) were completely visible to the seals and created the biggest disturbances to the seals in the water inlet.

It was noted during observations and discussions with people using the observation platform that there was a lack of information about the correct use of the observation platform. Many visitors were unaware of seal behaviour and seal responses to their movement on the dyke.

This lack of knowledge and incidental behaviour had a significant effect on the seal in the water inlet. Visitors were seen approaching the observation platform from the top of the dyke, which often creates a disturbance, compared to approaching from behind the dyke.

We must also take into consideration that the observation platform can enhance potential and actual disturbances on seals in the water inlet. Passers by that may not necessarily know about the seals hauling out in the area may be attracted to the site, thus increasing the usage of the observation platform and the disturbances associated.

Further studies are needed to examine the various aspects of the effectiveness of the observation platform. Recommendations on ways of potentially enhancing the current use of the observation platform will be discussed in the following Section, 4.1.7.

4.5 Water quality parameters

Tidal estuaries are dynamic environments where chemical properties can vary over small time-scales (Elsdon T.S, Gillander .B. 2006). The health of an aquatic ecosystem is highly dependent on the quality of the water.

Phosphorus is a necessary requirement for the growth of all organisms (Van Mooy, 2009). PO_4 is often a limiting nutrient in environment, especially freshwater ecosystems, and a value outside of the natural range may affect the rate of growth of organisms. The availability of PO_4 in the Dollard estuary and the effect on the seal's growth rate is an area of interest for future research.

Results indicate that the Dollard estuary has a higher reading of PO_4 compared to Lauwersmeer. Laurwersmeer is an area not dominated by industrial development and results showed that this location had 0.1mg/l of PO_4. This lower reading may be related to the lack of industrial development around this area. The high results of PO_4 in the Dollard estuary and Delfzijl could also be contributed to the industrial and agricultural development along the Eems River and Dollard estuary, however more research is required.

Calcium is necessary for all living organisms, and is a major material in used in the mineralization of bones and shells. Compared to the Dollard, calcium levels appeared slightly higher in Delfzijl and Lauwersmeer (260mg/l). Differences in result however are not significant. Marine waters generally have approximately 400mg/l of Ca. The Dollard estuary, an area of where fresh and marine water converge, would have significantly less Ca as indicated by our results. Delfzijl and Lawersmeer being located further away from a large input of fresh water would indicate slightly higher values, as demonstrated.

High concentrations of nitrate (NO_3) can contribute to eutrophication and potentially cause the death of aquatic species in freshwater and estuarine systems. While nitrate is much less toxic than ammonia or nitrite, levels over 30 mg/l of nitrate can inhibit growth, impair the immune system and cause stress in some aquatic species (EEA 2004, Romano. N, Zeng. C, 2007). NO_3 occurs naturally in rivers at concentrations around 0.4 to 4mg/l (EEA, 2004). NO_3 in western European rivers have recorded NO_3 levels of 15.5mg/l (2002) (EEA, 2004). Results in this report show that NO_3 levels in the Dollard estuary were 10mg/l. These results are also inline with values found in western European rivers (EEA, 2004). Results for Delfzijl and Lauwersmeer showed no NO_3, this might have been contributed to a mistake in analysis, and low sample size. The full impact on NO_3 on the health of seals in the Dollard requires further investigation.

The remaining water parameters (pH, KH, NO2, NH2/NH3 and Cu) showed little variance amongst results in the sampled areas, with Delfzijl and Lauwersmeer results falling within the result range of the Dollard estuary.

4.6 Conclusion

The indigenous population of common seals in the Dollard has increased in abundance, based on data collected throughout the duration of this report. The common seals (adults and pups) have shown preference to particular haul out sites within the Dollard depending on the time of the year. Certain sandbanks appear more favourable then others to give birth, lactate and rest, with preference given to sandbanks that are exposed for a longer period of time. The artificially created water inlet is an important birth location, however the seals are more prone to anthropogenic disturbances, which can potentially impact on the behaviour of seals and the health of suckling pups.

Movements between sandbanks have been observed between groups and individual common seals. These cyclic movements appear to be associated with the movement of tides within the Dollard estuary.

Disturbances recorded throughout the duration of this study have shown a negative impact on common seals hauling out in the Dollard estuary. These disturbances can alter seal behaviour and during the pupping season, can impact on pup health and survival, and therefore potentially impact on the population as a whole. With conservative estimates of just under one quarter of pups requiring rescue and rehabilitation by the SRRC, indicates that a substantial proportion of mother and pup pairs are subject to separation. Disturbances can lead to the prolonged suffering of individual pups and pedestrians still remain the main source of disturbance, despite the observation platform.

4.7 Recommendations

The following recommendations are personal opinions of the researchers involved in the study. These recommendations are formulated from observational and statistical information gathered throughout the duration of the study.

This research has shown that anthropogenic disturbances occurring at the Dollard is increasing and having a negative effect on seal behaviour and potentially seal health. People cause over 50% of actual and potential disturbances. This disturbance must be reduced to maintain a healthy colony of common seals in the Dollard.

An observation platform constructed on the dyke has shown to be an effective method in reducing people associated disturbances when used correctly (Figure 15). 99% of people standing behind the observation platform did not cause a disturbance to the seals, however people not using or not remaining hidden from the seals caused significant disturbances.

It is important to educate and encourage people to use the observation platform correctly when viewing seals to reduce disturbances.

It was noted during numerous discussions with visitors that they were unaware about the seals in the area and how their actions can lead to a disturbance. An informative sign is available on the right back panel of the observation barrier and at the fence on top of the dyke, however by the time the visitors get to the sign the disturbance has already been made.

To prevent this from occurring, informative signs need to be strategically placed to inform the visitors before they have the chance to cause a disturbance. Based on a survey of the area with emphasis on where visitors were accessing the area, sites for potential signs have been noted.

Visitors often accessed the area via the access road behind the dyke or on top of the dyke. Both of these access areas do not provide information about the local area and wildlife within. Ideally, information signs should be placed at the top of the dyke before accessing the dyke directly above the water inlet and at the access road gates (Figure 16). Ideally access should

be limited from the top of the dyke during the pupping season. This can be achieved by removing all of the step structure at the fence.

It is understood that information on signs about the seals in the area may encourage people to access the area or to use the observation platform. Therefore it is important that the wording of the sign is informative but not encouraging.

The current design of the observation platform has proven to be successful, however there are a number of aspects, which can be improved to reduced disturbances associated with its use. It was observed that numerous visitors accessing the observation made their way to the observation platform in direct view of the seals in the water inlet. Visitors were also seen standing beside the observation platform in direct sight of the seals. People standing beside the observation platform (54/56) caused a significant disturbance to the seal in the water inlet. A guidance barrier and stairs to the observation platform could reduce this occurrence (Figure 17 and Figure 18).

The guidance barriers would need to be removable, solid and not impact on the livestock in the area. Ideally a wooden post barrier that is easy to assemble and disassemble would be best. Posts could be inserted into permanent posthole secured to the dyke. A staircase would allow visitors to access the observation platform with ease (Figure 17 and Figure 18). It is also a more encouraging way to access the top of the dyke as walking up the dyke has shown to be difficult and dangerous at times. Guidance barriers would be ideal to assist with people accessing the observation platform and in reducing potential risks (Figure 17 and Figure 18).

Additional peepholes are recommended, as visitors were unable to see the seals when there were several people using the platform. When peepholes were unavailable, visitors would often stand beside or in front of the observation platform. People standing in front of the observation platform caused a 91.49% disturbance. This finding shows that the silhouette of the visitors is distinguishable from the wooden panelled background and does lead to a disturbance. With this in mind access should be limited to the front of the observation platform. A barrier (wooden or chain) may be sufficient enough to prevent people from accessing the front of the observation platform (Figure 17 and Figure 18). Peepholes should also be located at various heights to allow children and adults alike to view (Figure 18).

Education is an important tool in informing visitors about the importance of the local area and wildlife. Throughout the observation period numerous guided tours by the local Groninger Landschap proved to be a successful way of educating people about the local area and preventing disturbances to the seals. People associated with the Groninger Landschap were less likely to cause a disturbance even when larger groups were involved, as they were guided/informed to stand and remain hidden behind the observation platform.

Providing education and information alone will not guarantee sufficient changes in the reduction of disturbances to seals in the Dollard estuary. Technical changes to the observation platform are also required to ensure that the indigenous colony of common seals is protected for future generations.

Current aerial view of observation platform and surrounding area:

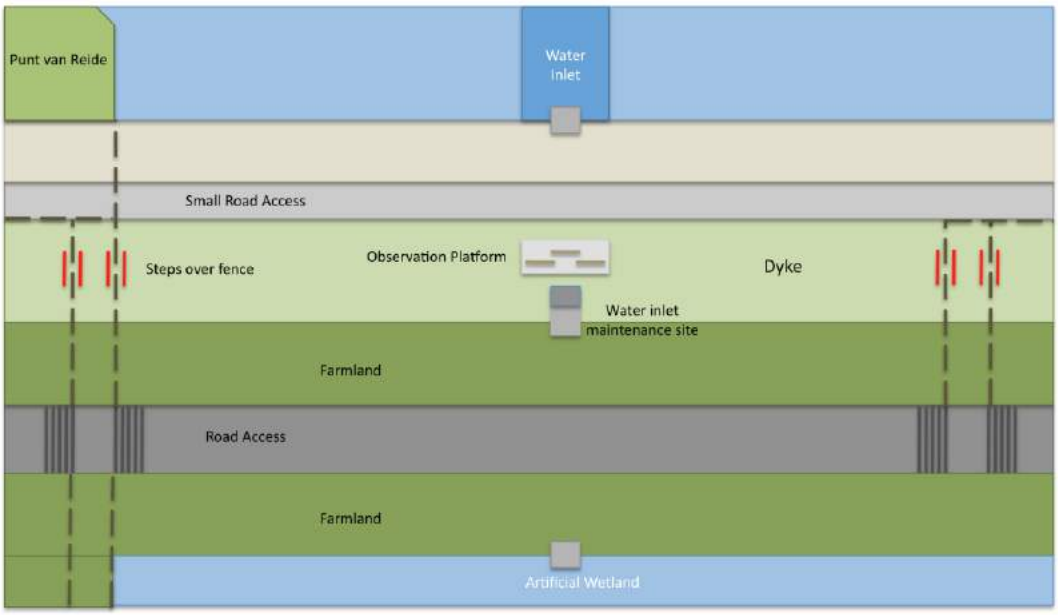


Figure 15: An aerial view of the current design of the observation platform and surrounding area at the Dollard.

Concept aerial view of observation platform and surrounding area:

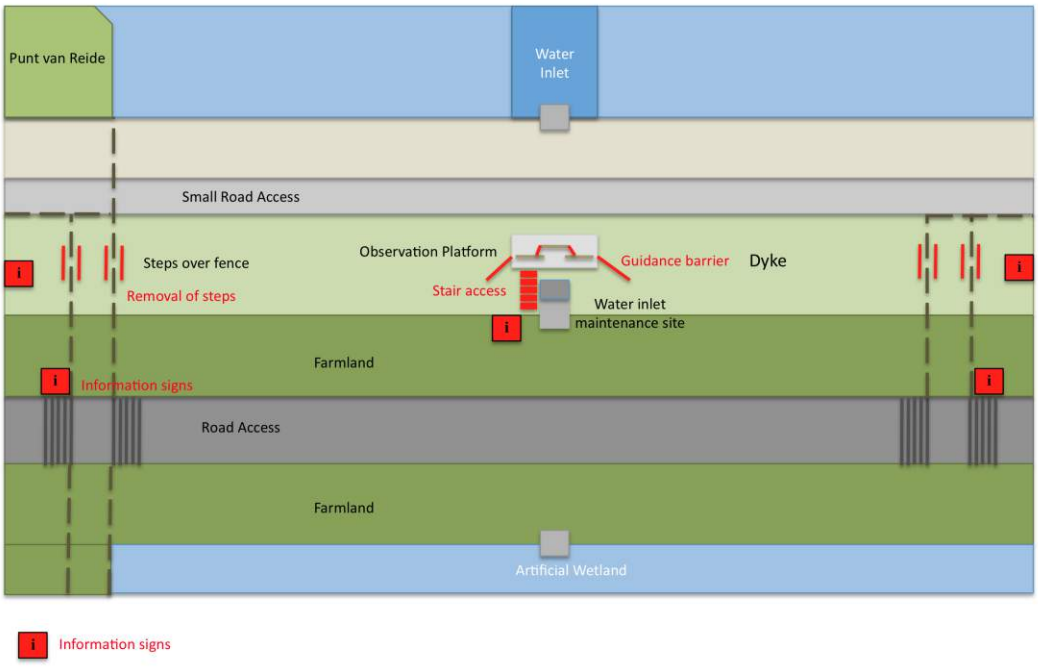


Figure 16: An aerial view of the concept design of the observation platform and surrounding area at the Dollard.

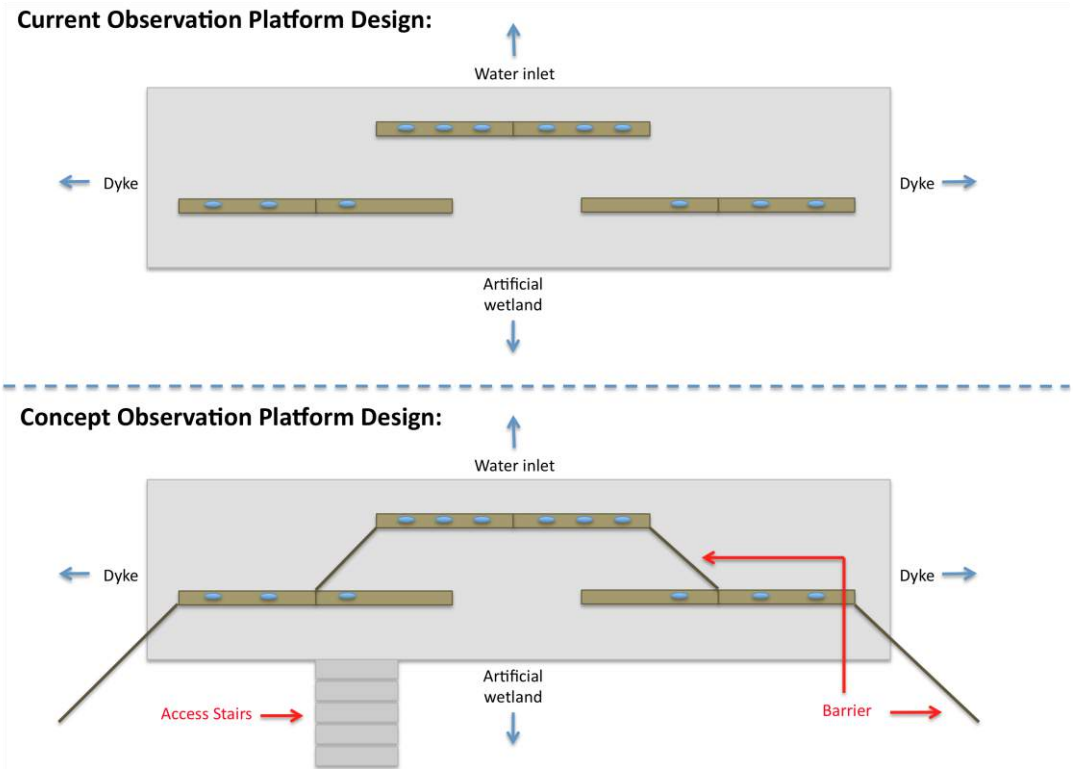


Figure 17: The aerial view of the current and concept design of the observation platform at the Dollard.

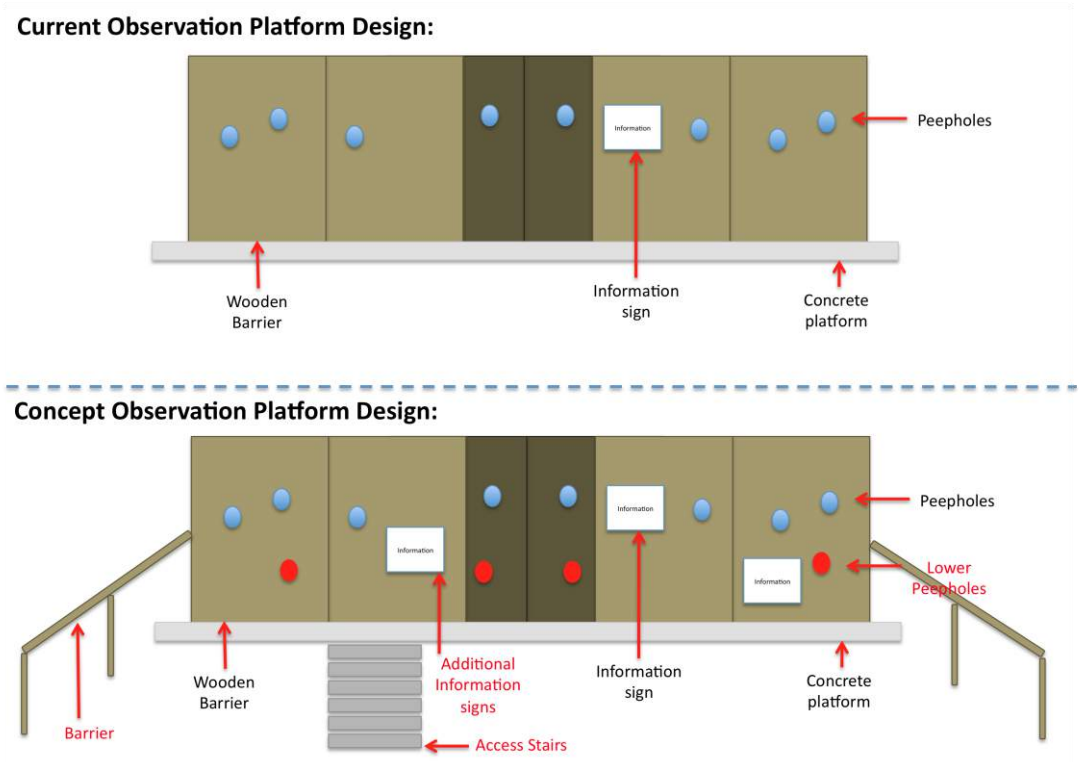


Figure 18: The current and concept design of the observation platform at the Dollard. (View facing landside)

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6 References

Dortch. Q 1982 Effect of growth conditions on accumulation of internal nitrate, ammonium, amino acids, and protein in three marine diatoms. Journal of Experimental Marine Biology and Ecology. Volume 61. Issue 63. 1982, Pages 243-264

Drescher H.E. 1979 Biologie, Okologie and Schtz der Seehunde im Schleswig-Holsteinischen Wattenmeer, Landesjagdverband Schleswig Holstein e.V., Meldorf Germany

EEA Data services (2004). (http://dataservices.eea.eu) IRENA 30.1 Nitrates in water

Elsdon. T. S, Gillanders .B. 2006 Temporal variability in strontium, calcium, barium, and manganese in estuaries: Implications for reconstructing environmental histories of fish from chemicals in calcified structures. Estuarine Coastal and Shelf Science, 2006; 66 (1-2):147-156

Google Earth 2011

Haaften van J.L. 1983 The life history of the harbour seal in the Wadden Sea, In: Wolff, W.J. (Ed). Ecology of the Wadden Sea, pp. 7/15-17/19

Hart 't P, 2007 *Zeehonden Jacht in Nederland 1591 – 1962.* Academisch Proefschift Vrije Universiteit Amsterdam.

Havinga B. 1933 Der Seehund (Phoca vituline L) in den Hollandischen Gewassern. Tijdschr. Der Ned Dierk. Ver. 3, 2&3: 79-111

Henery E., Hammill M.O. 2001 Impact of small boats on haul out activity of harbour seals (Phoca vituline) in Metis Bay, Saint Lawrence Estuary, Quebec, Canada. Aquatic Mammals 27, 140-148

Hewer H.R. 1974 British seals. Taplinger Publishing Co. Inc. New York.

Johnson A., Avevedo-Gutierrez A. 2007 Regulation compliance by vessel and disturbance of harbour seals (Phoca vituline). Canadian Journal of Zoology. 85, 290-294

King J. E. 1983 *Seals of the World. Oxford University Press*. Oxford, United Kingdom.

Newby T.C. 1973 Observations on the breeding behaviour of harbour seals in the state of Washington. J. Mamm. 54 (2): 540-543.

Pauli B.D., Terhune J.M. 1987 Tital and temporal interaction on harbour seal haul out patterns. Aquatic Mammals. 13 (3): 93-95

Reijnders P.J.H 1981. Management and conservation of the harbour seal (Phoca vituline, polulation in the international Wadden Sea area. Biological Conservation 19, 213 - 221

Richardson W.J., Greene Jr: C.R., Malme C.I., Thomson D.H. 1995 Marine Mammal and noise. Academic Press, Inc. San Diego, CA, 576p.

Ries E.H 1999 Population Biology and activity patterns of harbour seals (phoca vituline) in the Wadden Sea, DLO Institute for Forestry and Nature Research (IBN-DLO), Wageningen, p 104

Romano, N.; Zeng, C. (2007). Acute toxicity of sodium nitrate, potassium nitrate and potassium chloride and their effects on the hemolymph composition and gill structure of early

juvenile blue swimmer crabs (*Portunus pelagicus*). *Environmental Toxicology and Chemistry* 26: 1955–1962.

Selvaggi E. 1999 Effeti del disturbo sul comportamento della foca commune (Phoca vilulina) nell'estuario di marea del Dollard, Seal Rehabilitation and Research Centre, Pieterburen, The Netherlands

Selvaggi E. Effects of disturbance on daily rhythems and haul out behaviour in the Harbour seal (phoca vitulina) in the tide estuary of the Dollard (The Netherlands). Poster at the ECS Annual Conference, Rome (2001)

Suryan R.M., Harvey J.T. 1999 Variability in reactions of Pacific harbour seals, Phoca vituline richardsi, to disturbance. Fish. Bull. 97:332-339

Terhune J.M., Almon m. 1983 Variability of harbour seals on haul out sites. Aquat. Mamm. 10: 71 – 78

Thompson D., Lonergan, M., Duck, C., 2005 Population dynamics of harbour seal Phoca vituline in England: monitoring growth and catastrophic declines. Journal of Applied Ecology 42: 638 – 648

Thompson P.H. 1993 Harbour seal movement patterns. Symp. Zool. Soc. Lond., 66: 225-239

Van Mooy B. A. S. 2009 Phytoplankton in the ocean use non-phosphorus lipids in response to phosphorus scarcity. *Nature* 458, 69-72

Wagemann. R, Stewart. R.E.A, Lockwood. W.L, Stewart. B.E, Povoledo. M 1988 Trace metals and methyl mercury: Associations and transfer in harp seal (Phoca groenlandica) mothers and their pups. Marine Mammal Science. Volume 4, Issue 4 pages 339-355.

Wilson S.C. 1978 Social organisation and behaviour of harbour seals "Phoca vituline concolor", in Maine. Final Report contract MM6AC013, GPO – PB- 280 – 188, Marine Mammal Commission, Washington, DC, 36p

7 Appendix A: Observation Sheets

Common Seal Abundance Observation Sheet: Dollard 2011

Date: ____/____/____ L/Tide ___:_______cm H/Tide ___:_______cm

Observer/s: ______________________

Weather Conditions: ______________________ Wind Direction______ Temperature: ______ `c

Time Observed

Time Start: ___:___ Time Finished: ___:___

Time Interval	Actual/ Potential Disturbance	Water inlet				Sand Bank 1								Sand Bank 2		Sand Bank 3							
		Left		Right		A		B		C		D				A		B		C		D	
(Minutes)	A/P	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups	Adults	Pups
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Common Seal Mother Pup Relationship Observation Sheet:

Date: ____/____/____ L/Tide ___:_______cm H/Tide ___:_______cm

Observer/s: ______________________

Weather Conditions: ______________________ Wind Direction______ Temperature: ______ `c

Time Observed

Time Start: ___:___ Time Finished: ___:___

Time Interval	Actual/ Potential Disturbance	# of Pairs	Suckling				Nuzzling				Active				Resting		Resting	
(Minutes)	A/P		Water Inlet	Sandbank 1	Sandbank 2	Sandbank 3	Water Inlet	Sandbank 1	Sandbank 2	Sandbank 3	Water Inlet	Sandbank 1	Sandbank 2	Sandbank 3	Water Inlet	Sandbank 1	Sandbank 2	Sandbank 3
0																		
15																		
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Common Seal Disturbance Observation Sheet: Dollard 2011

Date: ____/____/____ L/Tide __:____ cm H/Tide __:____ cm

Observer/s: _____

Weather Conditions: _____ Wind Direction_____ Temperature: _____ °c

Time Observed

Time Start: ____:____ Time Finished: ____:____

Time	Actual/ Potential Disturbance	Recorded Event										Recorded effect					Additional Notes
	A/P	People	Cyclist	Car	Agriculture Vehicle	Boat	Ship	Airplane	Jet Fighter	Farmer	Other (please specify)	No Effect	Heads up	Commotion	Move towards water	Move into water	
TOTAL:																	

Appendix B: Water Quality Parameter Graphs.