

# The common seal in the Dollard (Wadden Sea)

a research into distribution and abundance,  
disturbance and  
mother-pup bond



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September 2007



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Cover picture: [www.Erik-van-ommen.nl](http://www.Erik-van-ommen.nl) (E. van Ommen)

## **Foreword**

This research has been carried out within the framework of the education of the two authors of this report, namely the education of Animal management at the van Hall Larenstein in Leeuwarden, the Netherlands.

For the start of our research and the advice during the making of our research proposal, we would like to thank Theo Meijer and Nynke Osinga.

Nynke Osinga was a great help for us during the overall period and served us with guidance, advice and help when and where possible during the internship.

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Arnout also wants to thank the people and staff of the SRRC personally for their hospitality during his stay at the centre and for the time he was hospitalised. The centre gave him a great support and a warm feeling.

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## Summary

In the Netherlands there are two species of seals, namely the common seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*). This report focuses on the common seal and has been carried out to learn more about the common seal, specifically about distribution and abundance, disturbance and its effect and the mother –pup bond. Three research questions have been formulated, which are in short: What is the distribution and abundance of seals and their pups over time, which events can be addressed as being disturbing for the common seals, what does the mother- pup bond look like.

The seals were being observed by means of a telescope in their natural habitat, namely in the North- East of the Netherlands in the Dollard area near the Punt van Reide, from 21<sup>st</sup> of May until 9<sup>th</sup> of July 2007. This period includes the birth season of the seals. The observation days were approximately seven hours long and started about two hours after high tide and ended about three hours after low tide. Five sand flats were identified for this study. Every 15 minutes the numbers of seals, with distinction between adult and pup, were registered for each of the sand flats. Every hour, these numbers were also inscribed into a map of the area. The potential disturbances were also recorded when present.

The first research question concerning distribution and abundance reveals that the different sand flats were not used in the same manner. Sand flat 3, the biggest sand flat, was occupied by the largest amount of seals followed by sand flat 1. Sand flat 4 was only used by a few seals and only when the tide was not at its lowest point. Latter was due to the fact that at the lowest point of the tide, there was not enough water left to swim in, and thus making it unable for a fast escape. Sand flat 2, the smallest, was mainly used in the peak of the season. The area near the water inlet was not used until the first pups were born on the 27<sup>th</sup> of May, but it was not until the 13<sup>th</sup> of June, that the water inlet was used throughout the day on a regular basis.

Concerning the disturbance, nine categories have been identified: Agricultural vehicles, Airplanes (propeller aircrafts), Boats, Ships, Cars, Cyclists, Farmers, Jet fighters (jet aircrafts) and Persons. To analyse the effect of the potential disturbance, five categories of effect have been identified; no effect, heads up, commotion, movement towards water and into the water. The latter four concern actual disturbance. In total 306 records of potential disturbance have been made, of which 58 (18,95%) were actual disturbance. Persons were recorded most often (52,61% ) and were also cause for most of the actual disturbance (50,00%). The category that was recorded secondly most often was Airplanes with 12,42% of the total of 306, but it is the Agricultural vehicles (6,86% of the potential disturbances) that comes second in causing actual disturbance with 13,79%. Airplanes, together with Boats, come third with 10,34% of the actual disturbance. It was also analysed whether the arrival of pups had influence on the sensitivity of the seals for disturbance. It can be said that the seals become more sensitive to disturbance, but this is not unambiguous, since it may also be that the seals started to use the water inlet more often when the pups arrived. The water inlet is right underneath the dike, close to potential disturbances on the dike. Pups were not as easily disturbed as the adults, especially the mothers. Observations also showed that seals can differ in sensitivity for disturbance, thus some day they will react to an event and on another day they won't respond to a similar event.

For the third research question concerning the mother-pup bond, it can be concluded that the mother does not leave her pup alone for the whole four weeks of the lactation period. When a pup is seen alone, it is an orphaned pup. Other seals, and especially mothers with pup, reacted aggressively against any pup that is not her own.

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# 1. Introduction

In the Wadden Sea area of the Netherlands there are two species of seals, namely the common seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*). This research focuses on the common seal in the Dollard, in the North-East of the Netherlands.

The common seal is an indigenous species in the Dutch Wadden Sea area. The common seals diet consists mainly of fish and, since they don't have natural enemies in the Netherlands, they are at the top of the food chain. This makes it an interesting species to study as the health status of the population reflects the environmental quality of the area. Besides this, the numbers of seals have declined greatly in some years, caused mainly due to the outbreaks of disease. In the year 1988 and 2002 there were major declines in the number of seals due to phocine distemper virus epidemics. In the year 2007, there was thought to be another outbreak, starting in Denmark, but as for now, the virus was not found yet in laboratory tests and also the disease did not spread any further. It still is not clear what gave rise to the increased mortality in Denmark and Sweden. The population has been growing steadily again, since the year 2002 and the numbers of seals are estimated at around 3500 in the Wadden Sea area at this moment based on aerial surveys (SRRC, 2007).

However, many aspects of the distribution and abundance of the seals still need to be studied, and as to how for example they use the different sand flats. Besides this, little is known about the scale of disturbance in the Dollard area, and about its effect on the seals. The Dollard area is important for the seals, since the area is used during the moult period and to give birth to pups. Literature research by the SRRC showed that there is a continues bond between mothers and their pups (Osinga & 't Hart, 2006). The current study includes field observations to further investigate the bond between mothers and pups. The Dollard area is an important haul out side for the seals and is therefore a closed area from the 15<sup>th</sup> of May until the 1<sup>st</sup> of September as formulated by the "Natuurbescherminswet". Since the three research aspects intertwine and all come together in the Dollard area, it provides a good opportunity to study all three together.

The main objective for this research is to learn more about the seals and specifically about the distribution and abundance, the nature and influence of disturbance and the mother- pup bond.

The research questions formulated for this study are:

1. What is the location of the individual common seals and their pups over time, between 2 hours after high tide and 3 hours after low tide, in the Dollard area , nearby the Punt van Reide during the observation period of 21<sup>st</sup> of May till 9<sup>th</sup> of July 2007?
2. Which events can be addressed as a disturbance for the common seals between 2 hours after high tide and 3 hours after low tide, in the Dollard area, nearby the Punt van Reide during the observation period of 21<sup>st</sup> of May till 9<sup>th</sup> of July 2007?
  - a. Which events occur during the observation period?
  - b. What is the response from the common seals to the occurring event?
3. What does the mother-pup bond look like, between 2 hours after high tide and 3 hours after low tide, in the Dollard area, nearby the Punt van Reide during the observation period of 21<sup>st</sup> of May till 9<sup>th</sup> of July 2007?
  - a. What is the activity from mother and pup together?
  - b. What is the distance between mother and pup?
  - c. How often is a pup left alone?
  - d. For how long is a pup left alone?

The next chapter, chapter 2, will be about Material and method, which starts of with a description of the research area and research species (the common seal, *Phoca vitulina*), followed by a description of the Seal Rehabilitation and Research Centre (SRRC). Chapter 2 will end with describing the method used for this study.

Chapter 3 presents the results and analyses, with each of the three different research questions in a separate subparagraph.

Finally chapter 4 will give the discussion, recommendations and conclusion of this study.

## 2. Material and method

This chapter will start with a description of the area where the study was conducted. After that, in paragraph 2.2, the species of the study is described. In paragraph 2.3 one can read about the rehabilitation and research centre. The final paragraph 2.4 will describe the research method. Paragraph 2.4 will outline the method for the three different research questions in separate subparagraphs.

### 2.1. Research area Punt van Reide

The position from where the seals were observed for this study is on the edge of an area called 'Punt van Reide'. This area is situated in the northeastern part of The Netherlands in the province Groningen, around 240 kilometers from Amsterdam. The exact position from where the seals were observed is: 53°17'51.39" N, 7°05'05.44" E

The waters in the Dollard are closed during a part of the year. Fishing and recreational activities are not allowed in the area during a period starting in 15<sup>th</sup> of May till the first of September. The waters are prevented to flood the land, by a dike, surrounding a complete polder. This polder is called the 'Breebaartpolder' and is a refuge for a lot of (wading-) birds. This polder is also connected to the sea with a water inlet, which is the same water inlet around which the seals were observed.

It is not allowed to enter both areas except from the pathways. Both areas are protected by article 461 of the criminal code and the 'Punt van Reide' is also protected by article 17 of the nature conservation law. The 'Punt van Reide' may not be entered all year long. It is one of Holland's only places which has an all year prohibition to enter. The complete area of 'Punt van Reide' is 46 ha. (113,67 acres).

The only people who have permission to enter the area are farmers with their sheep and employees of the 'Groninger Landschap'.

The 'Groninger Landschap' is an organisation which has the management on the area.

### 2.2. Common seal as research species

The common seal (*Phoca vitulina*), also known as harbour seal, is one of the two species of seals in the Wadden Sea.

The worldwide population contains an estimated 400,000 to 500,000 animals (WAZA, 2007). The number of seals living in the Wadden Sea was counted in 2007 by the Seal Rehabilitation and Research Centre (SRRC). The result was 3500 seals. This counting was done during the moulting season when seals haul out on the sand flats.

The common seal is categorized as 'Not Listed' by CITES and placed on the scale of 'Lower Risk' by the IUCN. The Convention on Migratory Species (CMS) placed the common seal on appendix II protection. This means that the seal will benefit from an international co-operation. The common seal is also protected under the trilateral Agreement on the Conservation of Seals in the Wadden Sea. The trilateral agreement is an agreement made by Germany, Denmark and the Netherlands.

In the Wadden Sea, the common seal has no natural enemies and its only threats are coming from human activities. Factors like pollution and disturbance harm seals. Incidentally, seals might become entangled in fishing nets, which are mainly lost or dumped. These nets are so called; 'ghost nets'.



Common seal males measure between 1,4 and 1,8 meter and weigh a maximum of 170 kg., while females are measuring 1,2 up to 1,6 meter and weigh up to 105 kg. Pups, when born, measure around 70 to 80 cm and weigh around 8 to 10 kilograms. (King, 1983/WAZA, 2007) For observing, these differences in size between mothers and pups are easy to recognize. When the pups get older and independent, on a greater distance it will be hard to distinguish weaned pups, yearlings and smaller adult animals.

Common seal males are sexual mature at the age of 5 or 6 years, while females are sexual mature at between their 2<sup>nd</sup> and 5<sup>th</sup> year. Females get around 25 years old. Some females are known to reach an age of 30 years or older. (King, 1983)

The mating season is from July until August which is after the pupping season which started in 2007 at the end of May. Pups will be independent after around 30 days. After this period, the females will soon be ready to mate again.

The common seal in the Wadden Sea lives in shallow waters near sand- and mudflats.

During haul out periods, they will be resting on haul outs with low tide. Although seals have a solitary way of living, these animals lay in large groups on the sand flats.

The pups will also be born on the sand flats during low tide. The pups are born with a equipped fur and not with the 'lanugo', the long white hairs, so they are ready to enter the water with high tide. Because seals haul out on these sand flats during low tides, it is easy to observe them and study the abundance of seals in a particular area.

Adult seals eat about 5 kilograms of fish a day. (Havinga, 1933) They feed on a known variety of 29 species of fish, for example sole, herring, cod, eel and flounder. (King, 1983) They are known to swim up to 45 kilometers in search of food and can stay under water up to 30 minutes if necessary. (King, 1983 and Havinga, 1933)

On land, seals do not see very well. They do detect movement and might be frightened by vertical moving objects (Lenie 't Hart, pers. comm. 28<sup>th</sup> of May 2007). This is one of the points which need to be taken into consideration at all times during the observations to not to disturb the seals.

### **2.3. Seal rehabilitation and research centre**

The Seal Rehabilitation and Research Centre (SRRC) is located in the northern part of The Netherlands in the village of Pieterburen. (Around 200 kilometers from Amsterdam)

This explains the former Dutch name of the SRRC; 'Zeehondencrèche Pieterburen'. Nowadays the centre is called 'Zeehondencrèche Lenie 't Hart'

The SRRC started in 1971 and was founded by Lenie 't Hart. It began as a basic shelter in her backyard. Now, more than 35 years later, it has grown out to a complete seal hospital with quarantine rooms and outside as well as inside enclosures. There is a daily presence of specialized caretakers and a veterinarian. Around 25 employees are working daily at the centre. Besides these employees, there are a lot of trainee students and volunteers from all over the world working at the centre in the different departments: seal care, education, science and administration.

Apart from the centre, another 50 volunteers are spread along the Dutch coastline and Waddensea islands, which are trained by the centre to give first aid on stranded animals. Because they are spread along the Dutch coastline, help for stranded marine mammals is never far away. This is called EHBZ (Eerste Hulp Bij Zeehonden) which is Dutch for Emergency Care for Seals.

The SRRC is depending on the support of their visitors, private donations, legacies and sales from the shop inside the centre. The centre does not receive any government subsidy and is

thereby a charitable organisation, an NGO (non governmental organization). It is also possible to adopt a seal financially. In exchange for the support, the person who adopted the seal is able to release the seal when it is recovered.

The centre offers visitors a lot of information and an insight in the seals habits by information signs, personal guiding tours around the centre and information/educational videos.

Also, the entrance fee is kept low because of the philosophy that information should be affordable and available to everyone.

Annually, around 175.000 people visit the SRRC.

At the moment that this report is written, 86 seals inhabit the SRRC. All of them receive daily care for three to four months until they are ready to be released. Most of the seals which are brought into the centre, in the summer period, are orphans or so called: 'Huilers'

Those pups lost their mother and can be recognized by their continued crying. In the winter, orphaned grey seal pups are rehabilitated.

Furthermore seals with a parasitic infection are rehabilitated and occasionally seals which are injured e.g. which are entangled in marine debris such as discarded nets, ropes etc.

## **2.4. Research method**

The data for this study was collected from 21<sup>st</sup> of May 2007 until 9<sup>th</sup> of July 2007 and was done by means of field observations in the natural habitat of the common seals (*Phoca vitulina*).

Afterwards, the collected data has been analysed with the program Microsoft Excel 2002.

The observations took place at the Wadden Sea area near "Punt van Reide", in the Dollard area.

This specific area was chosen since it provides a good opportunity for observations from land with a binocular and telescope. Besides this, the seals can also be observed from a small distance, when they are situated right underneath the dike, which was near where the observation spot was set up. In total five different sand flats had been selected to use for the study. However, more sand flats will surface when the tide reaches its lowest point, especially with very low tides. The seals use those areas as well, but not with great numbers in comparison with the other areas together and therefore these areas were not taken into account for this study. The area that was observed covered about 9,5km<sup>2</sup>.

During the observation period the data was collected between two hours after high tide and three hours after low tide, creating observation days that were around seven hours. During high tide, the sand flats disappear under the water surface. When the low tide coincided with the dark hours of the night, observations were not carried out, resulting in missing observation days. Underneath is Table 1, Observation days, showing which days observations took place.

The observations were carried out from land, positioned on top of the dike and was usually done with two persons, namely the two authors of this report. The first week of the observation period was used to find the best spot for the observations. In the beginning the observations took place from underneath the dike, but moved to a location on top of the dike from 24<sup>th</sup> of May, since this gave a better view. The spot on the dike was always the same spot, although in case seals were using the sand flat right under the dike (near the water inlet), the observation spot moved to a little behind the dike. This was done to prevent the seals from being disturbed by the observers.

The observations were done using a telescope and also binoculars and in case of the research question concerning disturbance, hearing and sight was also used to help collect the data.

This study contained three research questions, namely about distribution and abundance, disturbance and finally the mother- pup bond. All three will be outlined in a separate subparagraph.

Table 1; Observation days

This table presents the days that observation took place in grey.

May					June					July					
18	19	20	21	22	22	23	24	25	26	26	27	28	29	30	31
	7	14	21	28		4	11	18	25		2	9	16	23	30
1	8	15	22	29		5	12	19	26		3	10	17	24	31
2	9	16	23	30		6	13	20	27		4	11	18	25	
3	10	17	24	31		7	14	21	28		5	12	19	26	
4	11	18	25		1	8	15	22	29		6	13	20	27	
5	12	19	26		2	9	16	23	30		7	14	21	28	
6	13	20	27		3	10	17	24		1	8	15	22	29	

### 2.4.1. Distribution and abundance

For this research question, the five selected sand flats in the Dollard were scanned every 15 minutes for the number of common seals (*Phoca vitulina*) and these numbers were registered for each sand flat. A distinction has been made between adult seals and pup seals. When a pup was seen on its own, this was recorded. The seals that were seen in the water were also counted and added to the count of the nearest sand flat, with a note telling how many seals were present in the water. Every hour the distribution of seals were also recorded on a map of the area providing an overview of how the different sand flats were being used by the seals.

For this structured data acquirement two registration forms were created. The map which was used to register the location of the seals every hour is shown in Appendix A, Map of the area. This map also shows the main haul out sides of the seals.

For this research question the weather conditions were also recorded every hour.

### 2.4.2. Disturbance

This second research question deals with the occurrence of disturbance in the area where the seals are situated. All the events that occurred during an observation day were recorded according an ad libitum sampling observation method. The nature of the event was recorded as well as the onset and when relevant, the termination of the event. The reaction of the seals was then observed and was recorded.

The information of the potential disturbance was recorded extensively. This was done to give room to the wide variation between the different events and their dynamic character and to give room to unforeseen events that triggered a reaction. To enable the analyses of the collected data, the events as well as the reaction of the seals have been categorized before the analyses. A list and the descriptions of these categories can be found in Table 2, List of recorded events, and Table 3, List of recorded effects. Concerning the effect on the seals, this report will use the terms “potential disturbance” and “actual disturbance”. The potential disturbances are all the registered events that could be potentially disturbing for the seals. The actual disturbances are those events that triggered an effect from the seals, thus with the reactions heads up, commotion, movement towards the water and into the water.

As part of this research, other literature about disturbance in the Netherlands has been studied (de Glopper, 1993) to help identify potential disturbances. The first half of the first observation week was used to make the registration method fit the specific circumstances. In the beginning of the observation period all kinds of potential disturbing events were recorded, that turned out to be no cause for actual disturbance of the seals. Therefore the events that never triggered any kind of reaction were no longer recorded. Events that were no longer recorded were cars

(without a trailer) at the other side of the dike, airplanes at great height and any kind of boat that navigated the deepwater channel. The deepwater channel (the Eems) is a route that is a main water road from and towards the harbour of Emden in Germany and also to enter Germany by river. However, when Boats or Ships navigated somewhere else than the deep water channel, they were recorded. Also people that walked behind the dike, or too far away from the area where the seals were, they were no cause for disturbance and no longer recorded. The margin for 'too far away' was taken broad enough, to ensure no potential disturbance by people was missed. The records of all the events that were only recorded in the beginning of the observation period and were later considered irrelevant have been excluded from the analyses.

Table 2; List of recorded events

<b>Recorded events</b>	<b>Description</b>
Airplane	The smaller airplanes (propeller aircrafts) and helicopters. Both kinds fly at relatively low height and produce about the same amount of noise. They were recorded when they flew over the Dollard area or nearby.
Agricultural vehicle	All kinds of vehicles used in agriculture, casting noise around. This category includes grass mowers, tractors and vehicles with a trailer that drove over the gated cattle grid just behind the dike.
Boat	All kinds of smaller boats within the area of the seals, excluding the big cargo boats and big ferry boats.
Ship	All kinds of big boats, such as cargo boats and big ferry boats, sailing in the area of the seals.
Car	All kind of cars, excluding the farmers, which drove on top of the dike or on 'Punt van Reide'.
Cyclist	All persons that came on top of the dike with a cycle.
Farmer	All the farmers' activity in the surrounding area. They usually used a car, casting noise, to drive through the area and also on 'Punt van Reide'.
Jet fighter	A jet aircraft flying at high speed and casting a lot of noise around.
Person	Any person that visits the area, not belonging to Cyclist. Persons may walk the whole dike, or even underneath the dike at the Water inlet. They may even walk on the prohibited area of 'Punt van Reide'. Persons that visit the area for a specific purpose, such as watching the animals or doing research, also belong to this group.

Table 3: List of recorded effect

<b>Recorded effects of the seals</b>	<b>Description</b>
No effect	No effect attracted the attention of the observers.
Heads up	Heads up, hereby no difference was made between low or high head uplifting.
Commotion	Heads up, movements and restlessness of the seals.
Movement towards the water	The seal(s) move(s) toward the water but do(es) not enter the water.
Into the water	The seal(s) enter(s) the water as a consequence of the disturbance.

### 2.4.3. Mother-pup bond

The research question concerning the mother and pup bond uses the same data as is collected for the research question concerning the distribution and abundance. The information about the mother and pup bond can be abstracted from these data, because additionally to the information about numbers, information concerning the mother and pup bond was also recorded. The information concerning the mother and pup included the distance between mother and pup. The distance between mother and pup was estimated with the telescope from the observation spot. The activity of lactation was also recorded, when observed. When a pup was seen alone, this was also registered. Also the distribution of mothers and pups were recorded every hour on the map of the area.

### **3. Results and analysis**

This chapter includes the results of the analyses that were made to enable answering the different research questions as written down in the first chapter, the introduction. The three research questions are outlined in a separate paragraph. The data was analysed with the use of the program Microsoft Excel 2002.

Besides the date, a lot of interesting observations have been done during the observation period, which were not suitable for quantitative analyses. However, these observations do contribute to the understanding of the behaviour of the seals and are therefore included in the following paragraphs.

#### **3.1. Distribution and abundance**

This paragraph is separated into two subparagraphs. The first subparagraph in this chapter, 3.1.1, contains analyses and the second subparagraph, 3.1.2, contains a collection of sightings.

##### **3.1.1. Distribution and abundance based on data sets**

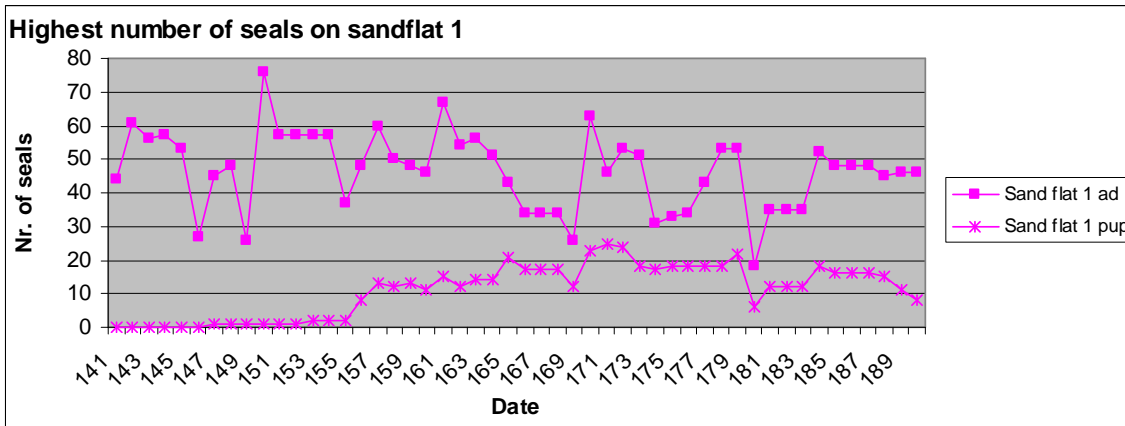
During the observation period, the location of the seals on the sand flats is noted down and also drawn on a map of the area. This map, including sand flat numbering, can be found in Appendix A; Map of the area.

By following the movements of the seals during the haul out periods and during most of the lactation period of 2007, a clear image can be made about which sand flats are favourite, which sand flats are used when the pups are born, as well as the preferred location on the sand flats.

Looking at the graphs shown in Appendix B, Additional graphs for chapter 3.1, and the graphs shown in this chapter, the usage of the sand flats becomes clear.

Sand flat number 1, the closest sand flat except from the water inlet, is a daily used sand flat. Even when the pups are not born yet, seals haul out at this sand flat. This can be seen in Graph 1, shown below. At the start of the observation period, a number of 44 adult seals was present (as a maximum) at this sand flat. At the end of the observation period, beginning of July, a number of 46 seals were present at the sand flat. During this period, the number of seals fluctuated, but came to a stable point again at the end of the period. Fluctuations during the day are due to weather changes or tidal changes. The first pup sighted at sand flat 1 was on day 147 (May 27<sup>th</sup>). From this moment, the number of pups grew and followed the same tendency as the line of the adult seals. Because of these facts named above, the conclusion follows that, also because the population on the sand flat reached stability at the end of the observation period, the population of seals resting on sand flat 1 may exist of a solid group of seals using this place. Further research is necessary to identify the further development on this sand flat.

During the period, other seals will use the sand flat as well, but it is thought that there is one group of seals which prefer this sand flat as a haul out place. This involves that the pups born and using this sand flat, fluctuate the same way as the line of the adult seals. Indeed the fluctuations over the lactation period are more or less the same.



Graph 1; The highest number of seals on sand flat 1

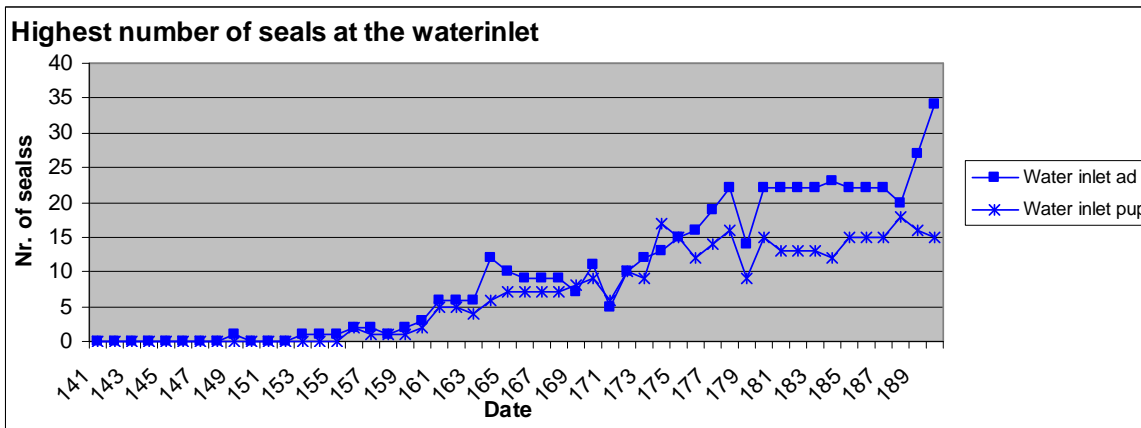
This first graph is showing the number of seals during the observation period on sand flat 1. For each day, only the highest number of adult seals and pups have been listed in the graph.

In contrary to sand flat number 1, the water inlet showed a completely different usage. The seals started to use the water inlet as a haul out site, only when they had pups or were expecting one. It was on 27<sup>th</sup> of May 2007 at 11:45 that the first pup was born in the Dollard area. From the 8<sup>th</sup> of June, seals started to use the Water inlet more often and from the 13<sup>th</sup> of June, the water inlet was used throughout the day on a more regular basis. Later in the season, an increasing number of seals were using this place as shown in Graph 2.

The water inlet is a special haul out site. Although there is a bigger chance of being disturbed, seal mothers and their pups do visit this place a lot. Outside the pupping season, seals were not sighted at the water inlet. Only highly pregnant mothers and mothers with pups used this place in the beginning. After a short while, also the orphaned pups start to use this place, occasionally in groups. From all sand flats, the highest number of orphaned pups was counted at the water inlet. A direct link between the inlet and the number of orphaned pups was not demonstrated, but it is not unlikely that it exist.

The beginning of the water inlet, close to the dike, stays dry, even during high tide. This is assumed to be one of the reasons why seal mothers and orphan pups choose this particular place to haul out.

At the end of the observation period, the number of seals at the water inlet was still increasing. The decrease in the number of seals at the water inlet, as sighted on the other sand flats, will take a longer time than on the other sand flats. This is noticed because of the fact that at the start of the season there are no seals at the water inlet and at the end of the observation period the number of seals is still increasing.



Graph 2; The highest number of seals at the water inlet.

This graph is showing the number of seals during the observation period at the water inlet. From each day, only the highest number of adult seals and pups have been listed in the graph.

The fourth and second sand flat, have the smallest distance between mother and pup (see Appendix B). These are also the sites on which the seals are not present all day. Sand flat 4 is abandoned at the beginning of low tide because it does not stay surrounded by water. Sand flat 2 is the smallest sand flat of all observed haul out places. Of all sand flats, this is also the one which is above water as last and disappears as first due the high tide. This can be the main reason why the seals do not prefer this place as their haul out site. During the observation period, seals have been seen being born on every haul out site, except sand flat 2. Probably, a combination of its smaller size and the short time of usage, makes it less attractive. The sand flat might be to unstable.

This may result in the difference in distance between mother and pup in comparison to the other sand flats as will be shown in chapter 3.3.

The third sand flat is the place on which the highest number of seals is recorded. This can be linked to a couple of factors. This is, except from sand flat 4, the first place to appear when low tide comes. It is also the largest sand flat in the Dollard. Sand flat one and two are laying in front of sand flat three, so the distance between sand flat 3 and the dike is very large.

Disturbance on sand flat 3 caused by events on the dike is hardly possible. Shipping is only possible on the back, seen from the coast, of sand flat 3 and because of the large size of this haul out place and so large distance to the ships, it does not bother the seals too much. These factors named above explain the high number of adult seals and pups on sand flat three.

Another reason for sand flat three to be used by these high number of seals, may be found in the fact of distance from the shore. Sand flat three is, from all observed sand flats, the most far away from shore.

Assumed can be that, just like on sand flat 1, seals use this sand flat also outside the pupping season. Although a smaller number, seals were present at the start of the observation period and decreased to almost the same number at the end of the season. What appears from the graph belonging to sand flat 3, see Appendix B Graph V, is that the number of seals present on sand flat 3 increases enormously with almost 80 seals in difference between the beginning of the season and the end.

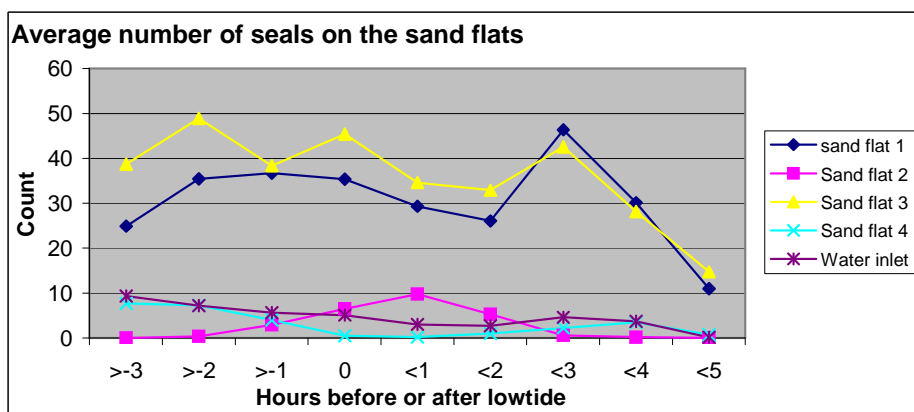
Sand flat 4 is, after number 2, the smallest sand flat. It is the first sand flat to be used when the low tide falls in. This is because this is the first sand flat to appear. On day 147, the first pup born in the Dollard, was born on this place. From this moment, seals started to use this sand flat



as a haul out site. Most of the animals using this sand flat were mothers with pups. Single animals were hardly seen on this place. With a maximum of 15 animals, sand flat 4 was no popular sand flat. It is positioned very far to the right, seen from the coast, as shown on the map in Appendix A. The area around this sand flat also falls dry and if seals wait too long to leave the sand flat, they are not able to enter the water quickly when needed.

After a few hours from appearing above water and starting to use the haul out place, the seals leave sand flat 4 and use other haul out sites like for example sand flat 1. This event is also shown in Graph 3 in chapter 3.1.

At the end of low tide, when the water starts to rise again due to the upcoming high tide, seals will move back to sand flat 4. Sand flat 4 will also mainly be used during the pupping season. When the ebb stream starts and the sand flats emerge, it is clear to see that there is a difference in appearance of the different sand flats. Sand flat number 4 is the first sand flat to be available and seals will be resting here first. When the water drops further, the seals resting on sand flat 4 will move to the other sand flats (mostly number 1 or 2) because these sand flats will stay surrounded by water instead of sand flat number 4 which will fall completely dry. Seals will enter the water when they suspect or detect any form of possible danger. This movement is shown on Graph 3. The decrease in numbers of seals on sand flat 1 and 3, are due to bad visibility. When the water drops at low tide, the seals move with the water and this causes that the seals are laying behind, and this way out of sight, the sand flat.



Graph 3; Average number of seals on the sand flats  
 This graph shows the absolute (maximum) number of seals outlined against the time before and after low tide. Low tide times of the nearest harbour (Delfzijl) are used.

### 3.1.2. Distribution and abundance based on occasional sightings

During the observation period a lot of interesting observations have been done, which were not suitable for quantitative analyses. However, these observations do contribute to the understanding of the behaviour of the seals and are therefore included in this chapter.

Concerning the mother-pup bond, the following events and facts were standing out.

- In general it was observed that when the pup moved and went into the water, the mother followed her pup. When there was a disturbance, it usually was the mother that reacted first, or solely the mother. The mother made sure the pup followed her.

- In general, when the pups are still very young, they were seen swimming right behind the mother, as if leaning on the back of the mother.  
The pups, when just born, were guided into the water several times during low tide. This might be done to practice swimming. The pups first started drinking milk and interacted with the mother, followed, after about an hour, by the swimming.
- It was never observed that a pup was on its own for a period of the day and being reunited with its mother later on the day. When pups were observed on their own on one day, the next day also showed the same amount of pups on their own, or more.
- From the 13<sup>th</sup> of June, a mother was seen several days at the water inlet, calling the pups which were laying on the sand flat next to the water inlet. Her attention especially went towards the orphan pups. These reacted by following her into the water. When she noticed that the pups were not hers, she started hitting the pups by using her front paws and trying to bite. The mother, characterized by a reddish skin and blue left eye, was seen two days earlier (11<sup>th</sup> June 2007) with a pup of her own. She persevered with this behaviour for about 4 weeks.
- On 25 June 2007: at 11:22 there were two persons on top of the dike which caused the seals at the water inlet to react and some went into the water. One mother moved towards the water about 6 meters, but her young stayed behind. The mother went back to stimulate her pup to come with her and she turns to the water again. Her young still stayed behind and the mother came back again. This time she slaps her tail to the ground, to get her pup to move. Eventually, the pup came with her.
- Orphaned pups were seen following each other and laying on the sand flats together quite often. You could also hear them cry. Orphaned pups sometimes tried to drink with one of the mothers, but this was not tolerated and the pups got beaten by the mother. Orphaned pups also got scared away and beaten and bitten for coming to close to a mother with pup. However, one time it was witnessed that an orphaned pup could get some suckling time from a mother with pup. This mother was laying on its back side. She might not have noticed in first instance that it was not her own pup. After a minute or so, she also beat the orphaned pup.

### **3.2. Disturbance**

This paragraph gives the results of the analyses concerning the disturbance research question. In this paragraph a difference will be made between potential and actual disturbance. When the term of “potential disturbance” is used, it includes all possible events that were recorded during the observation period. Some of these potential disturbances or events, cause the seals to be disturbed and raise their head(s), become restless, move to the water or to enter the water. These events will be referred to with the term “actual disturbance”.

#### **3.2.1. Disturbance and their effect**

For this research question, a total of 306 records have been made during the observation period, of which 58 records involve actual disturbance. An overview of the numbers of recorded events per day can be seen in **Appendix C.1, Table I**. From the 32 days on which observations took place, there were 23 days on which actual disturbance occurred. (Graph 8, Number of recorded events in paragraph 3.2.2, disturbance and consequences).

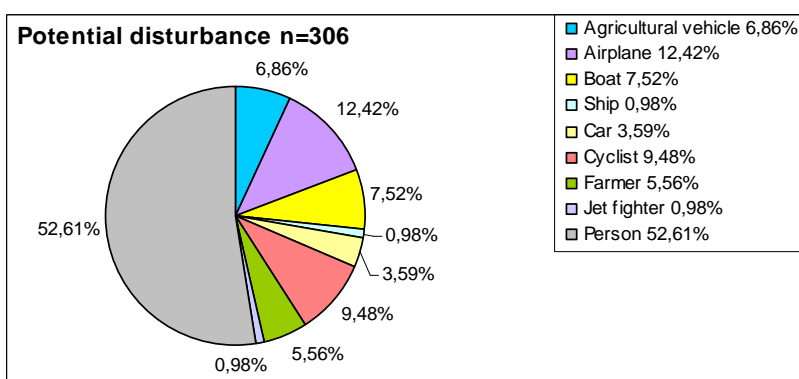
The 306 records have been categorized in nine categories, as was described in paragraph 2.4.

In this study 52,61% of the 306 records concern the category Person. The category that comes second is Airplane, with 12,42%. The other categories have shares smaller than 10% (Graph 4, Potential disturbance).

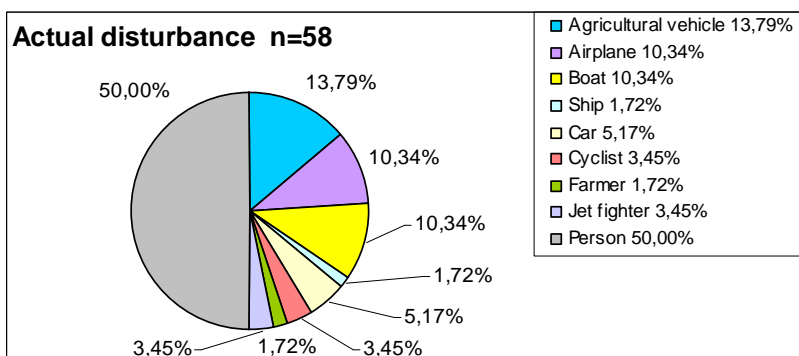
From the 58 records concerning actual disturbance the category Person has a share of 50%. Other main contributors to disturbance (defined as >10% of the actual disturbance) are Agricultural vehicles (13,79%), Airplanes and Boats (both 10,34%). (Graph 5, Actual disturbance)

It was also analysed what the shares of the different effect was. The different effects of disturbances on the seals have been classified as was described in paragraph 2.4. The analyses show that from the 306 recorded events 81,05% did not have any observed effect on the seals. The remaining 18,95%, which corresponds with 58 records, did have an effect on the seals and thus were actual disturbances (Graph 6, Effect of disturbance).

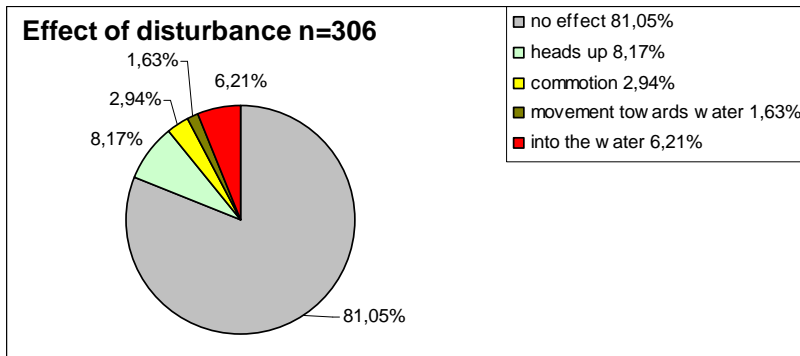
Finally all categories have been analysed separately. The analyses show that the relatively disturbance was highest for Jet fighter followed by Agricultural vehicles, Ships, Cars, Boats, Persons, Airplanes, Cyclists and finally Farmers. However, the sample size of Jet fighter and Ships is very small, with 3 records each. (Graph 7, Effect per category).



Graph 4; Potential disturbance.  
This graph shows the share of the nine different categories.

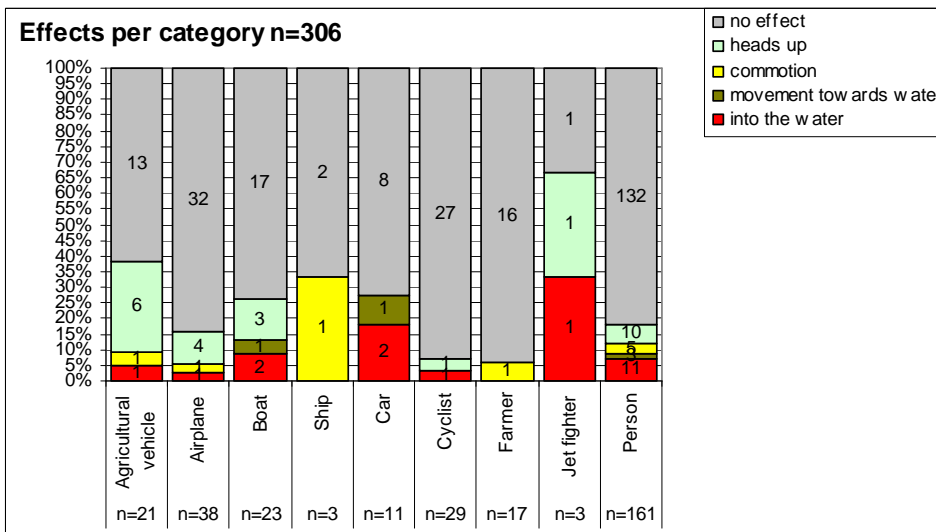


Graph 5; Actual disturbance  
This graph shows the share of each actual disturbance.



Graph 6; Effect of disturbance

This graph shows the share from each effect, from all the recorded potential disturbances.



Graph 7; Effects per category.

This graph shows the share of the different effects for each category.

### 3.2.2. Disturbance and consequences

To explore the consequences of the different kinds of events or categories, some further analyses have been made. It has been analysed whether the birth of pups had an influence on the seals. In the beginning of the observation period, the numbers of potential disturbances decrease while the level of actual disturbances did not change (Graph 8, Number of recorded events). It was on 27<sup>th</sup> of May 2007 at 11:45 that the first pup was born in the Dollard area. On the 8<sup>th</sup> of June, seals started to use the Water inlet more often and from 13<sup>th</sup> of June the water inlet was used throughout the day on a more regular basis. This shows that seals are more affected by the occurring events as the time (within the framework of the observation period) progresses.

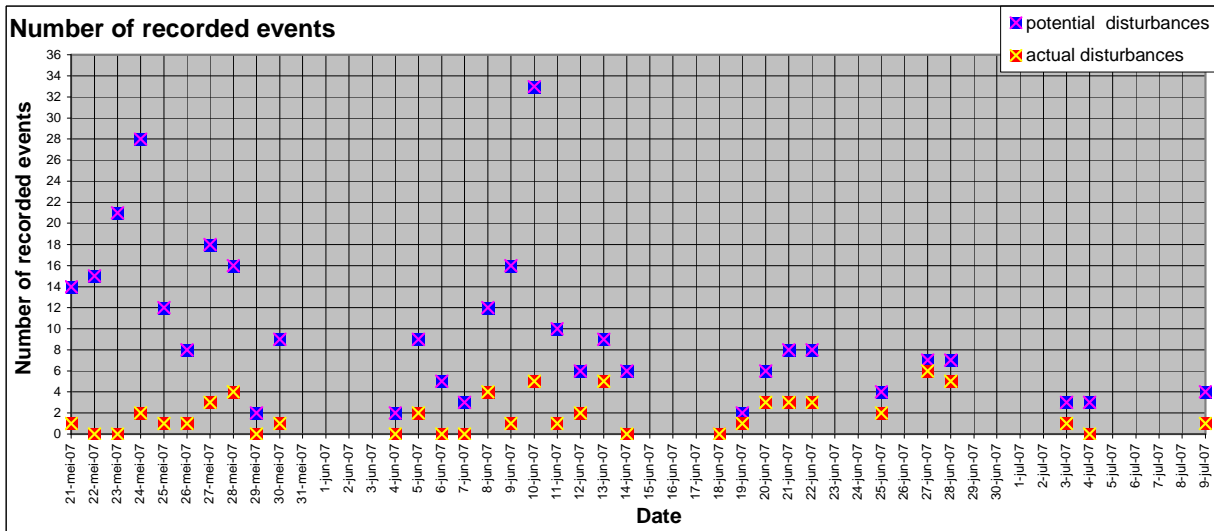
To explore the effect of an actual disturbance on the distribution and abundance of seals, Graph 9, Number of seals and disturbance 27 June '07, has been created. The occurring event is inscribed in the graph with two red squares and a thick red line between them. The event occurred between the red squares. In most disturbance cases there is a small decrease in numbers as only a number of seals enter the water. Also seals are counted every 15 minutes,

therefore numbers of seals might have recovered again at the time of counting. Eight more graphs like this graph, can be found in Appendix C.2, in Graphs VIII until XV. The days that have been selected for the graphs, all show at least one event with the effect of into the water

Observations in the field also showed that pups were not as easily disturbed as the adults, especially the mothers. Pups were more prone to stay and lay flat on the sand flat, even when an event occurred that made their mothers lift their heads, become restless, move to the water or enter the water. It was observed that in most occasions of a potential disturbance, it was most of the time the mother that reacted first, and the pup reacted later. It is hard to tell however whether the pups reacted because the mother was moving or because of the event. Observations also showed that the degree of response to disturbance varied. Sometimes seals stayed put, although on another day a similar event would have triggered a response from the seals.

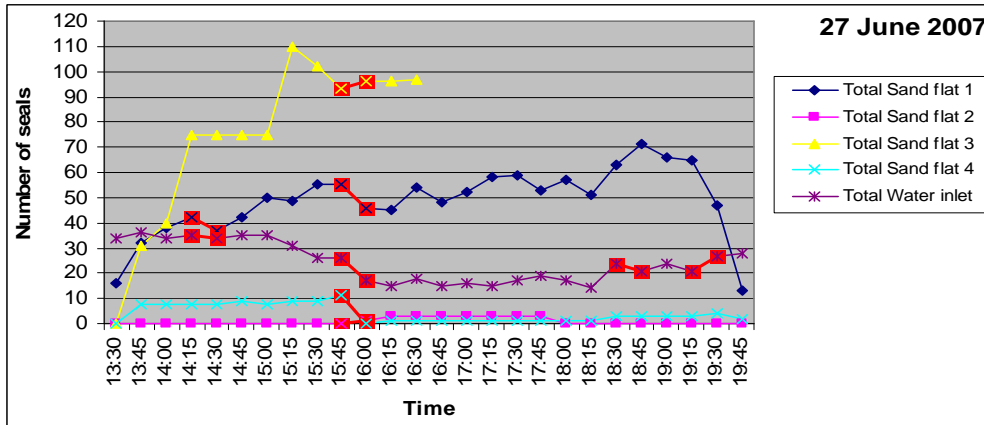
Other events that were observed disturbances were caused by indirect by human factors. Once it was observed that a bird colony on the other side of the dike was disturbed by an event and went into the air while making sounds of distress. The seals reacted not to the disturbing event behind the dike, but reacted to the birds in distress and some went into the water because of this. The water inlet, a man-made structure, may also be an indirect form of disturbance for the seals, since the water inlet may be too steep for the seals, making it impossible to get on shore. It was observed twice that a pup did not get up the shore and then went back into the water. However, the mother was still in the water as well, and she did not try to get up the shore. The pup might have been able, but it is impossible to tell.

Finally, seals were also being disturbed through natural events. Seagulls were witnessed more than once as being aggressive towards pups. On 21 June, a seagull was seen at the left side of sand flat 1, picking at a pup. The pup reacted. The seagull stayed close and picked at the pup again. Then suddenly the pup rushed into the water and the remaining seals became alert. The mother of the pup followed the pup into the water. On the 14<sup>th</sup> of June, an orphaned pup that was later rescued by the SRRRC, had the umbilical cord pulled of by a seagull and it had become infected. Once, a seagull started pulling the umbilical cord when it was still connected to the mother and her afterbirth. This was the only time observed that a seagull bothered an adult seal. Finally it was observed more than once that the event of rain, when being heavier than a drizzle, can also be cause for seals to enter the water. Heavy rain can even make all seals react with a sprint towards the water.



Graph 8: Number of recorded events

The red blue dots show the number of recorded events per day, the potential disturbances, a total of 306 during the observation period. The red dots show the number of actual disturbances per day, a total of 58 records during the entire observation period. Dates on which no dots are seen are days that no observations took place.



Graph 9: Number of seals and disturbance 27 June 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. The missing numbers on sand flat 3, are due to bad vision, and in the middle of the day averages have been taken between taken measurements. A total of six events of actual disturbance were recorded this day:

- 14:14; 2 persons on top of the dike and one of them was wearing a yellow raincoat. They cause one mother-pup pair to enter the water.
- 14:22; small airplane flew across the Dollard, causing 2 adults to lift their head.
- 15:51; a jet fighter flew across the Dollard casting around a lot of noise, causing all the seals at the water inlet to enter the water. (red squares)
- 16:16; jet fighter flew south of the Dollard, causing two seals raise their head.
- 18:35 and 19:21; one person on top of the dike, causing one mother-pup pair to enter the water.

### 3.3. Mother-pup bond

In the Eems-Dollard, the first common seal pup born, was spotted at the 27<sup>th</sup> of May. From this moment, the interaction between mothers and pups was closely followed. Apart from the activity of the mother and pup, special attention went to the recording of distances between the mother and pup when laying on a sand flat. Abandoning of pups by mother or any other case of separation was a point of interest to observe. The question was if pups ever were abandoned and if so, for how long.

The distance between mother and pup differs for each sand flat. There was a clear difference noticeable between the sand flats. Besides the number of seals on the haul out sides of which the results are shown in chapter 3.1, the distance between mothers and pups is also recorded. This way, an average could be calculated to show a possible difference in distance between the mother and pup. In Table 3, an overview is presented from the average distance between mother and pup per sand flat.

**Table 3** shows that on the third sand flat, the distance between mother and pup is the largest of all sides. Sand flat number one as well as the water inlet, are quite average.

The age of the seals might play a role in the distance. The older the pups get, the more often they wander off from their mother. Especially on the third sand flat, distances of more than 4 meter between a mother and pup were not an exception.

Later in the season, orphaned pups also rested in small groups or together. The distance between these pups was very small and in some cases the pups were resting body to body. Also, small orphaned pups were sometimes laying against a big rock.

Table 3: the average distance between mother and pup per sand flat

This graph is showing the average distance between mother and pups. During every counting, the distance between the mothers and their pups was recorded. From this data collection, an average number has been established.

Average distance between mother and pup per sand flat	
Sandflat 1	1,12 m.
Sandflat 2	1,06 m.
Sandflat 3	1,56 m.
Sandflat 4	1,09 m.
Waterinlet	1,17 m.

During the observation period, several seal-births have been witnessed and by studying these cases, it is possible to create a better view of the interaction between mother and pup.

All the pups of which the births were observed, were born soon after the first pieces of the particular sand flat became visible. Probably to stay as long as possible on the sand flat until they submerge.

Within minutes after the birth, the newborn pup starts suckling. The first half hour to one and a half our, the pup stays close to its mother and is suckling most of the time. After this period, the mother moves around very slow. The pups did always react on these movements by following their mothers. In the beginning, these movements are no more than 3 to 4 meter, but within the next two hours the distances increase.

After following the mother, the pups normally start suckling again or lay close to their mothers. When the movements increase, the mothers normally also take the pup into the water. This event is very complicated and requires a lot of attention from both animals. The pups follow their mother into the water and continuously stay in touch with the body of their mother. The pups do this by leaning on the back of the mother or the hind flippers.

These first rounds of swimming are repeated several times and never that far. The seals which were observed, did not take the pup away from the sand flat more than four to five meters. While swimming, the head of the pup stays above water at all times. Pups do react very nervous and with a lot of calls when they lose contact with the mother or when the mother takes a dive.

In the next hours, still during low tide, the pups will start diving and swimming under water.

During all interactions, a lot of physical contact takes place. While swimming near and resting on the sand flats, the mothers and pups touch each other regularly with their noses. When, like explained above, a pup is nervous and screaming, this interactions concerning the touching of each others noses, seems to comfort the pups. The pups stop screaming. The mother seal does not make any noticeable sounds, in contrary to the pups which are very vocal.

When some form of disturbance occurs, the mother seal will lead the pup into the water. After swimming away together (closely) the mother will touch the pup with her nose to the nose of the pup again. In cases when the pup did not follow immediately, the mothers waited. This is only observed three times. There was no real threat to the seals at that moment, but the mothers decided to go into the water. This may be different when there is a real threat or disturbing factor and the mother and pup do get separated in the act of panic.

If there is no threat or other reason to move towards or into the water, the mother will follow her pup most of the times. If the pup moves on the sand flat, the mother will take care that the distance between her and the pup does not become to large.

During the observation period, it is never observed that a mother seal left her pup. Because this event is never observed, it is not possible to attach a time to this event for how long it takes. On several occasions, mostly during bad weather, suspected was that seals might have lost there pups in a panic reaction or massive move into the water. Although never witnessed, it is not thought unlikely that also in other cases of disturbing events pups get separated from their mother or vice versa. Disturbing events taking place on the dike are likely to lead to separation, of mother and pup, as well.

Pups which were thought to be an orphan were observed for several hours to make sure that there was no mother that came back for her pup. In all cases of which orphan pups have been sighted, this never happened. In total, 58 times, orphan pups have been recorded. In this number, the same animals might occur. It is not always possible to reach the pups, which makes that pups will show up for several days. For this reason, the rough estimation of 35 orphaned pups is set together by comparing the number of orphaned seals to the number of seals which were brought to the SRRC. At the end of the observation period, 16 orphan seal pups were rescued by the SRRC. Two pups were found dead. This makes a total number of 18 rescued and/or registered orphaned pups in the Dollard region.

Orphaned pups did try sometimes to drink from another mother or lay next to one. This is not accepted and other mothers do not tolerate it. This behaviour is also sighted once when a mother probably did not lactate, so the pup, not orphaned, tried to drink at other mothers.

At one occasion, we observed a mother for several days in a time span of four weeks. She tried to take pups from other mothers and visited groups of orphaned pups regularly. This mother, seen with a pup of her own before, is not seen with her own pup again.



## **4. Discussion**

This chapter will elaborate on the conclusion for this report and will discuss the research method and compares the results with other researches.

With respect to the research method, there are some remarks. In the first place, the counts may be biased due to the weather conditions. When the weather was bad and it rained constantly or when there was a lot of wind, the observations were aborted. The rain caused the lens of telescope to become wet, making the counting a hard process. Besides this, the rain curtain and dim light resulted in poor visibility. When (additionally) it was windy, especially with wind stronger than 3-4 Bft, the telescope trembled too much, making it impossible to do a reliable count. The weather, also including foggy circumstances, is also the cause for the fact that there are data deficiencies, which is especially true for sand flat 3, which was the furthest away. Secondly, the counts were done from one spot on top of a dike. Although this spot was higher than underneath the dike and was in fact the highest point in the area, it could not prevent that not all seals were visible all the time. Seals may be situated behind each other, in close proximity of each other or behind the sand ridge of the sand flat. The latter was especially true for sand flat 1.

Concerning the disturbance research question there is the presence of the observers in the area. The behaviour of the people that visited the area may have been influenced by the presence of the observers. The observers were being cautious and this behaviour may have resulted in the fact that the visitors also were more cautious than they would have normally been. However, the opposite could also be true, since the presence of the observers also encouraged curiosity, resulting in people that came to ask questions, and thus increasing the chance of disturbances.

### **4.1. Distribution and abundance**

To conclude chapter 3.1, sand flat 1 and 3 are the only sand flats which the seals clearly use outside the pupping season. Sand flat 4 is used for giving birth to pups and rest when low tide starts. Sand flat 2 has not much of a function. It is used by a few seals but not a steady group. The water inlet is an important place, as well as for mothers and pups, pregnant mothers and for orphaned pups. In contrast to the other haul out sides, the water inlet had a higher number of orphaned pups. It is unclear whether there is an increased separation risk between mother and pup in this area, or that orphaned pups move towards this area.

For sand flat 3 can be concluded that it will be mainly used for the moment that pups are being born or present. Different factors are thought to influence the choice of sand flats. Influencing factors might be the size of the sand flat, distance to the water (caused by tidal changes for example), steepness of the shore.

Further research is necessary to identify the further development on sand flat 1. This involves that the pups born and using this sand flat, fluctuate the same way as the line of the adult seals. Indeed the fluctuations over the lactation period are more or less the same.

For the water inlet, further research is indicated to find out if there is direct linkage between influences from the water inlet and the number of seals at the water inlet.

### **4.2. Disturbance**

The analysis showed that from the 306 recorded events, 58 events (18,95%) triggered an effect from the seals, and thus were actual disturbance.

In this study, the category of Person was recorded most often, followed by Airplanes. The other categories each contribute less than 10%, which were in order from most recorded to less recorded; Cyclist, Boat, Agricultural vehicle, Farmer, Car, Ship and Jet fighter.

The category of Person was also cause for most of the actual disturbance. The Agricultural vehicles were the second main cause for actual disturbance followed by Airplanes and Boats. These categories are then followed by Car, Cyclist and Jet fighter, Farmer and Ship, each contributed less than 10%.

The Agricultural vehicles had the biggest impact on the seals relatively speaking, followed by Cars, Boats, Person, Airplane, Cyclist and Farmer. No conclusions can be drawn from the categories Ship and Jet fighter, since the sample size is too small for these categories. The categories Agricultural vehicle, Cars and Boats all have in common that they make noise, suggesting that noise and/ or big moving objects are most distressing for the seals. Also it can be said that Cyclist do not have a big impact on the seals and were only in some occasions cause for actual disturbance. This can be explained by the fact that this category usually stayed at the bench, which was to far off for the seals at the water inlet, approximately at 200 meters away. However, when taking everything into consideration, it is Persons that are cause for 50% of the actual disturbance and it can be said that this category is the main cause for disturbance. The fact that the number of potential disturbing events decreasing during the observation period, while the number of actual disturbance stays at the same level, might suggest that the seals become more sensitive to disturbance when pups are born. However, it can also show that the seals started to use the water inlet on a more regular basis, and at this spot they were more likely to be disturbed by for instance Persons on the dike. Observations also showed that the degree of response to disturbance varied, when the same kind of event not always triggering the same kind of response from the seals.

The results of this research question have been compared to the research by de Glopper (1993), who also did research into disturbance and was conducted near Ameland, the Blauwe Balg (a group of five to twenty seals), and Texel, the Steenplaat (a group of seven to twenty seals) in the Dutch Wadden Sea area. At the Blauwe balg, nine records were made and at the Steenplaat 24 records were made. The results of the studies are similar to each other, with boats mainly cause light disturbance (heads up). A major difference however is the fact that in this study, the seals were also being disturbed by activity on the main land; people or Farmers in the area, Cars and Agricultural vehicles, which was not possible in the other study.

On the whole, the protective measurements (e.g. no access to Punt van Reide) that have already been taken in the Dollard area have a positive effect and limit the disturbances. However, the fact that Persons contribute 50% in actual disturbance, warrant further investigation, since it is especially the group of seals with pups that use the water inlet that are effected by Persons. It would be a good additional measure when the influence of this group is also diminished.

Besides this, noise seems to be an important feature that is distressing for the seals, since Agricultural vehicles and Cars relatively have a big impact on the seals. However, the aspect of noise needs further investigation. The presence of Boats has almost the same impact on seals as the Cars in the area, which seems strange since Boats were not allowed in the area. Another aspect that needs further investigation is whether the seals become more sensitive to disturbance when pups arrive. The results of this study are not unambiguous about this.

Another thing that may be interesting for further investigation is how the weather conditions, specifically the disturbance that occurs when it starts raining, influence the distribution and abundance of the seals. The results of this should provide interesting information with respect to the aerial surveys to count the seals.

### **4.3. Mother- pup bond**

From the moment, day 147 at 11.45, the first pup in the Dollard was born, the relation between mother and pup was closely observed.

Body contact is very important in the first day of the seal. As well as in swimming for not losing each other out of sight, as well as for bonding and comfort.

After the pup is born, suckled and made contact with its mother, about an hour after birth the mother leads the pup to the water. By leaning on its mother and swimming in shallow water, the newborn seal learns to swim and follow its mother.

When the wind is blowing hard, mothers provide their pup shelter by letting them sleep under the lee of their backs/body. This way, the distance between mother and pup is again very small.

In most cases, the distance between mother and pup normally does not get larger than 1,5 meter. Occasionally, pups are further away from their mothers. This is observed when the pups are older and more mobile. They increase the distance more often but never lose contact by sight with their mothers. The largest distance, this way, estimated was five meters. Although this event happened on all sand flats on which pups were present, sand flat three had a higher number of occasions on which pups wandered off. Like written before, the distance in the water between a mother and her pup is very small and often consisted not more than one meter.

During the observation period, not even once is the moment witnessed on which a pup loses its mother or the other way round. There were events on which it is suspected that pups were separated from their mothers, although never seen. The confirmation of these suspicions became clear the next day when a higher number of orphan seals were present at the haul out places. Orphan pups have been saved by the SRRC during our observation period. To be sure, the mother did not come back, the orphan pups were observed for a couple of hours before picking them up. In none of the cases a mother seal came back for the screaming pup.

To conclude the above, mother seals and their pups have a strong bond, carefully maintained by regular physical contact and focal display by the pup. Especially in the period of days close after birth, the interactions are numerous. When the pup gets older the interactions stay, but are less numerous. Another fact which can be concluded after this research, is that mother seals in the Dollard region do not leave their pups. It is unclear how large a disturbance must be to cause a separation of mother and pup. Chaos in a large population and a massive run to the water, as was occasionally observed, is certainly thought to lead to separations. Mothers, who lost their pups, are assumed to look for their pup for a short while. In one case only, the mother kept trying to find her pup amongst orphan pups for a period of four weeks. However she was unsuccessful. Pups, in contrary, seem to take more effort in finding their mothers. Further research should help in finding an answer to this theory.

The final conclusion relating to the mother-pup bonding is about the question if the mother follows the pup or the reverse.

The mother will lead the pup into the water and through the water when a disturbing event takes place. When the pup is going into the water or moving around on the sand flat, the mother will follow the pup. When entering the water, the mother will lead the pup again and in most cases the pups will lean on the mother during swimming so they don't lose contact. The strong bond observed between mother and pup is in line with earlier field studies in the Wadden Sea, as summarised by Osinga and 't Hart (2006).

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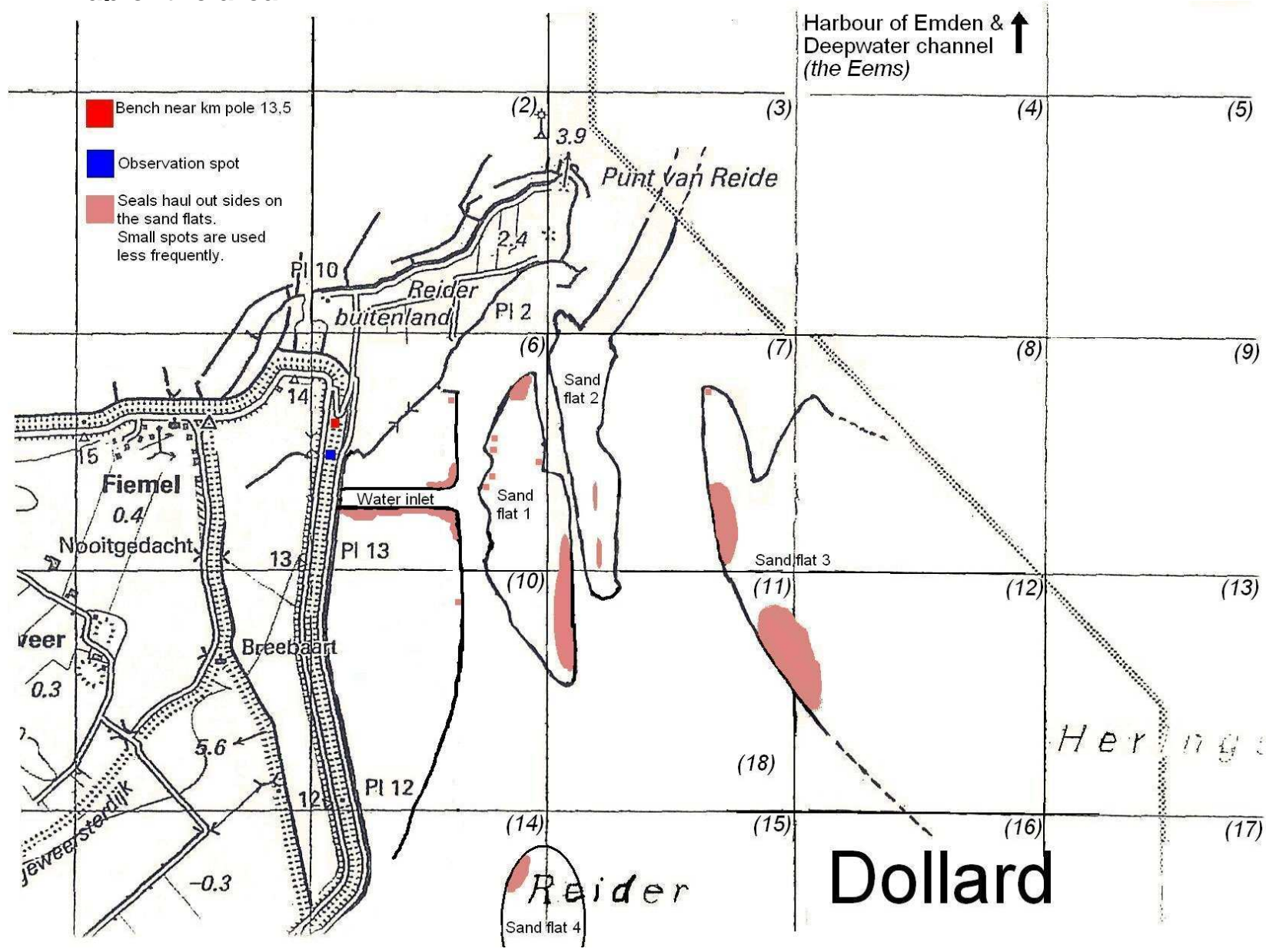
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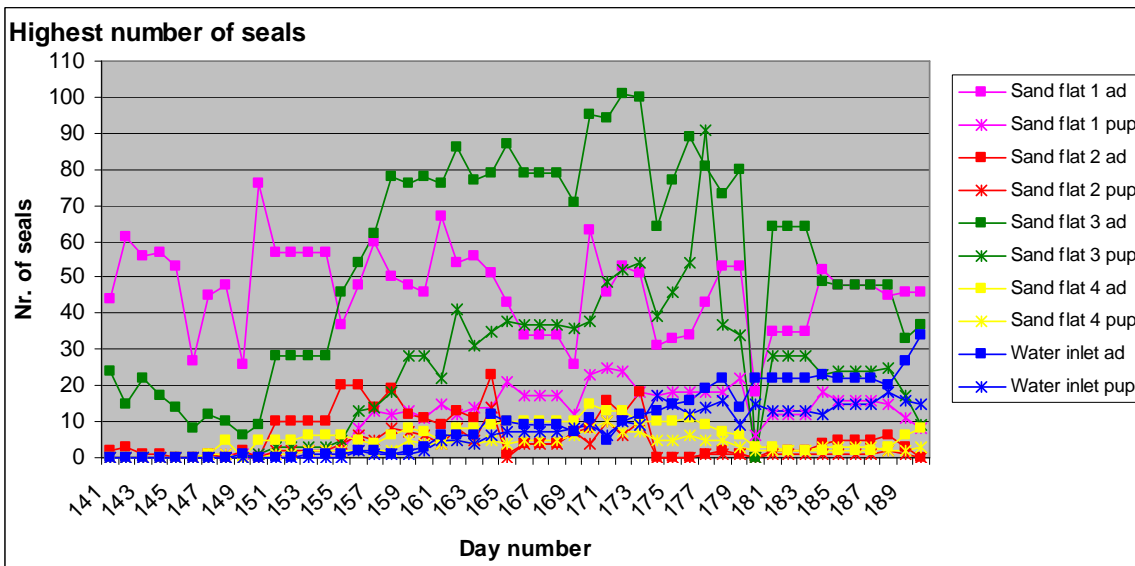
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# A. Map of the area

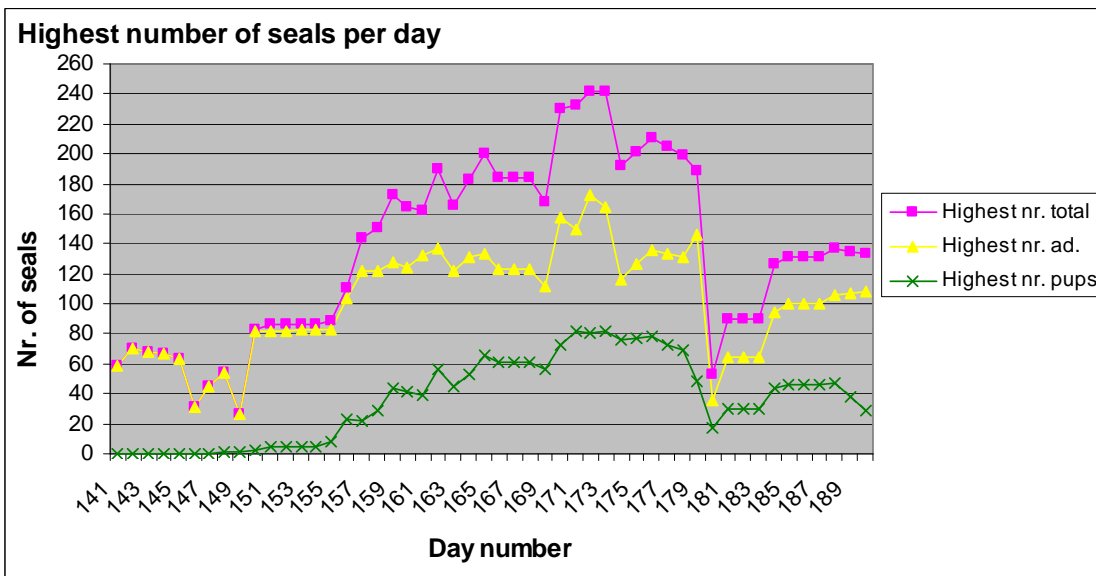


## B. Additional graphs for Paragraph 3.1



Graph I; Highest number of seals per sand flat.

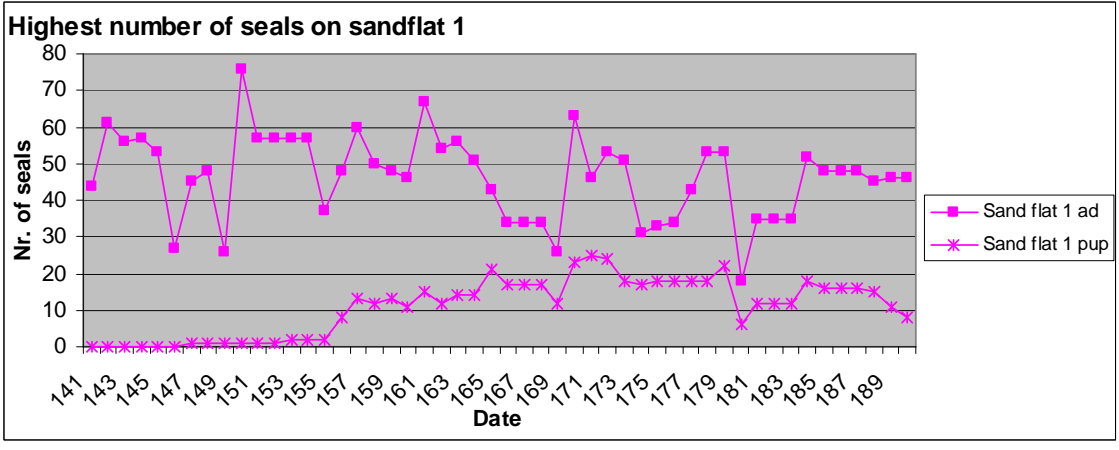
This first graph is a collection of all sand flats. It shows the number of adult seals and seal pups per sand flat. The green line with square points presents the seals on sand flat 3. This was, as the graph shows, during the season, the sand flat with the highest amount of seals. The pink line, represents the seals on sand flat 1, a sand flat which is popular among seals also outside the pupping season.



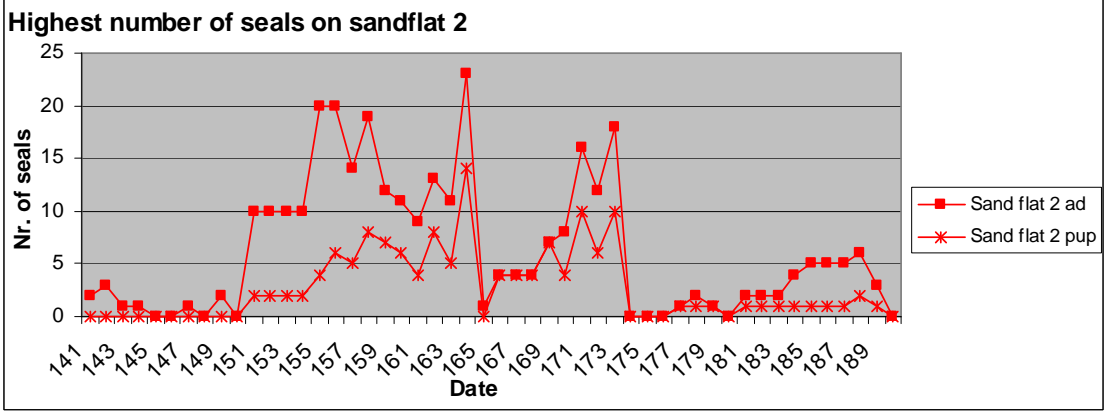
Graph II; Highest number of seals of all sand flats

This second graph is showing three lines presenting the total number of seals. This total is conducted by putting all the highest numbers of seals counted on each day, per sand flat, together. The other two lines resemble the amount of adult seals and the green line stands for the pups. The graph line of the adult seals is showing only the highest counted amount of seals. These highest numbers of all the sand flats are put together in this line. The same happened to the graph line of the pups.

**Commentaire [NO1] :** Deze zou ik uit de bijlage halen en in tekst plaatsen samen met data eerste pup etc.

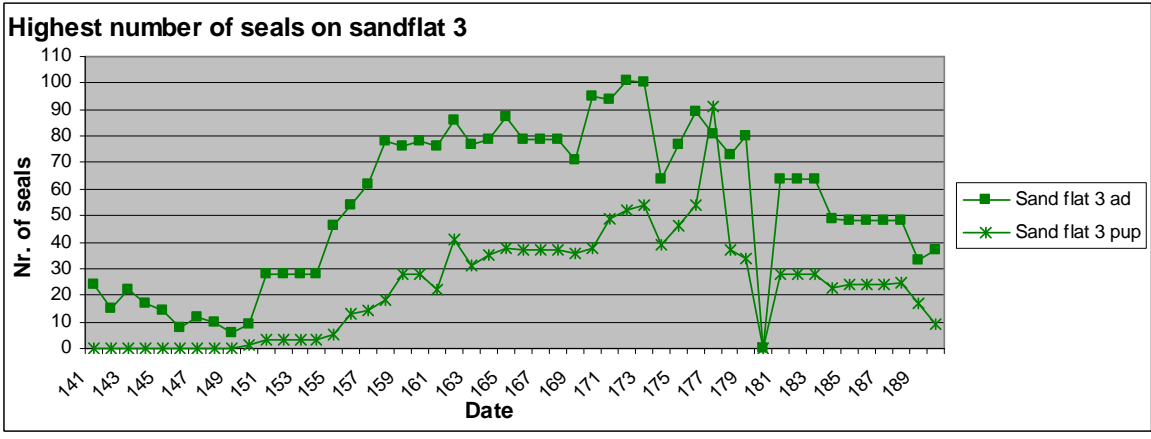


**Graph III; Highest counted number of seals on sand flat 1**  
 The upper line in this graph is showing the adult seals counted on sand flat 1. This graph, as well as the following, are set up by putting the highest counted number of seals per day together. As this graph clearly shows, sand flat 1 is also in use by the seals outside the pupping season. The graph starts with an amount of around 44 adult seals and ends with practically the same number. The highest number of seals on sand flat 1 is 76 seals. This number was recorded on day 150.



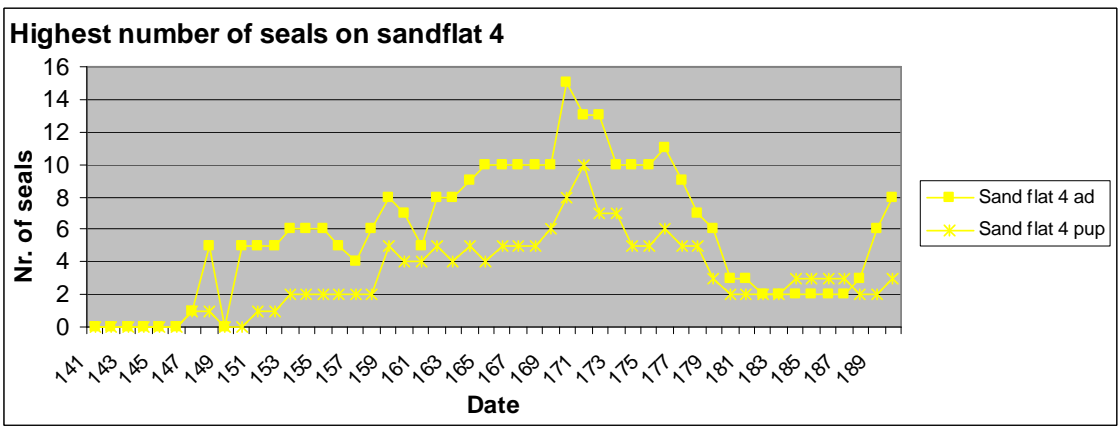
**Graph IV; Highest counted number of seals on sand flat 2**  
 Sand flat 2, as shown in the graph above, is used mainly during the pupping season. Of all sand flats, number 2 is the smallest. This sand flat is also as last visible and disappears as first when the high tide comes. The highest number of adult seals, present at sand flat 2, was 23. 14 pups was the maximum counted number of pups.





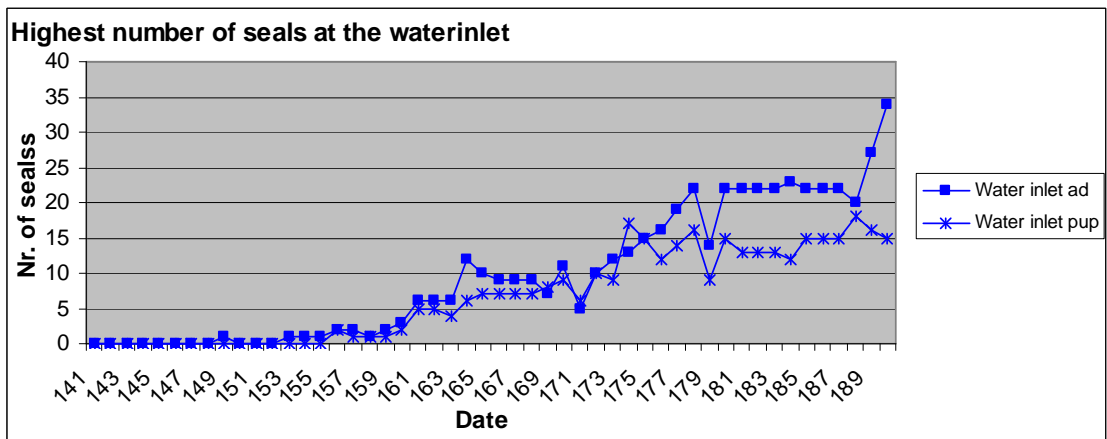
Graph V; Highest counted number of seals on sand flat 3

Sand flat 3 is a haul out side on which seals also rest outside the pupping season. In contrary to sand flat 1, this sand flat is not as popular. At the start of the observation, 24 seals were counted as a maximum on the third sand flat. At the end of the observation period, a maximum of 37 seals was recorded. During this period, a large increase of numbers took place in the population on sand flat 3. On this sand flat, the majority of the pups in the Dollard region was present. A The highest number of pups counted on this side was 91 on day 177. On day 172, the highest number of seals was recorded on sand flat 3; 101 adults.



Graph VI; Highest counted number of seals on sand flat 4

The first pup born in the Dollard, was born on sand flat 4. This took place on day 147. This was also the moment from which the seals started to use this sand flat. The number of seals on this haul out side did not grew to very high numbers during the observation period. A maximum of 15 adult seals was recorded on day 170. At the end of the pupping season, the number of seals which use sand flat 4, starts to decline again.



Graph VII; Highest counted number of seals at the water inlet

Usage of the water inlet as a haul out side, started later in the breeding season. Adult seals did swim by in the beginning, but started resting at the water inlet only when the pups came or were already born. During the season, no real decline was recorded and the number of seals stayed growing. The water inlet is also a special place when the number of pups is observed. From the moment that the first pups were observed in the Dollard, orphan pups started to rest and visit the water inlet. Because the maximum number of seals is listed in the graph, it does not come out that on a lot of times there were more pups present at the water inlet, than adult animals.

## C. Additional graphs for Paragraph 3.2

### C.1. Additional graphs for par 3.2.1

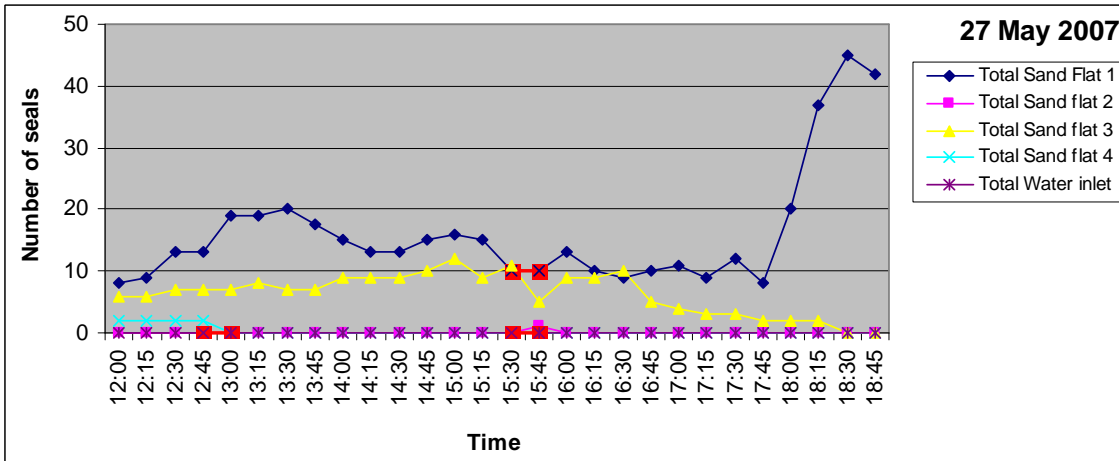
Date	day nr	potential disturbances	actual disturbances
21-mei-07	141	14	1
22-mei-07	142	15	0
23-mei-07	143	21	0
24-mei-07	144	28	2
25-mei-07	145	12	1
26-mei-07	146	8	1
27-mei-07	147	18	3
28-mei-07	148	16	4
29-mei-07	149	2	0
30-mei-07	150	9	1
31-mei-07	151	0	0
1-jun-07	152	0	0
2-jun-07	153	0	0
3-jun-07	154	0	0
4-jun-07	155	2	0
5-jun-07	156	9	2
6-jun-07	157	5	0
7-jun-07	158	3	0
8-jun-07	159	12	4
9-jun-07	160	16	1
10-jun-07	161	33	5
11-jun-07	162	10	1
12-jun-07	163	6	2
13-jun-07	164	9	5
14-jun-07	165	6	0
15-jun-07	166	0	0
16-jun-07	167	0	0
17-jun-07	168	0	0
18-jun-07	169	0	0
19-jun-07	170	2	1
20-jun-07	171	6	3
21-jun-07	172	8	3
22-jun-07	173	8	3
23-jun-07	174	0	0
24-jun-07	175	0	0
25-jun-07	176	4	2
26-jun-07	177	0	0
27-jun-07	178	7	6
28-jun-07	179	7	5
29-jun-07	180	0	0
30-jun-07	181	0	0
1-jul-07	182	0	0
2-jul-07	183	0	0
3-jul-07	184	3	1
4-jul-07	185	3	0
5-jul-07	186	0	0
6-jul-07	187	0	0
7-jul-07	188	0	0
8-jul-07	189	0	0
9-jul-07	190	4	1
total		306	58

Table I; Number of potential disturbances.

This table shows the number of recorded events per day and the number of times the seals were disturbed by this event. The table included observation days that were ended premature.

The cells with a frame around them are observation days on which actual disturbances took place. The Grey days, are days on which observations did not take place.

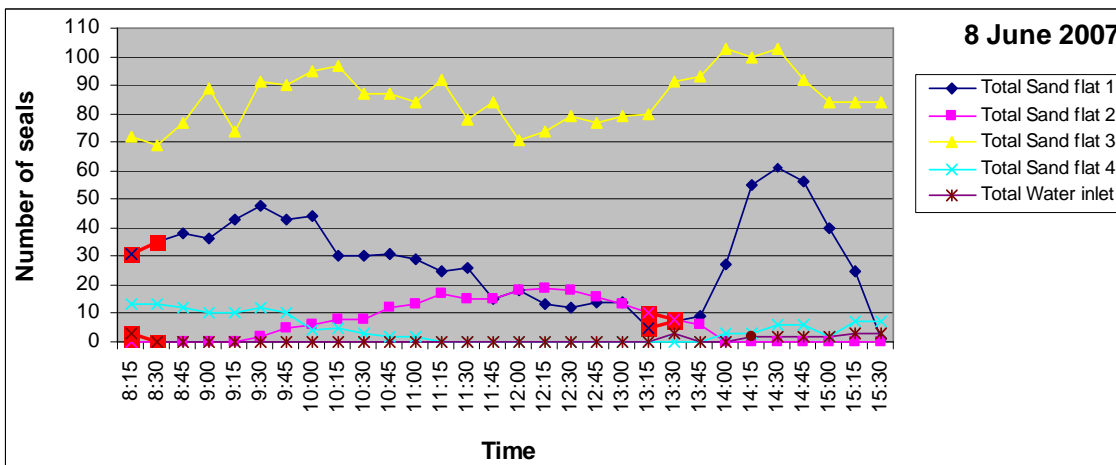
## C.2. Additional graphs for par 3.2.2



Graph VIII; Number of seals and disturbance 27 May 07.

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. A total of three events of actual disturbance were recorded this day:

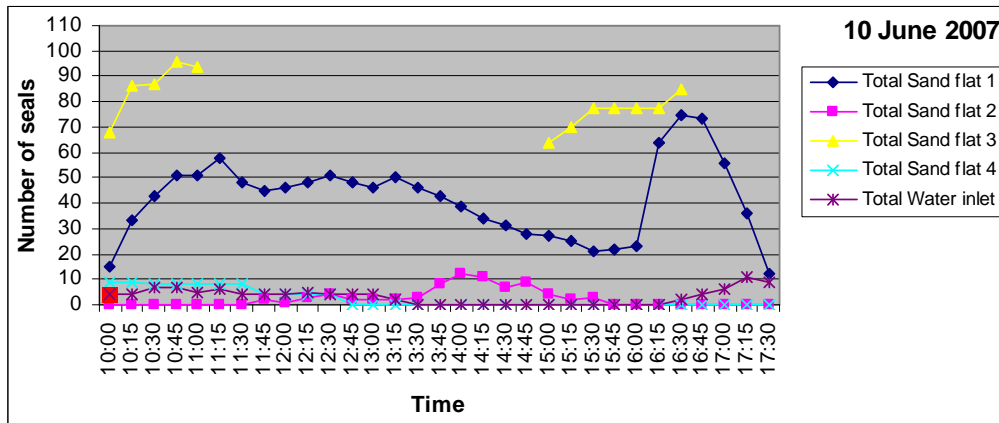
- 12:49; a group of 4 people, including two screaming children, on top of the dike, causing seals at the water inlet to enter the water.
- 13:30; 4 persons on top of the dike at the bench and causing the seals to become restless.
- 15:25; 2 persons at the bench and causing seals to enter the water.



Graph IX; Number of seals and disturbance 8 June 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. A total of four events of actual disturbance were recorded this day:

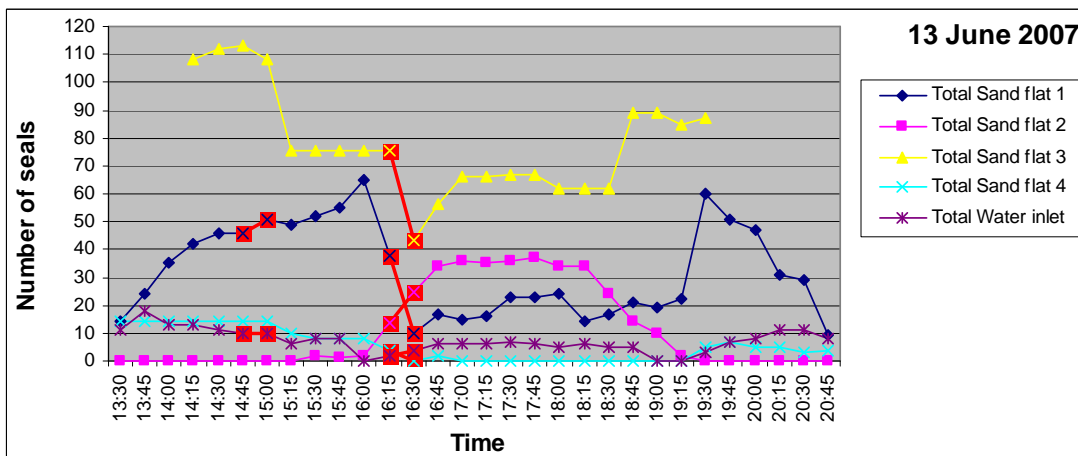
- 8:23; a little van with trailer drives over the gated cattle grid behind the dike, causing seals to lift their heads at the water inlet.
- 8:25; a little van drives on the Punt van Reide, causing seals to enter the water.
- 13:15 till 13:24; a boat near sand flat 1, causing the seals to enter the water.
- 14:15; 2 persons walk everywhere, on top of dike, underneath, at bench, causing the seals to lift their heads.



Graph X; Number of seals and disturbance 10 June 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. The missing numbers on sand flat 3, are due to bad vision, and in the middle of the day averages have been taken between taken measurements. A total of five events of actual disturbance were recorded this day:

- 10:00 till 13:08; a boat is anchored near sand flat 1, causing the seals to lift their heads.
- 10:00; one person on top of the dike, causing seals to enter the water at the water inlet.
- 11:12 till 11:49; 2 persons on top of the dike, causing commotion.
- 14:05; a small airplane flew towards the harbour of Emden, causing seals to raise their heads.
- 15:45 till 15:57; 3 persons on the Punt van Reide, causing seals at sand flat 1 to move towards the water.

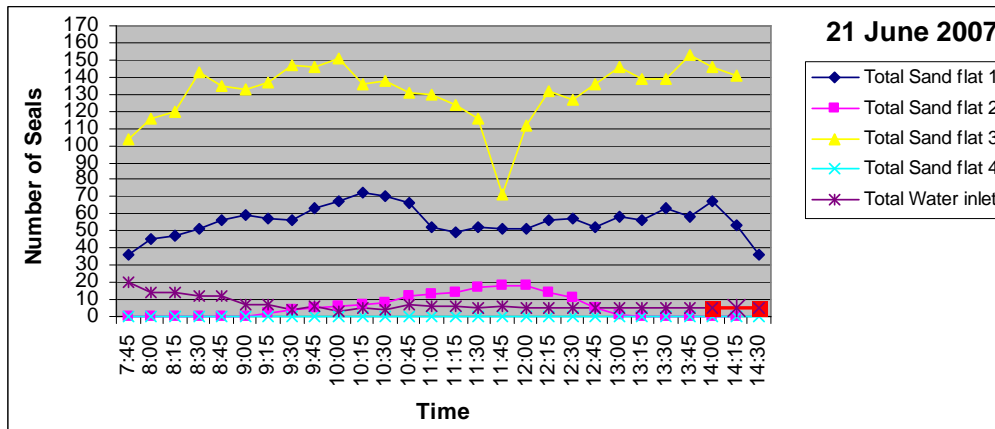


Graph XI; Number of seals and disturbance 13 June 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. The missing numbers on sand flat 3, are due to bad vision, and in the middle of the day averages have been taken between taken measurements. A total of five events of actual disturbance were recorded this day and one natural cause:

- 14:49; a car on top of the dike, causing the mothers to raise their heads and one adult entered the water.
- 14:55; 4 persons on top of the dike, causing one mother and pup pair to enter the water.
- 15:52; 7 cyclists at the bench, causing 3 adults to raise their heads.

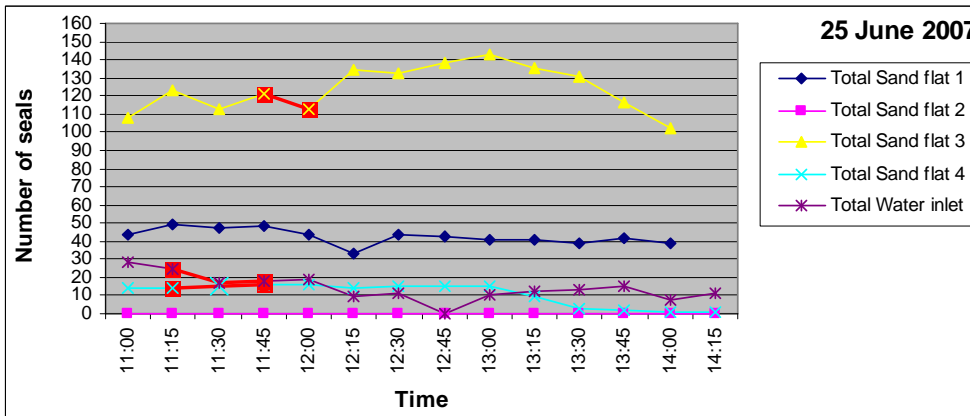
- 16:06; cyclist at the bench, causing 1 mother-pup pair to enter the water at the water inlet.
- 16:15 till 16:27; a short but heavy downpour, causing many seals from sand flat 1, 4 and the water inlet to enter the water. Sand flat 3 was not visible because of the rain.
- 17:02; small airplane flew across the Dollard and low above all the different sand flats. It caused seals to raise their head and the birds were also disturbed.



Graph XII; Number of seals and disturbance 21 June 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. The missing numbers on sand flat 3, are due to bad vision. A total of three events of actual disturbance were recorded this day:

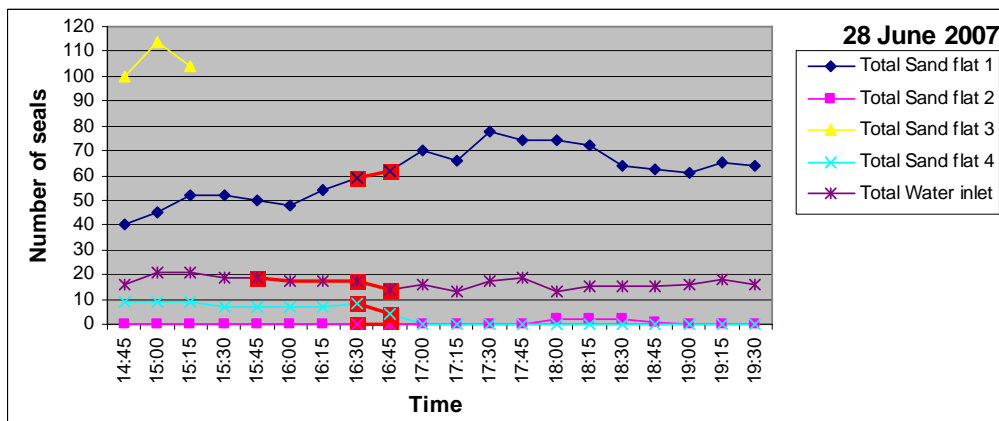
- 10:35 till 10:52; a grass mower behind the dike, causing some seals at the water inlet to raise their heads slightly.
- 13:49 till 14:03; farmer underneath the dike, causing the seals at the water inlet to become restless. However, the tide is also coming, which may also cause the seals to be restless.
- 14:12 till 14:29; one person on top the dike, causing 3 mother-pup pair to enter the water at the water inlet. May also be because the tide is coming.



Graph XIII; Number of seals and disturbance 25 June 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. The missing numbers on sand flat 3, are due to bad vision. A total of two events of actual disturbance were recorded this day and one natural cause:

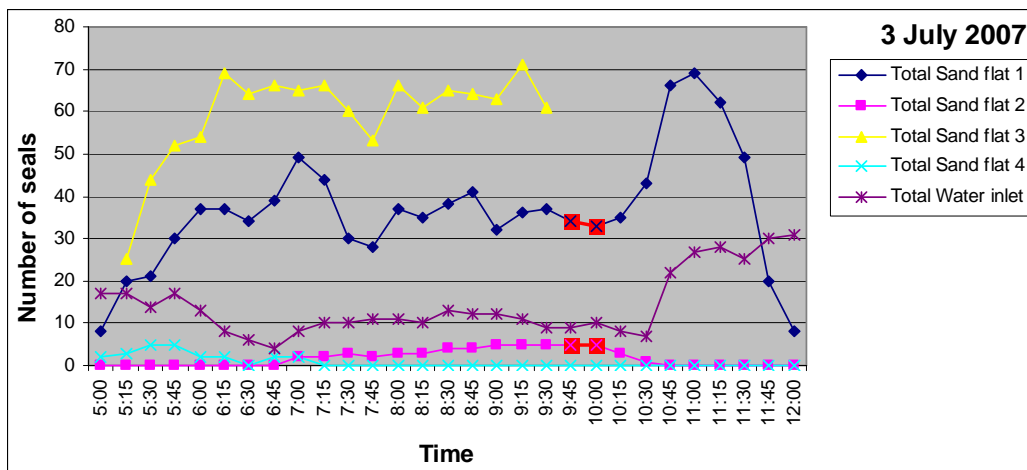
- 11:22; 2 persons walk on top of the dike, causing commotion and also seals to enter the water.
- 12:00; a very dark sky above sand flat 3 and there is heavy rain causing all the seals to sprint to the water.
- 12:37; a boat near sand flat 1 causing an adult to raise its head.



Graph XIV; Number of seals and disturbance 28 June 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide comes up. The missing numbers on sand flat 3, are due to bad vision. A total of five events of actual disturbance were recorded this day:

- 15:01; 2 persons on top of the dike, causing two adults to lift their head.
- 15:43; 2 persons on the dike looking at the seals, causing seals at the water inlet to enter the water.
- 16:35; small airplane flew across the Dollard, causing seals to lift their head, and seals at sand flat 4 to enter the water.
- 18:40; 2 persons on top of the dike, causing seals at the water inlet to become restless.
- 19:35; one person on top of the dike and underneath the dike, a runner, causing seals at the water inlet to lift their head.



Graph XV; Number of seals and disturbance 3 July 07

This graph shows the number of seals per sand flat. Between two red squares joint with a thick red line, the event occurred with the effect of “into the water”, and the event is placed on the line of the sand flat on which the event could be potentially disturbing for the seals. The increase at the end of the day on sand flat 1 can be explained by the fact that seals are behind the sand ridge during low tide, and become visible when the tide

comes up. The missing numbers on sand flat 3, are due to bad vision. A total of one event of actual disturbance was recorded this day:

- 9:48; a boat near sand flat 1, causing 1 adult to raise its head and one mother-pup pair to enter the water.