The common seal

in the Dollard, the Netherlands

Distribution, disturbance and the relationship between mother and pup during birth season 2013

VU VRIJE UNIVERSITEIT AMSTERDAM

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Pieterburen, 30-08-2013

2nd draft

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Abstract

This research studied the common seals, one of the two seal species in the Netherlands, in the Dollard. This protected area is one of the few European remaining brackish tidals. A group of common seals comes to the Dollard every year to give birth. This makes it a good place to observe the seals and look into abundance and distribution, disturbance and the mother-pup relationship. Three research questions have been formulated, which are in short: What is the abundance and distribution of seals and their pups over time, which events are a disturbance for the seals and how is the mother-pup relationship.

The seals were observed from May 15th until July 31th, using a binocular and a telescope. One observation day was seven hours, from 4 hours before until 3 hours after low tide, in which three sandbanks and the sand around the water inlet appeared. Every 30 minutes, the number of seals, with distinction between adult and pup, were listed for each sandbank. Every hour, these numbers were written down on a map of the area. The potential disturbances, actual disturbance and the activity of mothers and pups were recorded when present.

The research question concerning distribution and abundance revealed that the different sandbanks were not used in the same way. Sandbank 2 was used more before the pups were born, sandbank 1 and 3 were used the entire period but more when the pups were born and the water inlet was only used when the pups were present. The distribution is similar to previous years and the abundance is a little bit lower than the previous year.

Concerning the disturbance, 816 potential and 71 actual disturbances were recorded. 90.1% of the actual disturbances disturbed the seals at the water inlet. Although walkers are the number one cause of actual disturbance (in numbers), only 5,3% of the walkers is a disturbance because most of them used the observation screen. Only 0,4% of the people that used the screen in a normal way caused a disturbance. Sheep (100%, N=13), sudden heavy rain (100%, N=4), a speedboat(100%, N=1) and airplanes (87.5%, N=16) have the biggest potential to become an actual disturbance. However, the reaction of the seals is very different for each disturbance source.

For the last research question concerning the mother-pup relationship, it can be concluded that pups stay close to their mother in the first days. Mothers react aggressive against other pups but it is possible that mothers incidentally allow other pups, then their own, to suckle. And there is a possibility that pups can find their mother back when they are alone.

1. Introduction

Human influence on nature is a big issue these days. Currently, there are 7,17 billion people on earth with an increase of 1,17 billion for the last 14 years (www.worldometers.info, 27st of July 2013). All these people need a place to live and access to enough food and water. To provide everybody with these sources humans use approximately 10 to 55% of terrestrial photosynthesis products each year (Rojstaczer *et al*, 2001), use 60% of fresh water run-off (Postel *et al*, 1996) and change a lot of nature into human living area or agricultural land. Due to all those changes, the habitat for a lot of animals and plants are dramatically reduced. To maintain nature and prevent animals from disturbances, a lot of areas are now protected. A good example is the Wadden Sea, the largest unbroken system of intertidal sand and mud flats in the world, with natural processes undisturbed throughout most of the area (unesco.org, 26th of August 2013).

The Wadden Sea is a World Heritage site since 2009 (WHSP report, 2011) and protected by Natura 2000 (Article 20, Nature Protection Law). Specific parts of the Wadden Sea, like the Dollard (figure 1A), are forbidden areas for a period or throughout the year to create resting areas for birds and seals. A part of the land adjacent to the Dollard, the Punt van Reide (figure 1B), is a closed area throughout the year and the waters around Punt van Reide are forbidden for boats from the 15th of May until the 1st of September (Article 20, Nature Protection Law). The Dollard is one of the few remaining European brackish tidals, the salt water comes from the North Sea, the fresh water derives from the river Eems and a small river Westerwoldse. Besides that there is water coming from the water inlet, south of the Punt van Reide, to the Dollard during low tide. The water inlet was installed in 2001 to allow water to pass through the dyke into an artificially constructed wetland, polder Breebaart. This area around the Punt van Reide, property of Natuurmonumenten and managed by Het Groninger Landschap, is an important breeding area for birds and resting area for common seals. Even though the Punt van Reide is a closed area there are a lot of people visiting Polder Breebaart and the dyke between Polder Breebaart and the Dollard, which may cause disturbance. The population of common seals in this area use the three sandbanks and a site close to the water inlet, which appears during low tide, to rest and give birth. Which is maximum 2100 meter from the dyke and makes good observations for this research possible (Huigen & Vogel, 2007).

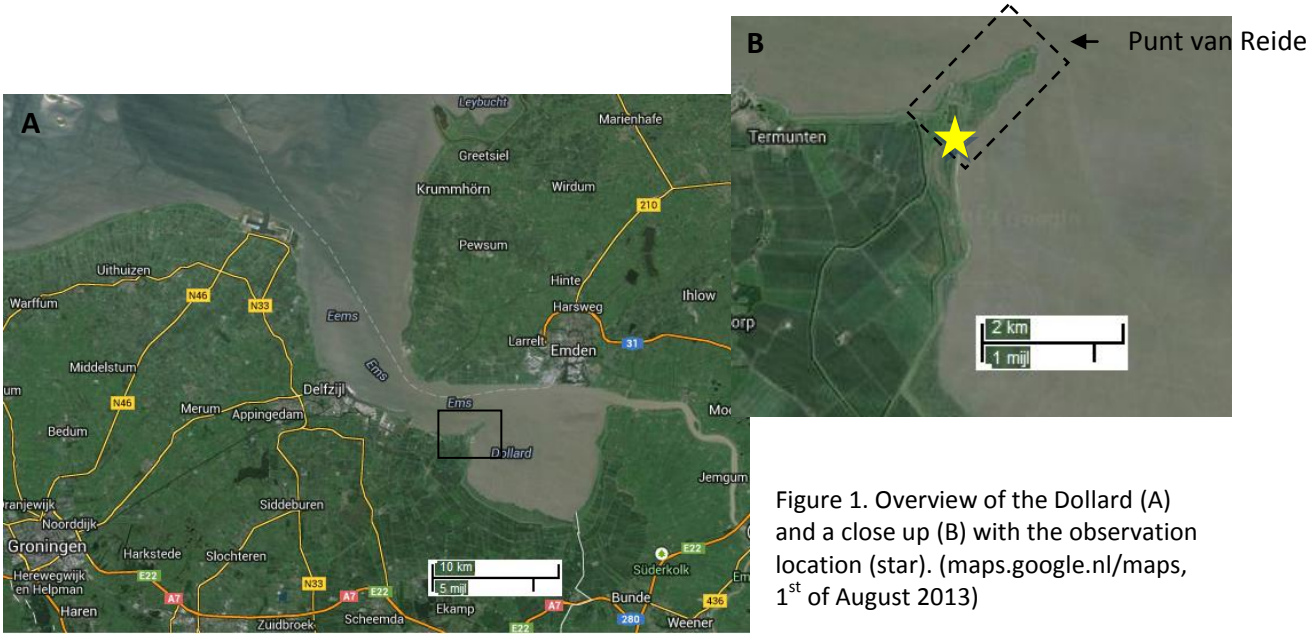

Figure 1. Overview of the Dollard (A) and a close up (B) with the observation location (star). (maps.google.nl/maps, 1st of August 2013)

1.1. Common seal

There are 19 species of seals worldwide, and two of these live in the Wadden Sea: The common seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*). This research concentrates only on the common seal, the Dollard is no habitat of grey seals.

1.1.1. Species

The common seal (also called harbour seal) is a marine mammal and is found along almost all coasts of the northern Atlantic and Pacific Oceans and bordering seas (Stewart *et al*, 2002). They are characterized by their V-shaped nostrils, large eyes, fat body and narrow head with a flat forehead. Their colour varies from light to dark grey or brown and their belly is always lighter than their back, which has a variable spotted pattern. Sexual dimorphism in common seals is very minimal, the only difference is that males become slightly bigger, maximum 1.9 m and 170 kg against maximum 1.7 m and 130 kg (Stewart *et al*, 2002). Most of the time seals are seen in tidal regions, like the Wadden Sea and river mouths where they use haul-out sites, e.g., exposed sandbanks or stones to rest upon. Common seals lay in groups on the sandbanks while they are actually solitary animals. The group is beneficial because it provides protection, there is always an attentive animal inside the group which alerts others about potential danger. Natural enemies like sharks and orcas do not live in the Wadden Sea and hunting is forbidden along the Dutch and German coast. In other countries seal hunting still plays an important role in everyday life, for example in Canada where in 2009 still 72.400 seals are killed for their coat (DFO, 2010).

1.1.2. Diet

The variation in the diet of common seals is large, 29 different species of fish are recorded, but each seal has his own preference (King, 1983). Fish that live close to the bottom, such as flatfish and cod species, are most preferred. Depending on their diet, adult seals need 5 up to 8,5 kilograms a day (Joustra, 2003). Their bodies are specially adapted for deep diving while hunting. They are perfectly streamlined with a thick layer of blubber and their breathing is adapted to stay under water for a longer time. First of all, seals have twice the amount of blood that humans have, and their blood cells can store more oxygen. Secondly, seals can conserve oxygen while underwater. Because their body temperature and metabolism drop drastically, they can stay submerged for up to 5 or 6 minutes while they are foraging. If really necessary, they can stay under water up to 30 minutes (Brader, 1975). The eyesight of common seals is better under water than above but still not very good. Their eyes have large blood vessels which help to stabilize the eye temperature during a dive (www.zeehondencreche.nl, 8th of May 2013). Because their sight is not very good, seals probably make more use of their whiskers to catch fish (Brader, 1975).

1.1.3. Reproduction

Common seals become mature between the age of two to five, females are sexually mature at age 4 and males at age 6. Mating takes place between early August and mid September and the period that common seals give birth is from May until August. The period between mating and giving birth is eleven months but the pregnancy lasts seven to eight months. The implantation is delayed; three months after the mating the fertilized egg enters the womb and starts to grow (Hewer, 1974). The pups have a white baby fur called lanugo, just like the grey seal, but they lose this before they are

born (King, 1983). If they kept this lanugo, they would be unable to swim. This would be detrimental because they are born on a sandbank during low tide and only have, at maximum, 6 hours before the water rises.

For the first weeks the pup drinks milk from the mother. This is very nutritious and has a fat content of approximately 45% (Harrison, 1960). This is why the pup grows fast and doubles its weight in the first weeks. After this period the mother leaves her pup that then needs to find food on its own, a so called weaned pup. Most of the pups need some time to become experienced at catching a meal, which is why the pup needs as much as possible of its mother's milk (Brader, 1975; van Wieren, 1981).

1.1.4. Population size

In recent years the number of seals in the Wadden Sea grew rapidly. In 2012, 6529 common seals were counted in the Dutch Wadden Sea (TSEG, 2012). The real number of seals is possibly higher because scientists assume that part of the seals is under water during a count.

The population of common seals in the Dutch Wadden Sea had peaks and drops over the last 50 years, caused by disease, hunting and pollution (figure 2). The latest major decline was in 2002 and was caused by an epidemic of Phocine Distemper (Jensen *et al*, 2002). Many seals died but the population increased again from 2004. Compared to 2011, the population of common seals in the Dutch Wadden Sea decreased in 2012 but the population in the entire Wadden Sea increased with 11% (TSEG, 2012). The scientist of the Trilateral Seal Expert Group (TSEG) think that this means that the distribution of seals had shifted towards the east within the Wadden Sea. Which can mean that the seals move around to optimise their feeding and breeding, and avoid disturbance. Therefore, it is important to monitor different populations to look for local effects, especially human disturbance.

To monitor the population in the Dollard, the following research questions were formulated for this part of the research: What is the abundance of common seals and how is the distribution of the seals and their pups during the observation days, from 4 hours before low tide until 3 hours after? These observation days are in the period between the 15th of May and the 31st of July in the Dollard close to the Punt van Reide.

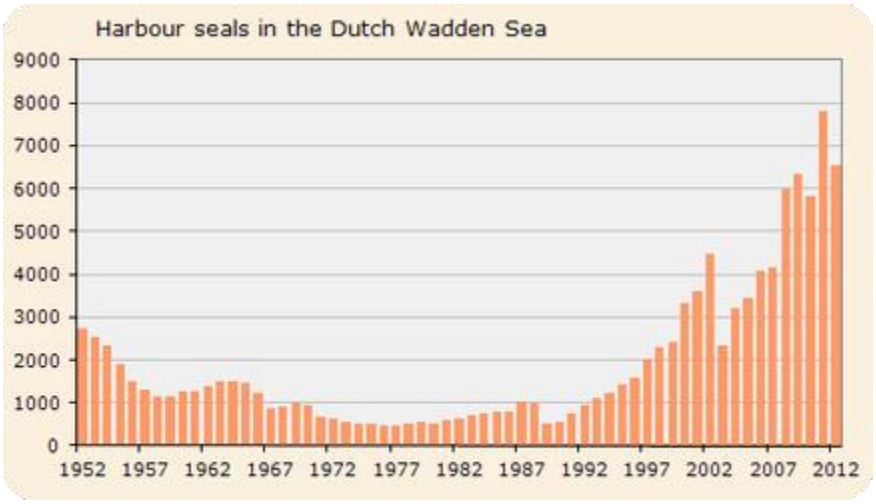

Figure 2. Total number of common seals in the Dutch Wadden Sea.

1.2. Human influence in the Wadden Sea and the Dollard

General threats to the common seal in the Wadden Sea are pollution and disturbance. There is pollution in two forms, first by non-degradable substances which stay in the environment for a long time, e.g., PCB's[1] and other PHAH's[2] that results in suppressed immune function and less successful reproduction (Swart *et al*, 1996; Laane *et al*, 2013). Secondly, by the increasing amount of waste material. Seals get caught up in old fishing nets, the percentage stranded common seals that died due to by-catch was 19% from 1979 until 2008 (Osinga *et al*, 2012b). And the percentage of entangled seals rehabilitated in the Seal Rescue and Rehabilitation Centre (SRRC) increased from 0,32% (1985-2000) to 0,86% (2001-2010) (Van Liere *et al,* 2012). Besides that, it is possible that seals eat small pieces of plastic, e.g., 12% of the seals in the Netherlands are found to contain plastic in their stomachs or intestines (Bravo Rebolledo *et al*, 2012).

An additional threat in the Dollard is the input of polluted water from the Eems, a nickname for this river is the yellow river because of all the silt and fluid mud in the water. More silt means less algae, less oxygen, lower amounts of fish, less life on the bottom and finally less nature. This pollution is caused by human activity, the Eems is important for the shipping industry so the river is being dredged regularly (Sips & de Leeuw, 2009). This also ensures that the bottom attrition of the Dollard is not natural anymore, the speed of the flood stream has increased with 73% since 1937 by all the changes in the bottom (www.waddenvereniging.nl, 9 th of May 2013). The created water flow could be dangerous for pups when they go into the water, for example when they are disturbed, they could lose their mother more easily because their mother is stronger and can handle the strong water stream. The pollution and speed of the flood stream are not easy to change but reducing the amount of disturbance should be easy when it is known how much disturbance is caused by human activity and what the consequences are.

Disturbance generally occurs when seals are hauling out on sandbanks. The source of disturbance creates commotion, seals are moving to the water or get in to the water. In general this is only a disturbance of the resting period of the seal, also called haul out. However, during the birth season it is possible that pups lose their mother because of a disturbance. Human activities, e.g., airplanes, boats or walkers are a big source of disturbance. For this reason tourism is an important cause of disturbance. In the summer months there are thousands motorised and sailing boats on the Wadden Sea. Tourists moor their boat on sandbanks, which are also used by common seals (van Wieren, 1981). On this part, seals in the Dollard have an advantage because boats are only allowed in the fairway north of the Dollard and not in the remaining part of the Dollard from the 15th of May until the 1st of September (Article 20, Nature Protection Law). However there are many people that visit the Dollard, for example on foot to see the seals and birds in the area, which creates disturbance (Osinga *et al*, 2012a). Because of these disturbances Het Groninger Landschap, the water board Hunze en Aa's and the SRRC in Pieterburen decided in 2011 to place a screen on the dyke with holes to peek through (www.groningerlandschap.nl, 9th of May 2013). People can watch the seals from behind the screen and do not cause disturbance because the seals cannot see movements when the people stay behind the screen (Jenkins and Cimmino, 2011).

[1] PCB's: Polychlorinated biphenyls
[2] PHAH's: Polyhalogenated aromatic hydrocarbons

For this part of the research the following research question was formulated: Which factors are potential/actual disturbances to the common seal during the observation days between the 15th of May and the 31st of July, from 4 hours before low tide until 3 hours after?
Supported with the sub questions:

- Which factors cause disturbances?
- Does the screen induce a decrease in disturbances from the dyke?
- How do the seals respond to the different disturbances?

One of the possible consequences of disturbance is that a pup could lose its mother. Therefore it is important to study if pups are left alone, e.g., for foraging, or that it is a pup that loses its mother. The research question for this part is: How is the relationship between a female common seal and her pup, when they are on the sandbanks close to Punt van Reide, during the suckling period?
Supported with the sub questions:

- What is the distance between mother and pup?
- Which interactions are there between a mother and (her) pup?
- Does the mother leave her pup alone?
    - If so, for how long is the pup left alone?
- How many days are a mother and pup together for?

Methods

2.1. Research methods

To get answers to the research questions, the seals in the Dollard were observed with a telescope (Leica Televid 77, magnification: 60x) and a binocular (Eden Quality XP, magnification 10x42). Therefore the observations were only possible by daylight hours (sunrise and –set times 52°00 northern latitude and 5°00 eastern longitude) which excluded some days because an observation day begins four hours before low tide and ends three hours after (appendix 1). This period took approximately seven hours and was appropriate because the sandbanks appear by low tide. For tidal information, the low tide times of Delfzijl, the nearest town, were used. Table 1 gives an overview of the observation days. In this area there are a lot of seals hauling out on these temporary sandbanks. There were different methods of observation used because there were multiple research questions. A part of the observed data was collected on prepared schemes, which were copied to digital files, the other part was noted when the event occurred and afterwards copied to a digital file.

Observation Days	May					June				July				
Week:	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Mo		6	13	20	27	3	10	17	24	1	8	15	22	29
Tu		7	14	21	28	4	11	18	25	2	9	16	23	30
We	1	8	15	22	29	5	12	19	26	3	10	17	24	31
Th	2	9	16	23	30	6	13	20	27	4	11	18	25	
Fr	3	10	17	24	31	7	14	21	28	5	12	19	26	
Sa	4	11	18	25	1	8	15	22	29	6	13	20	27	
Su	5	12	19	26	2	9	16	23	30	7	14	21	28	

Table 1. Overview of the observation days. Green; observation days. Red; no observation day due to bad weather. Orange; observation day but not completed due to bad weather. White; no observation because the observation period was (partially) during the night.

During the observations it was important, for the research question about disturbance, that the two observers did not disturb the seals by themselves. This is also not allowed by law because common seals are a protected species (Flora and Fauna act). Punt van Reide, approximately 1/3 of the distance toward the Punt was the best location to observe the seals, but a permit is required because the Punt van Reide is a closed area throughout the year. Therefore the observations took place near the fence that closes the Punt van Reide just below the top of the dyke, similar to previous years (Bakker & de Vries, 2007; Nussbaum & Selvaggi, 2008; de Boer, 2009; Groothedde, 2010; Jenkins & Cimmino, 2011; Allbrook & Bernabeu Lopez, 2012).

2.1.1. Abundance

Concerning the first research question, regarding the abundance and distribution of the seals, the scan sampling observation method has been used. The three sandbanks were scanned on predetermined time intervals. This leads to time-sampling as the registration method (Hill *et al*, 2006). The time interval was 15 minutes in the first 24 observation days and 30 minutes in de last 14 observation days. The time interval between two counts was changed to spend more time to look to the mother-pup relationship. The distribution and amount of seals on one day was still clear with half

of the counts. During each count, the seals on the different sandbanks were counted separately and on each sandbank the pups and adult seals were counted individually. From observation day 32, 19th of July, onwards, the adult seals and pups were counted together because the pups became similar in size as the seals which were born last season, a year ago. In addition, a drawing was made on a map every hour to see where the seals were located on the sandbanks. The seals that were visible around the sandbanks, because their head was above the water, were also counted in both of the measurements. Additionally, there was a note of the weather type during the day to see if this plays a role in the distribution or disturbance. There was an observation form used to register the number of seals (appendix 3) and a map (appendix 4) to draw where the seals were, which made the data gathering of this research question a structured method.

2.1.2. Disturbance

For the second research question, regarding the disturbance of the seals, an 'ad libitum sampling' is used as observation method. This means that everything that seemed important was written down. This was done during the entire period of every observation day so the registration method was continuous. Disturbances that were documented were for example cyclist, cars, airplanes, walking people and all the others cases that are a potential disturbance. This source of disturbance, the reaction of the seals (heads up, commotion, move to water, get in water or no reaction) and the time they were disturbed for were listed to get a good view about the different disturbances. The time was noted on the observation form in the zone where the source of the disturbance took place. The observation area was divided into 7 zones (figure 3): OL; from the gate to the first fence on the dyke, L; from the first fence on the dyke to the fence that closes the Punt van Reide, C; from the fence that closes the Punt van Reide to the fence to the right of the observation screen, R; from the fence to the right of the observation screen to where one can see the road behind the dyke, OR; on the dyke from the point where one cannot see the road any more to anything further right as far as the eye can see, B; beach strip between the sea and the road, Platform; People that used the observation screen: behind or in front of the observation screen.

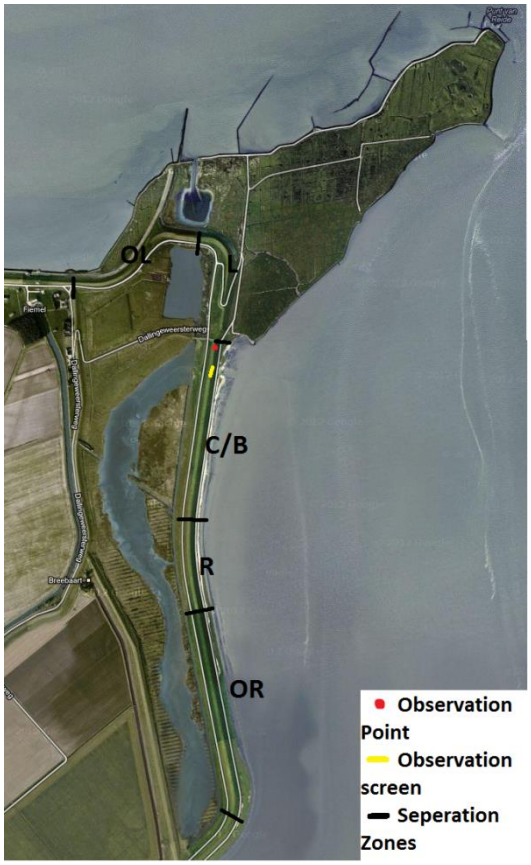

Figure 3. Zones in the observation area.

Previous research proved that the presence of walking and cycling people is more frequent in comparison with e.g. airplanes or boats, causing more potential disturbances when they were visible or could be heard by the seals. Therefore walking people or cyclists were only noted when they were on top of the dyke or when they used the observation screen. People that walked or cycled behind the dyke were not regarded as a potential disturbance, except for people who made a lot of noise. The same observation form is used for both types of continuous registration but not all parts are used for walkers and cyclist (Area OL, R, OR not).

2.1.3. Mother-pup relationship

The same data was required for this research question as for the research question about the location, the number of seals (pup or adult) and where they were. Other than that there was a continuous registration of the activity of the mother and her pup, only for the seals by the water inlet. This was noted as suckling, resting, pup is alone, distance between the mother and her pup, were they moving or having other activities. To find out how long mother and pup are together until weaning, visible characteristics of adult were noted.
Table 2 gives an overview of all the observations made during the observation days.

Time-interval	Subject	Research question
15 minutes/ 30 minutes	Number of seals (adult/pup) for each sandbank	Abundance and mother –pup relationship
1 hour	Map of location and age of the seals	Distribution and mother-pup relationship
Each event	Activity of mother and her pup	Mother-pup relationship
Each event	Source of disturbance	Disturbance
During the day	Weather	Abundance

Table 2. Overview of the activities during one observation day with their time interval and for which research question they were important.

2.2. Data Analysis

During the observation period (15th of May-31st of July) the data was digitally processed. After the observations, data about the number of seals were compared with the collected data of the past years. Together with the data about the distribution, it was studied whether the distribution changed over time. The data about disturbance was analysed to find out which sources disturbed the seals and how long the seals were disturbed. The amount of disturbance from the dyke was compared with the past years to see if there was a decrease in disturbance from the activities on the dyke since the placement (and improvements) of the screen. The data was analysed with the use of Microsoft Excel 2007. Chi square tests are performed with Excel 2007 and Pearson correlation and One-way ANOVA test were performed with SPSS. The data about the mother-pup relationship is particularly important to evaluate if the mother temporarily leaves her pup and for how long. In the end, all the data is analysed to collect as much information as possible.

3. Results

This section of the report includes the results of the analysis based on the research questions as mentioned in the introduction. Distribution and abundance will be described first, followed by the disturbance and finally the mother-pup relationship.

3.1. Abundance

During the entire observation period from day 135 (15/05/2013) until day 212 (31/07/2013), a maximum of 274 adults (18/06/2013) and 141 pups (30/06/2013) were counted. On both days the highest number of seals (adults and pups at the same time) was 392, also the highest number of seals during one count in the entire period. The highest observed number of seals on one day, maximum number of adults and pups, was 409 (30/06/2013) (figure 4).

However, the number of seals during one observation day fluctuated. During 35 of the 38 days, the highest numbers of seals was not during low tide (4^{th} and 5^{th} hour) but in the last two or in the first three hours of an observation day. During 17 of the 38 observation days the highest number was in the first 3 hours, during 18 of the 38 days the highest number was in the last 2 hours and only on 3 of the 38 days the highest number was during low tide. The number of seals increased faster after the observation of the first pup, day 149 (29/05/2013) (figure 4). The number of pups increased steadily until the highest number was reached, day 181, after which the number of adults and pups decreased again. The date of the first pup and the highest number of pups were in line with previous years (table 3).

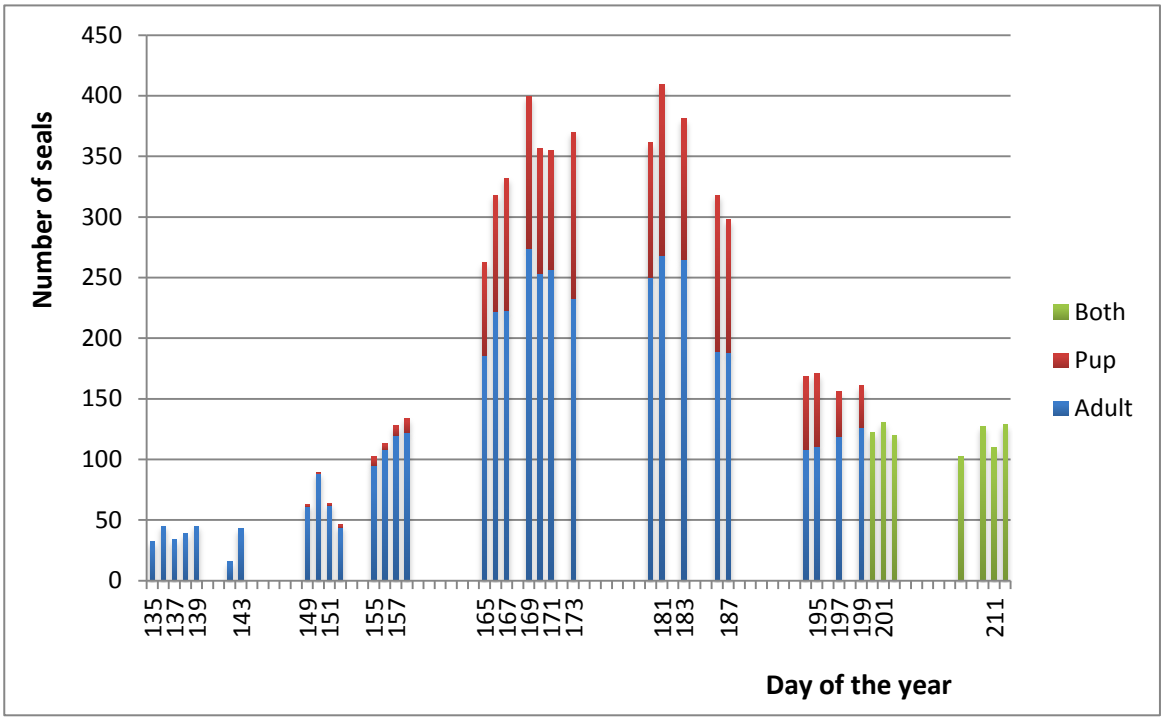

Figure 4. Maximum number of adults and pups during each observation day.

Date	2007	2008	2009	2010	2011	2012	2013
First pup	27/05	30/05	31/05	26/05	27/05	27/05	29/05
Highest number of pups	20/06 22/06	30/6	30/06	17/06	28/06	29/06	30/06

Table 3. The date of the first pup and the highest number of pups for each year.

The abundance of common seals in the Dollard is compared with the maximum numbers of adult seals and pups from the past years (Bakker & de Vries, 2007; Nussbaum & Selvaggi, 2008; de Boer, 2009; Groothedde, 2010; Jenkins & Cimmino, 2011; Allbrook & Bernabeu Lopez, 2012). Since 2010 is a decrease in adult seals and an increase in pups observed (figure 5). In comparison to last year both adult seals and pups decreased slightly.

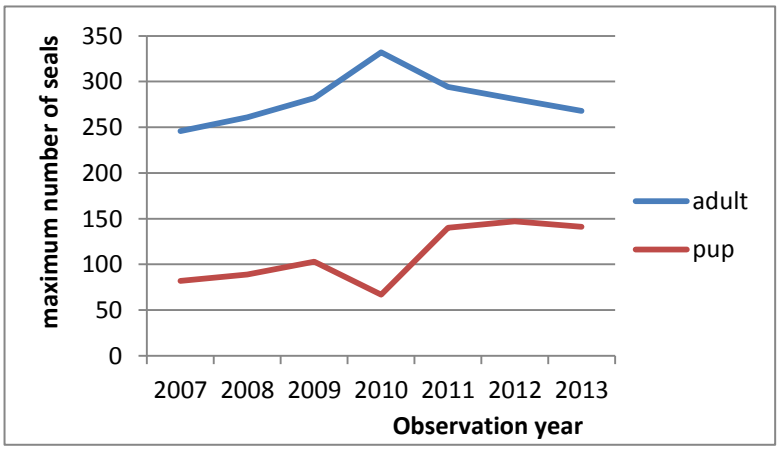

Figure 5. Maximum number of seals during each year.

The pattern of numbers of common seals over the season on the three sandbanks and the water inlet was significant different (Adults; N=38, WI: $\chi^2 = 669,4$; $P < 0,001$, S1: $\chi^2 = 430,6$; $P < 0,001$, S2: $\chi^2 = 431,3$; $P < 0,001$, S3: $\chi^2 = 1550,8$; $P < 0,001$. Pups; N=31, WI: $\chi^2 = 831,4$; $P < 0,001$, S1: $\chi^2 = 513,5$; $P < 0,001$, S2: $\chi^2 = 431,3$; $P = 0,001$, S3: $\chi^2 = 879,5$; $P < 0,001$) (figure 6). Sandbank 1 was used the entire period and the number of seals increased a little bit from the moment the pups were born, day 149. Sandbank 2 was used more before the pups were born and scarcely when the pups were in the Dollard. Sandbank 3 was used the most with a large increase from the moment the pups were born and a gradual decrease, starting 12 days earlier then the decrease in total numbers. The water inlet was not used in the first weeks. Day 155 (04/06/2013) was the first day that a seal stayed at the water inlet for the entire observation day. After that day the number of seals that used the water inlet increased. Notable is that from day 180 (29/07/2013) the number of pups at the water inlet was higher than the number of adult seals.

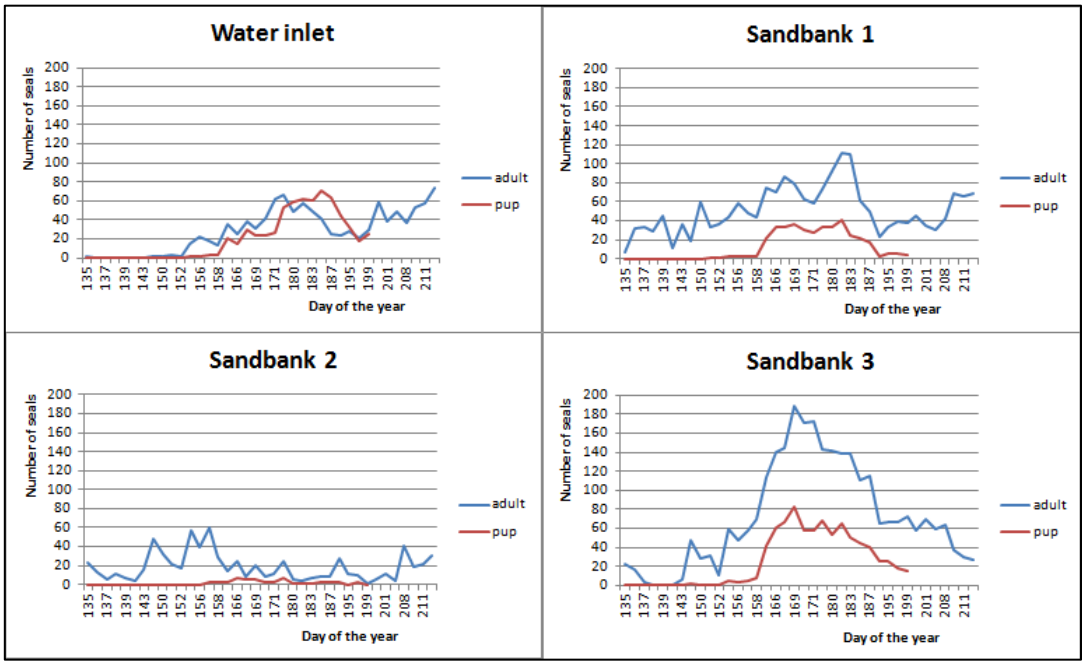

Figure 6. Abundance of adults and pups for the water inlet and each sandbank during the entire observation period (Adults; N=38, WI: $\chi^2 = 669,4$; $P < 0,001$, S1: $\chi^2 = 430,6$; $P < 0,001$, S2: $\chi^2 = 431,3$; $P < 0,001$, S3: $\chi^2 = 1550,8$; $P < 0,001$. Pups; N=31, WI: $\chi^2 = 831,4$; $P < 0,001$, S1: $\chi^2 = 513,5$; $P < 0,001$, S2: $\chi^2 = 431,3$; $P = 0,001$, S3: $\chi^2 = 879,5$; $P < 0,001$).

Just like the pattern over the entire period, the pattern during one observation day is also different on each sandbank and significant different between the sandbanks (F = 79,8; df = 3; P <0,001) (figure 7) The number of seals on sandbank 1 was increasing in the first 3 hours, decreased a little bit in the following three hours and increased again in the last hour. Sandbank 2 is the only sandbank which is empty at the beginning and at the end of the observation days, the maximum at this sandbank lies on average during the 5th hour. Sandbank 3 is most stable in number of seals during a day, with a peak during the second hour and a little increase between the 6th and 7th hour. In contrast to the sandbanks, the peak in number of seals at the water inlet lies during the 1st hour. There is a decrease during the first five hours, after which the number increases again.

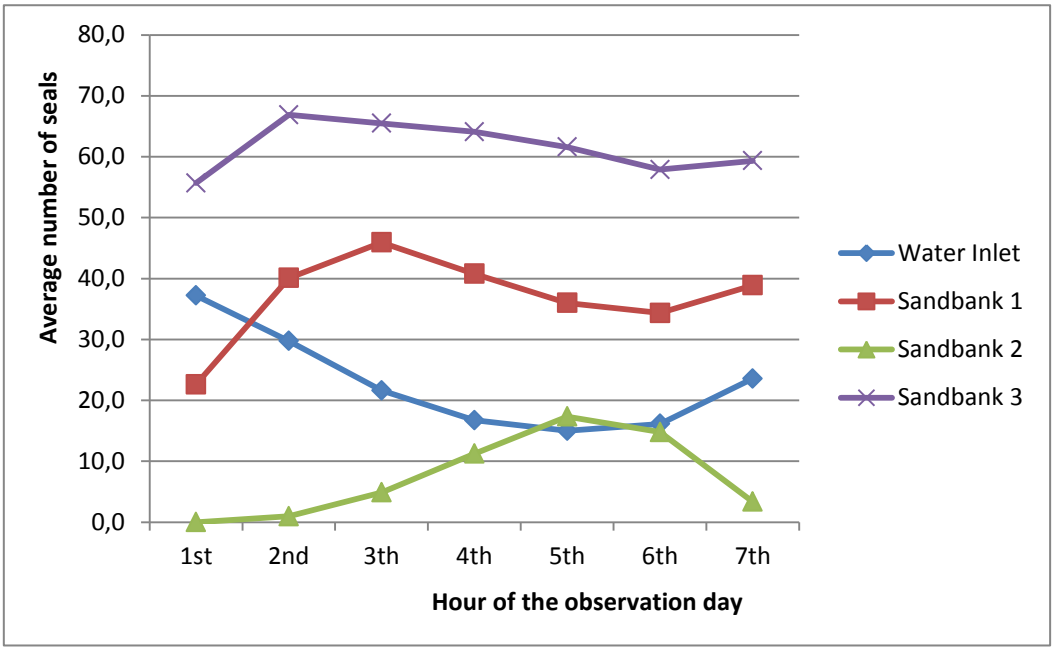

Figure 7. (F = 79,8; df = 3; P <0,001) Average number of seals during each observation hour, over the entire observation period.

With the use of the map it became visible that the seals had their favourite places on the sandbanks (figure 8). Dividing the data in before the presence of pups and during the presence of pups (from day 149), the difference is clear. Sandbank 2 is used less with pups. In contrast, the water inlet is used more with the presence of pups.

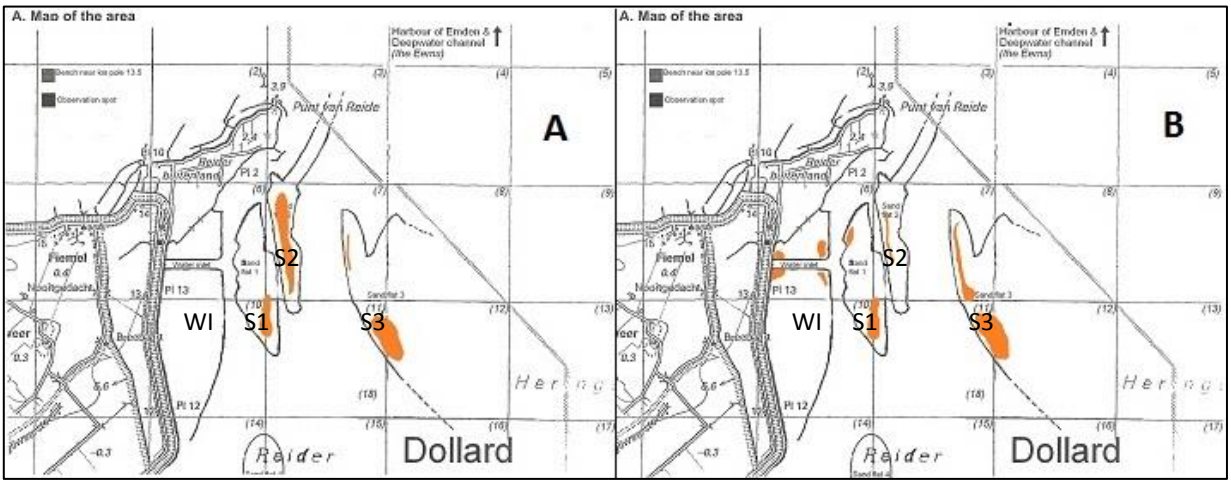

Figure 8. Distribution of seals before pups where born (A), day 135-148, and with pups (B), day 149-212.

3.2. Disturbances

To find out which sources are the causes of a disturbance, every event that can cause a reaction is noted as potential disturbance. The potential disturbances are the events that did not cause a reaction as well as the events that caused a reaction of the seals (figure 9). In total, 816 potential disturbances were recorded in the 38 observation days. All these potential disturbances were caused by 14 different sources. Walkers, cyclists and cars together caused 91,2% of the events.

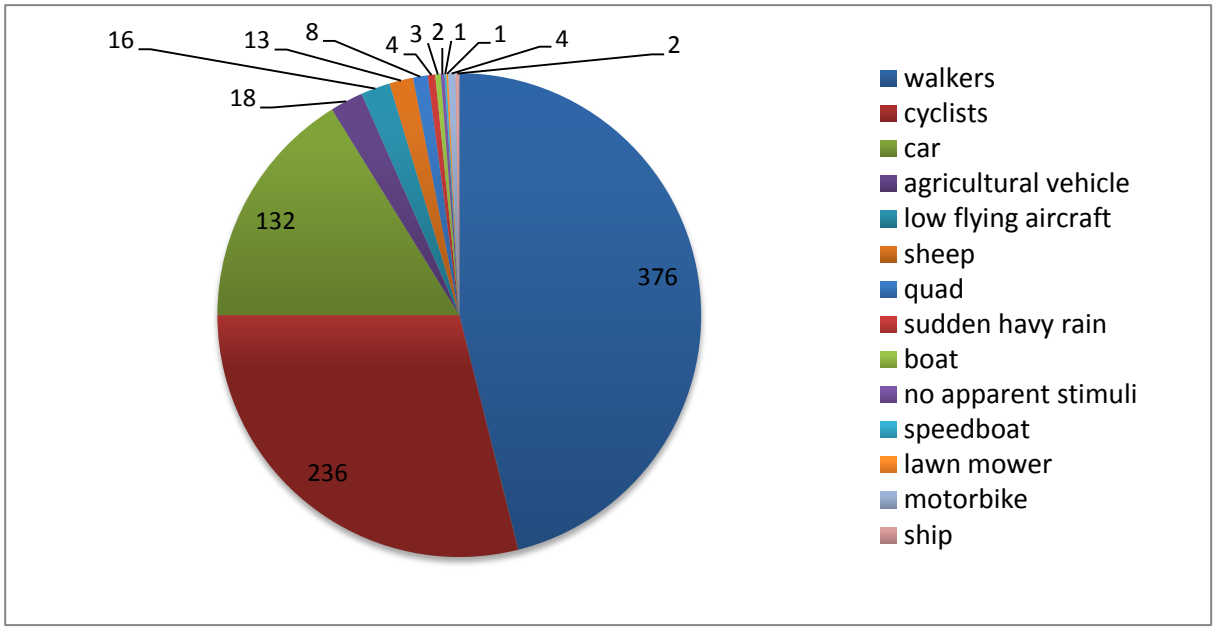

Figure 9. Potential disturbances from day 135 (15/05/2013) until day 212 (31/07/2013).

When one looks at the actual disturbances (with a reaction from the seals varying from heads up to into the water) these three sources caused only 45,1% of the events (figure 10). From a total of 71 actual disturbances 90,1% of the events disturbed the seals at the water inlet.

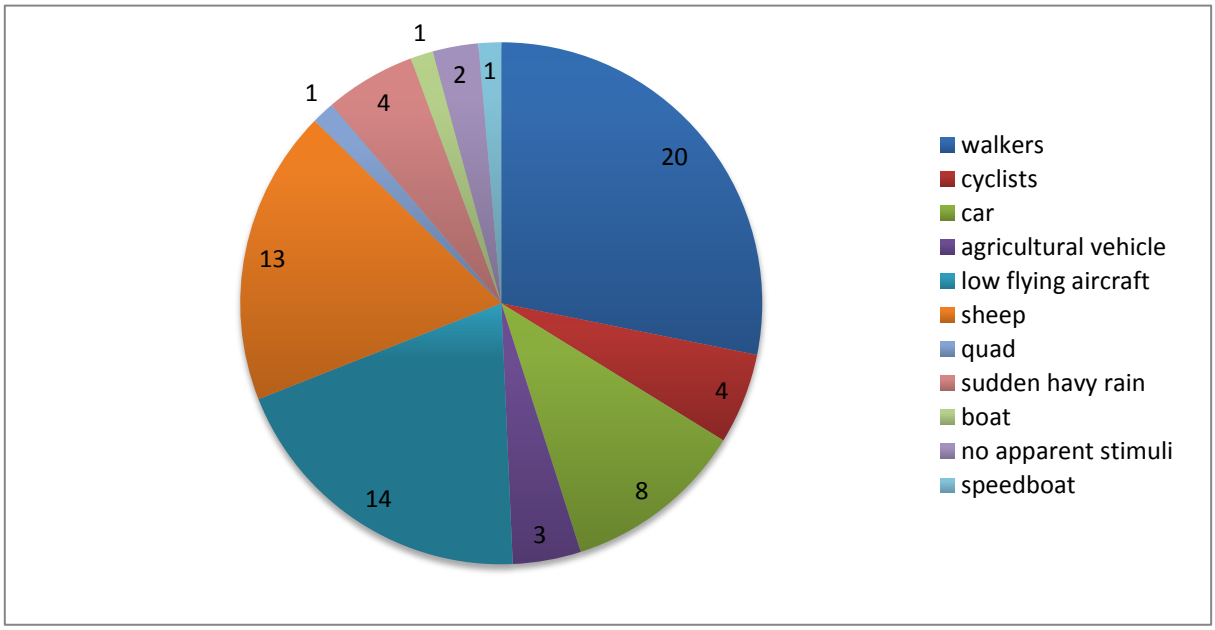

Figure 10. Actual disturbances from day 135 (15/05/2013) until day 212 (31/07/2013).

Walkers (5,3%, N=376), cyclists (1,7%, N=236) and cars (6,1%, N=132) did not have a high percentage actual disturbances. Looking at the other sources: a speedboat (N=1), sudden heavy rain (N=4), sheep (N=13) and no apparent stimuli (N=2) were all 100% actual disturbances and low flying aircrafts (N=16) caused for 87,5% of the events an actual disturbance. They did not appear regularly in the area but when they appeared the seals reacted often on the source.

Although a speedboat, sudden heavy rain, sheep and low flying aircrafts caused an actual disturbance at almost every event there was a big difference in the type of reaction of the seals (figure 11). Comparing low flying aircrafts (N=16) and sheep (N=13), low flying aircrafts caused two times 'no reaction', 14 times the reaction 'heads up' and in one of those 14 times also 'move to the water'. While sheep caused six times 'heads up', four times 'commotion', four times 'move to the water' and six times 'get in the water', this happened during 13 events so during some events different reactions occurred.

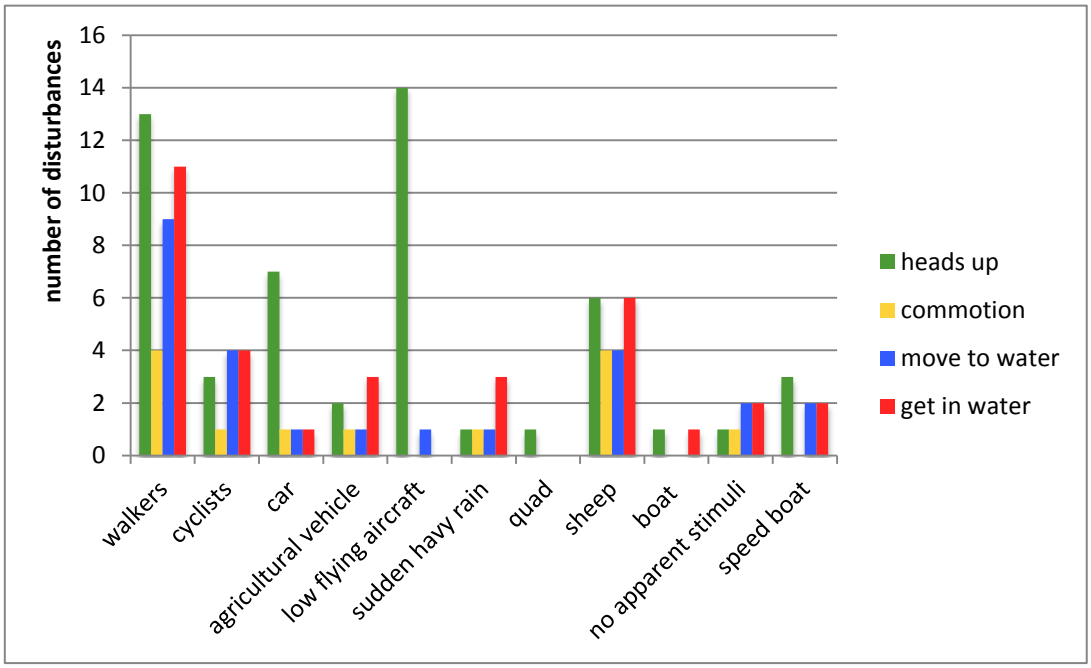

Figure 11. Number of disturbances with the specific reaction of the seals

Furthermore there was a difference in the reaction of adult seals and pups. For example, when the sheep came close to the seals. All the adults seals reacted to the sheep but the pups did not. There were two events (both 02/07/2013) with a group of weaned pups where only one of the 8 pups reacted. On the first event one of the pups raised its head and during the second event one of the pups moved to the water (figure 12), the other 7 pups did not react at all.

Figure 12. Actual disturbance with sheep, only one pup reacts.

The occurrence of the potential and actual disturbances during the observation period changed, there was an increase from May until July (Table 4). In May, only 2,7% (3/113) of the potential disturbances was an actual disturbance. In June, 7,5% (21/280) and in July 11,1% (47/423).

Potential Disturbance	**May**	**June**	**July**	**Total:**	**Actual Disturbance**	**May**	**June**	**July**	**Total:**
walkers	54	136	186	376	walkers	0	8	12	20
cyclists	22	64	150	236	cyclists	0	1	3	4
car	29	55	48	132	car	0	1	7	8
low flying aircraft	2	4	10	16	low flying aircraft	2	3	9	14
Boats	1	2	3	6	Boats	0	0	2	2
agricultural vehicle	3	5	10	18	agricultural vehicle	0	1	2	3
other motorized vehicle	1	7	5	13	other motorized vehicle	0	0	1	1
sheep	0	5	8	13	sheep	0	5	8	13
sudden heavy rain	1	2	1	4	sudden heavy rain	1	2	1	4
no apparent stimuli	0	0	2	2	no apparent stimuli	0	0	2	2
Total:	113	280	423	**816**	**Total:**	3	21	47	**71**
Potential disturbances/ Observation hours	1.66	3.04	4.32	**3.16**	**Actual disturbances/ Observation hours**	0.04	0.23	0.48	**0.28**

Table 4. Number of potential and actual disturbances in each source, by month.

Compared to other years (Table 5), the number of actual disturbances for this year (71) was average, while the number of potential disturbances was the highest (Bakker & de Vries, 2007; Nussbaum & Selvaggi, 2008; de Boer, 2009; Groothedde, 2010; Jenkins & Cimmino, 2011; Allbrook & Bernabeu Lopez, 2012). Comparing the interval between successive actual disturbances, hours between two disturbances, this year (3.6 hours) was average. There is a significant correlation between the observation hours and the total potential disturbances (N = 7; P = 0,044) but no significant correlation between potential and actual disturbances (N = 7, P = 0.831) and between observation hours and actual disturbances (N=7; P = 0,94).

Year	**First-last observation day**	**Total observation hours**	**Total potential disturbances**	**Total actual disturbances**	**Percentage of potential disturbance causing a response (% actual disturbance)**	**Interval between successive actual disturbances (hours)**
2007	141-190	224	306	58	19	3.9
2008	141-212	232	291	203	69.8	1.1
2009	150-200	126	93	29	31.2	4.3
2010	138-170	252	762	65	8.5	3.9
2011	147-194	168	401	192	47.9	0.9
2012	145-210	122	240	104	43.3	1.2
2013	135-212	258	816	71	8.7	3.6

Table 5. Potential and actual disturbances over the years.

Even though boats are not allowed in the Dollard, six observations of boats were made. Four boats stayed on the left side of the observation area close to the fairway and did not come close to the seals. The other 2 did come close to the seals, this happened both on the last observation day, 31th of July. The first boat arrived at 9.55 and started to fish on the left side of the observation area (figure 13 left). The second boat arrived at 10.40 and moved from the left to the right between sandbank 1 and 3, sandbank 2 was just appearing so there were no seals (figure 13 right).
The second boat entered close to sandbank 1 so the seals on the left side of sandbank 3 did not react on it. But when the boat came closer to the seals on the right side of the first sandbank the seals already raised their heads, the boat stopped on approximately 50 meter from the seals, they kept looking at it. After 4 minutes the boat moved again towards the seals and all the 38 seals moved towards the water of which 31 seals moved actually in to the water. The 9 seals on the right side of the third sandbank moved towards the water as a reaction of the movement on the first sandbank, they moved also in to the water when the boat came closer. After that, the boat went more to the right but came back in 17minutes.
In between no seals returned on the right side of the 3 sandbank, 45 seals retuned on the right side of the first sandbank, 1 seal started to haul out on the second sandbank and the first boat started to move to the right. The seal on the second sandbank raised its head when the first boat came close but the boat did not stay for long and the seal could haul out again. When the second boat started to move to the left side, it was close to the third sandbank and only 17 of the 45 seals on the right side of the first sandbank raised their heads. 2 seals were hauling out on the second sandbank when the boat came close, both were looking but did not move.


Figure13. Boats in the Dollard, left from the observation area (left) and between sandbank 1 and 3 (right)

3.2.1. Observation screen


Figure 14. Observation screen, 2013.

Before 2011 season the observation screen was placed consisted of 3 separate panels. This attracted people to watch the seals but 72,5% did not use it in a correct way which caused in 86,9% of the events a reaction of the seals (Jenkins and Cimmino, 2011). Before May 2012 the screen changed from 3 panels to one, the percentage actual disturbance from people that used the screen was 41,1% (Allbrook & Bernabeu Lopez, 2012). During this research, the screen also consisted of one part and the fences next to it were improved to electrical fences (figure 14).

Besides that, information signs were placed on the fences that close the C area and the gates were closed. These additional measures decreased the percentage actual disturbances from the people that used the screen to 3,6% (18/495) (figure 15).

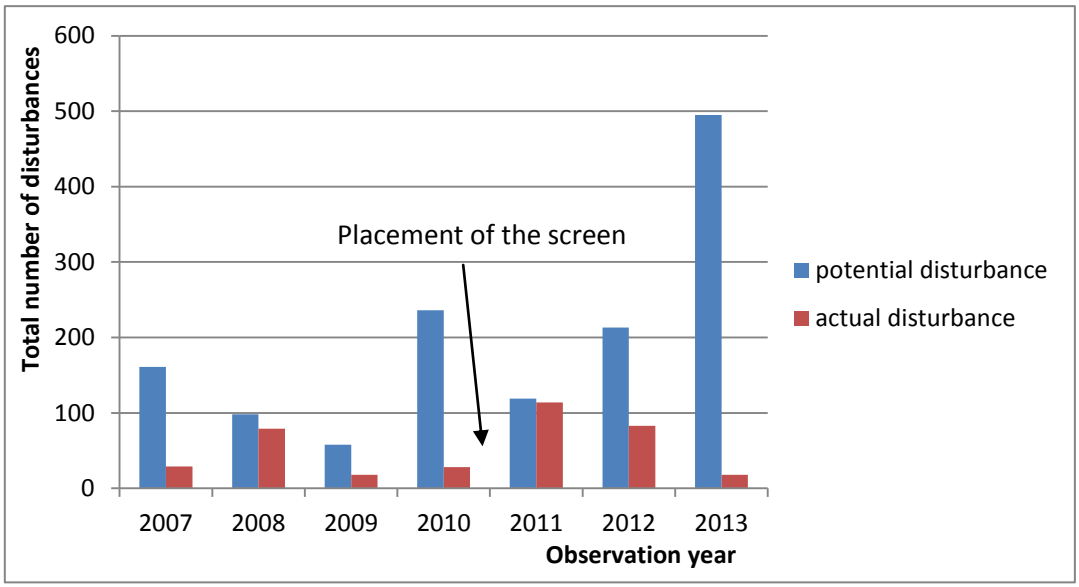

Figure 15. Potential and actual disturbances from people in the area C.

Only in 0,4% (2/457) of the events where people used the screen in a normal way, stood behind the screen, an actual disturbance followed (figure 16). Both, on 20/6/2013 and 31/7/2013, the actual disturbance from behind the screen was caused by 2 cyclists who made a lot of noise. 30,8% (4/13) of the times that people went over the fence and 45,83% (11/24) of the times that people used the dyke or path to walk or cycle, there was a reaction of the seals. There was only one event (27/07/2013) from a man on the beach, so 100% actual disturbance; he was taking pictures for five minutes which made 13 seals raise their heads, one seal moved to the water and seven seals went in to the water. Two minutes after the man left, all the seals came back to haul out on the other side of the water inlet.

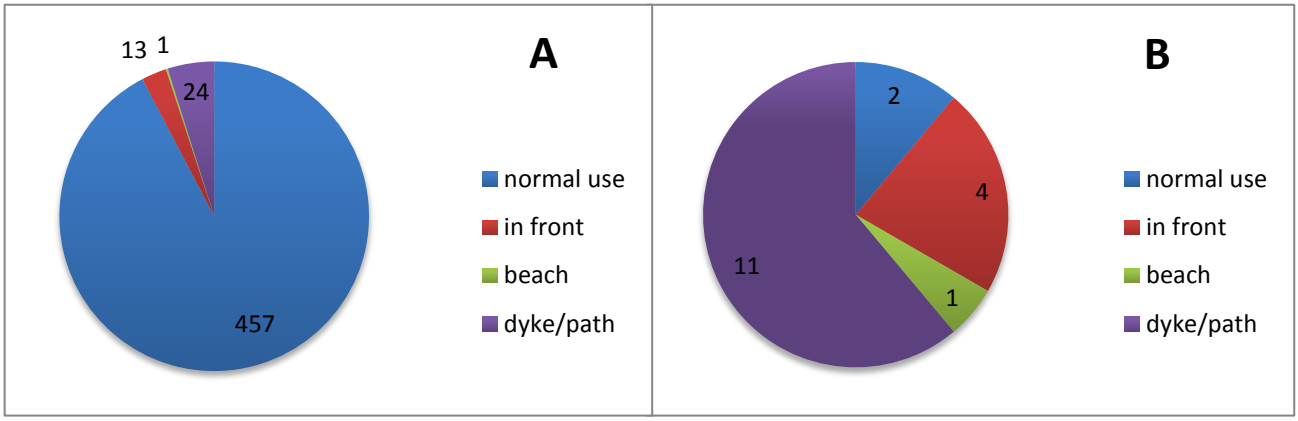

Figure 16. Number of potential (A, N=495) and actual (B, N=18) disturbances from the people that used the observation screen normal, stood in front of it or used the dyke/path/beach to walk on.

3.3. Mother-pup relationship

To learn more about the short period that common seal pups are together with their mothers, the observers looked at the distance to the mother, interactions, suckling and whether the pups were left alone and reunited with their mother. The observations were only made at the water inlet, because the other sandbanks were too far away, with a few exceptions on sandbank 1.

3.3.1. Distance

Looking at the distance between the mother and her pup, the observations of pups hauling out close to their mother or swimming on the back of their mother were observations of small pups (figure 17). When the pups looked bigger, the distance between the mother and pup became larger and they were swimming next to each other. Some pups were even lying closer to other adults than to their mother but when another seal moved towards the pup, the mother always reacted. However, there was one mother, with a small pup, that stayed in the water while the pup was lying on the sand of the water inlet, this was observed on day 165, 166 and 167 (circle figure 17).

Figure 17. Distance between mother and pup (left) and a pup swimming on the back of its mother (right).

3.3.2. Interaction

Most of the interaction between mothers and pups took place in the first and last hours of the observation days. With the changing of the tides, the water is moving, causing movement of the seals. When a mother was moving she often looked at her pup. When the pup could not follow, the mother went back, touched the nose of her pup and moved again. On day 158 a pup got stuck in the mud when the mother and pup were going out of the water at the water inlet, the mother went back to her pup and pushed it a little bit, they were touching noses and the mother moved a little bit and waited for her pup to follow again (figure 18). The pup was able to follow and they moved further to haul out together on the sand.

Figure 18. Interaction between mother and pup.

Another part of the interaction was between adults and pups that were not their own. Certainly when they had a pup of their own, adult seals were very aggressive towards other pups. Moving the front flipper towards the pup, growling or even biting the pups (figure 19). This protective behaviour happened a couple of times when a weaned pup came too close to a mother with pup.

Figure 19. Adult seal attacking a pup.

3.3.3. Suckling

During 20 of the 38 observation days suckling pups were observed at the water inlet and sometimes on the first sandbank (figure 20). The first observation (4th of June) was 4 days after the observation of the first pup and the last observation (20th of July) 20 days after the highest observed number of pups in the Dollard.

Figure 20. Pups suckling at the water inlet.

With a total of 85 observations, there was a significant difference when suckling occurred during an observation day (χ^2=20; N=7; P=0.003) (figure 21). Two of the 85 observation occurred on sandbank 1 the rest was at the water inlet. There was a peak during the second, sixed and seventh hour while there was a decline from one hour before until one hour after low tide.

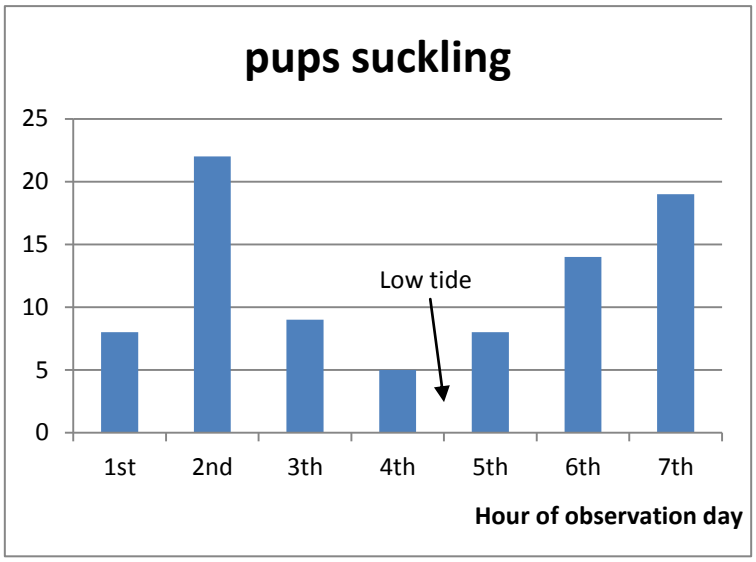

Figure 21. (χ^2=20; N=7; P=0.003) Number of observation of suckling pup for each observation hour over the entire observation period.

Looking to the four days with the most observations, the observations of suckling were not necessarily on the moment that the highest number of pups was present at the water inlet (figure 22).

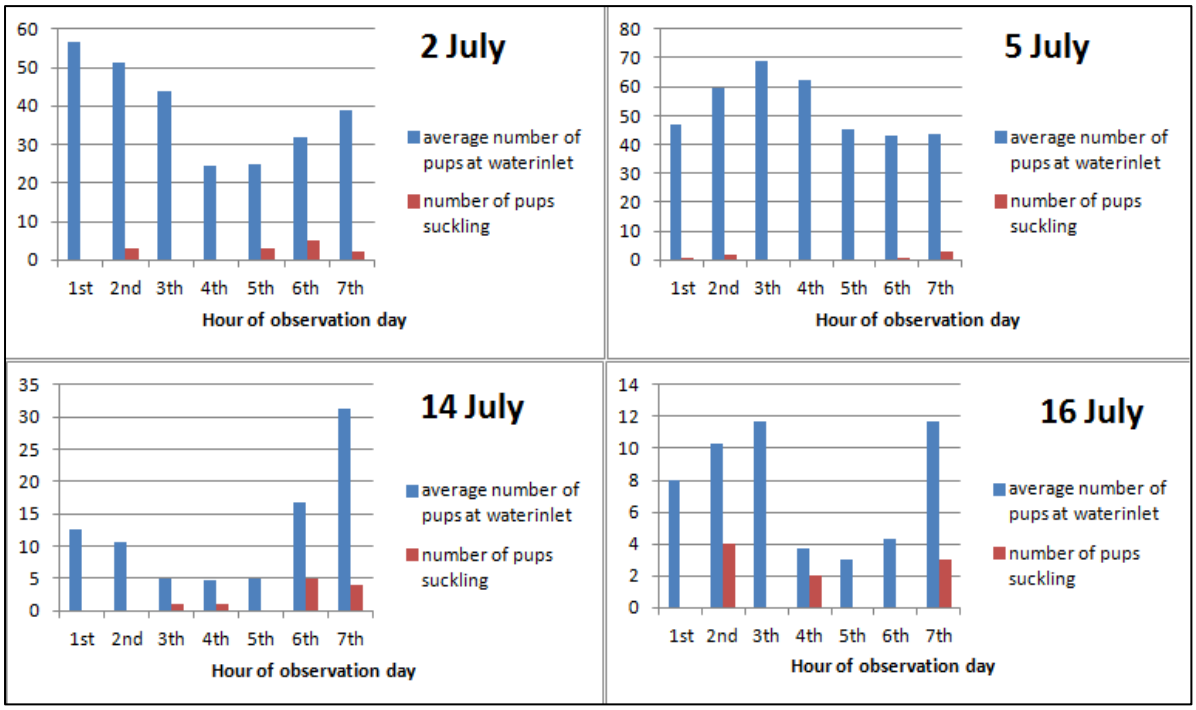

Figure 22. The average number of pups of each hour at the water inlet and the number of pups suckling in that hour for the four days that the most observations of suckling were made.

3.3.4. Weaned pups

Figure 23. Group of weaned pups.

Weaned pups were often observed in groups, with only weaned pups, lying at the same place all day (figure 23). It is difficult to know for sure pups are weaned, but the first certain observations were made on day 173 (22th of June), 24 days after the observation of the first pup. Some of the pups started to follow other adults when they were just weaned, a part of the observations is described in appendix 5. Pups followed mothers who still took care of their own pup and tried to suckle. The mothers reacted aggressive towards the weaned pup and/or moved away. Except two mothers who allowed 2 pups to suckle at the same time, this occurred on day 194 and 195 (figure24).

Figure 24. Two pups suckling at the same time on day 194 (left) and day 195 (right).

3.3.5. Pups alone/reunited with mother

A lot of observations of pups that were alone were made at the water inlet, some pups were crying or moving a lot but others of them were just sleeping. A couple of times the pups left together with a group of seals to haul out on another place or the pups were still alone when the observation day was finished. However, during some events the pups were reunited with an adult seal (appendix 6). Table 6 gives an overview of these observations, the time that the pup was alone, the interaction between the adult seal and pup and the last made observation of the couple. During 7 of the 14 events the adult seal came to the pup (yellow), during 5 of the events the pup went into the water to the adult seal (blue) and 2 times were they both moving. Looking at the last observation of the couple, 7 of the 14 events the adult seal and pup were seen swimming together, 4 of the 14 events the pups was alone again after a while (red) and in 3 of the 14 events the pup was suckling or hauling out all day with the adult seal (green).

Date	Time alone	Observations water inlet	Last observation
14/6	15 min.	Pup alone, adult seal comes out of the water	Adult seal and pup swimming together
15/6	2 hours	Pup alone, adult seal in the water, pup goes in to the water	Adult seal and pup swimming together
15/6	2 hours	Pup alone, adult seal in the water, pup goes in to the water	Adult seal and pup swimming together
15/6	3 hours	Pup alone, adult seal in the water, pup goes in to the water	Adult seal and pup swimming together
15/6	4,5 hours	Pup alone at the bottom of the water inlet, adult seal moves to the pup	Adult and pup moved to the end of the water inlet, pup is suckling
16/6	2,5 hours	Pup 'crying' alone, adult seal comes out of the water	Adult seal and pup hauling out together for at least 4 hours (end observation day)
16/6	3 hours	Pup alone, adult seal in the water, pup goes in to the water	Swimming on the back of a adult seal, after a couple of minutes alone again
16/6	3 hours	Pup alone, adult seal in the water, pup goes in to the water	Moved to adult seal in water inlet, short interaction, alone again
18/6	2 hours	2 pups alone, adult seal comes out of the water	touching noses, 2 pups following adult seal in to the water but she leaves them there
19/6	1 hour	2 pups alone, adult seal comes out of the water	2 pups following adult seal, swimming together
20/6	2 min.	Pup alone after disturbance, adult seal came back	Together in to the water
22/6	1 hour	Pup alone, adult seal comes out of the water	touching noses, adult seal and pup swimming together, touching noses
30/6	1 hour	Pup alone, adult seal comes out of the water,	touching noses in the water, pup again alone
5/7	1 hour	Pup alone adult seals comes out of the water	touching noses, pup follows adult seal in to the water, touching noses again

Table 6. Overview of the pups that were reunited with an adult seal (yellow: adults seal came to pup, blue: pup went to the adult seal) and a note of the last observation from the adult seal and pup together (green: it is assumed that it is the mother, red: pup alone again).

3.3.6. Recognisable individuals

Multiple observations of adult seals with visible characteristics were made and some of them were seen together with a pup (figure 25). Unfortunately, all the seals where still together with their pup when they were seen for the last time, which was most of the time 2-3 weeks after the first observation. Therefore it was not possible to see how long the mother and pup stay together. Because all the seal with a visible characteristic had a red colour, it was sometimes difficult to know for sure that the observation were from the same seals.

Figure 25. Observations of seals with a visible characteristic with pups.

4. Discussion

4.1 Evaluation of monitoring methods

With respect to the research method, there are some external factors that may have influenced the results of this research. In the first place, the counts for distribution and abundance may have been biased due to the weather conditions. The presence of rain and fog reduced the visibility and impaired the vision through the lens of the binocular and telescope, especially on sandbank 3. Strong wind made the telescope tremble, reducing the ability to focus. On very sunny days the shimmering of the sun made the count on sandbank 3 difficult. When the weather was bad (constant rain, strong wind, fog or thunderstorms) the observations were aborted. This happened 7 times before the observation day even started (day 140, 141, 172, 179, 184, 185 and 209) and 2 times during the observation day (day 170 and 171).

There is a drop in the middle of the observation period which may be explained looking at the weather conditions. During day 169 (18th of June, highest number of observed adults) and day 181 (30th of June, highest number of observed pups) it was only slightly cloudy and most of the time sunny, while the weather in between these days was bad. Day 170 and 171 were aborted after 3,5 and 4,5 hours due to heavy rain and thunderstorms. Day 173 lacks one counting during one of the 7 rain showers during the observations and day 180 was affected by fog in the morning and a strong wind throughout the day.

Secondly, not all the seals were visible all the time from the observation spot. Although this spot was higher than the level of the seals and in fact the highest point in the area, the seals may be situated behind each other or behind the sand ridge of the sandbank. The latter occurred especially on the right side of the first sandbank and at the end of the water inlet. When pups were present they disappeared easily behind their mothers or another seal hauling out on the same sandbank. This happened mainly on sandbank 1 and 3.

Finally, the presence of the observers in the area could have biased the observations about disturbance. The observers behaved in such a way trying not to disturb the seals but their presence in the area may have influenced the behaviour of the visitors to the Dollard. This could have led to more caution of the visitors while they were looking at the seals but it also resulted in curiosity of the visitors, approaching the observers to ask questions which increased the change of disturbances.

4.2 Distribution

The counts of the seals are affected by the weather and the visibility of the seals. As shown in the results, the highest numbers are counted in the first or lasts hours of an observation day and the average number of seals on sandbank 1, sandbank 3 and the water inlet shows a drop after low tide, which strengthened the idea that some seals are behind the sandbanks during and after low tide.

Comparing the abundance of common seals in the Dollard over the years (figure 5). It does not change a lot when the number of adults and pups would have been a little bit higher for this year. But the decrease in number of pups and increase of adults in 2010 deviates. Looking at the date of

the observation of the highest number of pups, the observation day in 2010 is on average 10 days (3-13 days) earlier than all the other years (table 3). While the observation day of the first pup is on average only 2,5 days (1-5 days) earlier then in the other years. So possibly a part of the pups was previously counted as adults, which would also explain the increase in number of adults.

In comparison to other years (2007, 2008, 2010 and 2011), the distribution of common seals in the Dollard is almost equal looking at the ratio adult/pup on the different sandbanks, with a little difference in abundance for each year (Bakker & de Vries, 2007; Nussbaum & Selvaggi, 2008; Groothedde, 2010; Jenkins & Cimmino, 2011). Sandbank 2 is used less with pups, probably because this sandbank is under water longer. Opposite is the water inlet, a stretch of sand is even dry with high tide, which is more used with the pups. In all years, except 2007, the number of pups at the water inlet exceeded the number of adults. This is probably because the water inlet is used by weaned pups which is not seen on the sandbanks.

4.3 Disturbance

90,1% of the actual disturbances disturbed the seals at the water inlet which can be explained by the short distance between the seals and most of the potential disturbances. But this high percentage can also be explained by a further distance from the observation point to the sandbanks. There was a good overview of the seals at the water inlet with the naked eye, while the seals at the sandbanks had to be observed with the binoculars or telescope making it impossible to look at all the seals at the same time during a potential disturbance.

Despite of the fact that boats are not allowed in the Dollard (Article 20, Nature Protection Law), there were 6 observations of boats. The boats that approached the seals disturbed them which shows the importance of the law. Boats may be a large disturbance factor in unprotected areas of the Wadden Sea.

The increase in potential disturbances during the observation period can be explained by better weather, which attracted more people to go for a walk or to cycle. And the start of the summer holidays (29/06/2013) gives people who live further away, and are unknown with the area and the seals, the opportunity to visit the Dollard/polder Breebaart. The increase in actual disturbances during the observation period (table 3) is presumably due to the increase in potential disturbances in combination with the increase in number of seals that used the water inlet.

4.3.1 Observation screen

The increase in actual disturbances from 2010 to 2011 (table 5) can be explained by the placement of the observation screen (figure 15), it attracted people but 72,5% did not use it in a correct way which caused in 86,9% of the events a reaction of the seals (Jenkins and Cimmino, 2011). Before May 2012 the screen changed from 3 separate panels to one, which brought the actual disturbance to 41,1% (Allbrook & Bernabeu Lopez, 2012). During this research the screen still contained one panel and was improved with electrical fences, only 3,6% of the people that used the screen caused an actual disturbance. The amount of people that used the screen increased from 119 to 495, from 2011 to 2013, it draws attention that there is something worth seeing.

The electrical fences and the placement of the information signs resulted in a decrease of people that used the dyke (area C). The information signs informed people about the resting area for seals and asked them to go to the road behind the dyke and to continue their walking trail after the C area. Visitors knew they could disturb the seals when they would go over the fence and went instead to the observation screen. Despite of the decrease in actual disturbances, this observation year was influenced by stolen information signs and fences that were not closed. The information sign on the fence close to the observation spot was stolen at least 5 time, causing people to go over the fence because they did not see the seals or thought the fence was only to keep the sheep inside.

4.4 Mother-pup relationship

Most of the observations about the mother-pup relationship were made during the first and last hours of an observation day. This can be caused by the not-observable seals behind the sand at the end of the water inlet but particularly by a lot of seals moving to another place during low tide and coming back when the water was higher again. Unfortunately, it was impossible to observe this behaviour on the sandbanks. Sometimes it was already difficult to properly see the seals at the water inlet from the observation spot. Behind the observation screen would be a better place to observe the behaviour of the seals.

Separation between mother and pup was observed in the Dollard in 2009 (N=1), 2010 (N=14) and during this research (N=1) (de Boer, 2009; Groothedde, 2010). These observations were made at the water inlet, where mother and pup can haul out both at low and high tide, and could not be observed at the sandbanks. Separations were related to pups sliding down the steep edges (2010), pups resting on top of steep edges at the water inlet while the water level was declining (2010), to disturbance (2013), and to unknown reasons (2009,2010). After disturbance the mother and pup were reunited within 2 minutes while the separation in 2009 took about an hour before reunion and the separations in 2010 on average 1.90 ± 0.49 hour (de Boer, 2009; Groothedde, 2010). A study of Wilson (1974) showed that mothers and pups were separated for short times and that the mother left her pup alone for a longer period just before weaning. This can explain the reunions after on average 1.87 ± 1.25 hour for this research.
The pups were already alone at the start of the observation day so the reason for the separation is unknown but in 13 events the pups were seen with an adult seal. Of these 13 reunions it was not sure if the adult seal were really the mother. Even after interaction, swimming on the back or touching noses 4 of the 13 pups were after a while alone again. 7 of the 13 pups were swimming next to an adult seal, this can be the mother but is not necessary an interaction between mother and pup. 1 pup was after the reunion hauling out together with the adult seal for the rest of the day. And the pup that was alone for the longest time period, minimum 4,5 hours, moved together with an adult seal to the end of the water inlet and started to suckle, this is most likely a reunion with the mother but can also be a observation of fostering.

Fostering in seals, taking care of a pup that is not their own, is documented in 10% of a sample of 76 paint-marked female common seals on Sable Island. In a subsample of 30 pairs, 3 of the 16 females that lost her own pup fostered, while none of 14 females that maintained continuous association with her pup throughout the suckling period did so. (Boness, 1992) This suggests that females only foster when they lost their own pup, this was not observable in this research because the seals were

not marked. During most of the observation mothers reacted aggressive to pups that tried to suckle but were not their own pup, except for two observations in two consecutive days. Two pups (one observation repeated 3 times on one day) were suckling at the same mother; the mother on the second day had a red coloured head the mother on the first day did not. This observations together with the observation of 2008 (Nussbaum & Selvaggi, 2008) could be accidental observations of mothers not chasing other pups away or these individual mothers intentionally allowed both pups to suckle to take care of both pups.

5. Conclusion

The population of common seals in the Dollard decreased this year a little bit in abundance may be related to bad weather in peak days. Throughout the study it was observed that seals regularly hauled out in the same area and on the same sandbanks. The haul out behaviour is mainly affected by the tidal cycles which create a difference in abundance on the different sandbanks, especially with the presence of the pups. Although the seals encounter more disturbance, human and environmental, at the artificially created water inlet it is still an important haul out location for mothers with pups.

The observation screen protects mothers and pups, and the other seals, at the water inlet from disturbance from people on the dyke. Since the placement of the screen the percentage actual disturbance from people on the dyke (area C) decreased from 86,9% to 3,6%. Even though the screen works good and reduced the actual disturbances from people on the dyke, still 90,1% of all the actual disturbances disturbed the seals at the water inlet. These disturbances were made by walkers, cyclists, cars, agricultural vehicles, low flying aircrafts, sudden heavy rain, quads and sheep. The disturbances on the sandbanks were also made by low flying aircrafts and sudden heavy rain and by boats. The sources of disturbance caused a different reaction of the seals, some caused particularly the reaction ‘heads up’, like low flying aircrafts. Others caused often the reaction ‘move in to the water’, like boats, sheep and agricultural vehicles.

Suckling, touching noses and active pups were mostly seen during the first 3 and last 2 hours of an observation day but mother and pup were inactive and hauling out the main part of the day. During the active and hauling out period, the pups stayed close to their mother during the first days. When the pup became bigger the distance between mother and pup increased too. Reuniting between mother and pup is observed after at minimum 1 to 4,5 hours but it is unknown if the mother left her pup on purpose or that they lost each other.

With all the taken measures in the Dollard the last years, the disturbances decreased a lot. This together with the fact that people who ignored the measures, with a boat or standing in front of the screen, caused a lot of disturbance shows that it is important to continue protecting areas like the Dollard.

Recommendation

The following recommendations are a personal opinion of the researcher and formulated from observational information and the results of this research.

This area is ideal to carry on performing research on seals as well as for people to learn more about seals. However, it is important to avoid human disturbance, the observation screen at the dyke is a very important element in the protection of the seals. This research showed that the screen is working good but closing the fences earlier and more and a better attached information signs, would be a good addition on the already taken measures.

It is important to educate people. During numerous conversations with visitors is revealed that some people are unaware of the presence of the seals or do not know how their actions can lead to disturbance. So a small information sign which informed people about the possibility to watch seals form behind the screen is not enough. People need to know why the screen is there and that they need to be silent before they are there. Therefore it is maybe useful to place the information sings in multiple languages, now they are only in Dutch while the German border is on about 15 kilometres distance, and place them further away from the screen for example where people enter the area, at the gate or the walking path form the visitor centre of Het Groninger Landschap.

To learn more about the mother-pup relationship, I recommend the SRRC to start a separate research to this subject. This observations are better to make from the observation screen because the seals are closer and in a better angle while the observations of the abundance and disturbance are better from the observation point used this and previous years. Besides that it is too much at once to count the seals, look to the potential disturbances and if the seals react on this and at the same moment look to the behaviour of the mothers with pups.

To respond at the observations of pups that were possible reunited with their mother and the observations of two pups that were suckling at the same mother I recommend the SRRC to do the observation also during high tide. A lot of visitors told me, and I saw it once, that there were a lot of seals on the stretch of sand from the water inlet during high tide. The pups of the reuniting which I observed were already alone when I arrived for an observation day. So it is possible to observe the separation during high tide. Next to that it is important to do the same observations on a different location. The water inlet in the Dollard is unique, because of the absence of tidal submerging, in the Wadden Sea so it is possible that the behaviour of the seals is different in this area.

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Appendices

Appendix 1: Observation scheme

Yellow; observation days planned. Blue; only when more days were needed		Green; observation days. Red; no observation day due to bad weather. Orange; observation day but not complete due to bad weather.				
Observation week		Low Tide in Delfzijl			Observation time	
1		We 15 May	09:52	-175	05:45-12:45	
		Th 16 May	10:26	-168	06:30-13:30	
		Fr 17 May	10:55	-164	07:00-14:00	
		Sa 18 May	11:46	-159	07:45-14:45	
		Su 19 May	12:42	-152	08:45-15:45	
2		Mo 20 May	13:50	-147	09:45-16:45	
		Tu 21 may	15:10	-154	11:15-18:15	
		We 22 May	16:20	-170	12:15-19:15	
		Th 23 May	17:20	-182	13:15-20:15	
3		We 29 May	10:03	-195	06:00-13:00	
		Th 30 May	10:46	-192	06:45-13:45	
		Fr 31 May	11:31	-187	07:30-14:30	
		Sa 1 June	12:18	-180	08:15-15:15	
		Su 2 June	13:15	-172	09:15-16:15	
4		Mo 3 June	14:26	-166	10:30-17:30	
		Tu 4 June	15:30	-167	11:30-18:30	
		We 5 June	16:41	-171	12:45-19:45	
		Th 6 June	17:46	-176	13:45-20:45	
		Fr 7 June	18:32	-179	14:30-21:30	
5		Fr 14 June	10:10	169	06:15-13:15	
		Sa 15 June	10:46	-165	06:45-13:45	
		Su 16 June	11:26	-164	07:30-14:30	
6		Mo 17 June	12:16	-161	08:15-15:15	
		Tu 18 June	13:16	-156	09:15-16:15	
		We 19 June	14:26	-155	10:30-17:30	
		Th 20 June	15:41	-163	11:45-18:45	
		Fr 21 June	16:46	-173	12:45-19:45	
		Sa 22 June	17:56	-181	14:00-21:00	
		Su 23 June	19:01	-190	15:00-22:00	
7		Fr 28 June	10:34	-202	06:30-13:30	
		Sa 29 June	11:13	-199	07:15-14:15	
		Su 30 June	11:56	-191	08:00-15:00	
8		Mo 1 July	12:42	-178	08:45-15:45	
		Tu 2 July	13:36	-162	09:30-16:30	
		We 3 July	14:51	-152	10:45-17:45	
		Th 4 July	16:01	-152	12:00-19:00	
		Fr 5 July	17:06	-159	13:00-20:00	
		Sa 6 July	18:06	-167	14:00-21:00	
9		Fr 12 July	09:29	-176	05:30-12:30	
		Sa 13 July	10:01	-171	06:00-13:00	
		Su 14 July	10:36	-166	06:30-13:30	

10		Mo 15 July	11:09	-165	07:15-14:15	
		Tu 16 July	11:50	-164	07:45-14:45	
		We 17 July	12:46	-158	08:45-15:45	
		Th 18 July	13:45	-151	09:45-16:45	
		Fr 19 July	15:06	-150	11:00-18:00	
		Sa 20 July	16:22	-160	12:15-19:15	
		Su 21 July	17:41	-171	13:45-20:15	
11		Mo 22 July	18:49	-186	14:45-21:45	
		Sa 27 July	10:14	-206	06:15-13:15	
		Su 28 July	10:50	-201	06:45-13:45	
12		Mo 29 July	11:26	-190	07:30-14:30	
		Tu 30 July	12:06	-172	08:00-15:00	
		We 31 July	12:51	-152	08:45-15:45	

Appendix 2: Observation form: Disturbances

Day/
Date:

Observer(s):

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

Disturbance Type Categories: w* = walker c* = cyclist h* = horse m = motorbike c = car a = agricultural vehicle la = low flying aircraft ma = military aircraft (**+H** = only heard but loud) sb = small (quiet) boat sp = speed boat sh = ship os = another seal R = sudden heavy rain S = storm N = no apparent stimuli O = other (specify)
* Follow type with noise category: 1 = silent/very discreet 2 = ambient/average 3 = loud/shouting/running

Appendix 3: Observation form: Number of seals

Day/ Date: _______/__/____ Observer(s): ____________

Start time:	Number of seals							
Time interval(min)	Water inlet		Sandbank 1		Sandbank 2		Sandbank 3	
	Adult	Pup	Adult	Pup	Adult	Pup	Adult	Pup
0								
15								
30								
45								
60								
15								
30								
45								
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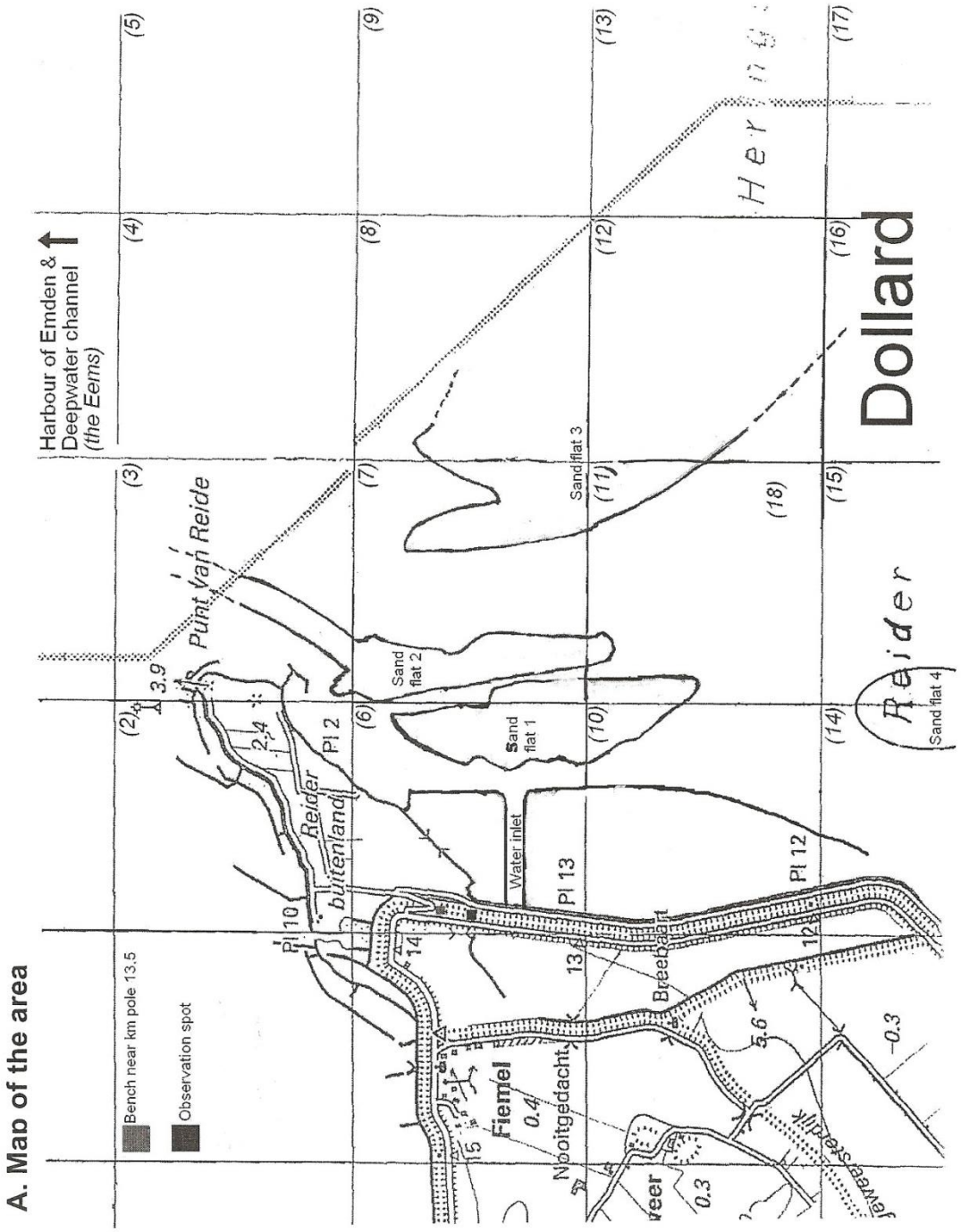
Appendix 4: Observation form: Map



Appendix 5: Observations weaned pups

- 22nd of June, 14:00; One adult seal and 4 pups were on the left side of the water inlet, 3 pups were close to the adult seal. One pup tried to suckle while a second pup came closer, the adult seal attacked the second pup first and after that also the first pup. She moved to the water, all three pups were following, but stopped close to the water. The pups went in to the water and were swimming away from the water inlet, the adult seal moved also in to the water when the pups were already gone.
- 2nd of July, 11:56; An adult seal, followed by 3 pups, is coming out of the water at the water inlet, start to haul out.

  12.05; The adult seal moves in to the water, 2 pups were following her immediately and the third a little bit later. The adult seal is faster in the water and wait until the second pup is also in the water and close to her before she swims away. At that moment the third pup is still on the sand, crying, and continues crying when it is in the water.
- 2nd of July, 16.00; An adult seal was followed by 3 pups, two of them were trying to suckle. The adult seal attacks one of them, the other pups is allowed to suckle.
- 5th of July, 13.45; 4 pups were close to one adult seal, one of them was allowed to suckle. Two other pups tried to suckle but the adult seal attacked them, after which the first pup start to suckle again.
- 5th of July, 19.45; An adult seal together with a pup on the right side of the water inlet, pup is suckling. 2 other pups were coming closer to the adult seal and one of them tried to suckle, the adult seal attacked the pup. After the attack she moves in to the water and swims to the left side of the water inlet with her pup on her back. When she arrived at the left side there are still 3 pups around her, one of them tried to suckle and the adult seal moved immediately back to the water. The 3 pups followed her in to the water, she went back to the right side were still 2 pups are following her. The pups are both close to the adult seal but she stayed on her belly to haul out.
- 13th of July, 8.05; One adult together with 2 pups at the left side of the water inlet, both pups are suckling at the same time. Looked like a attack to one of the pups when the mother is moving. She moved in to the water with one pup very close to her, the other pup is following on two meter distance.
- 13th of July, 10.30; one adult with 2 pups on sandbank 1, both pups are suckling at the same time. They stopped suckling short after each other after 18 minutes.

  12.10; the 2 pups are hauling out next to each other approximately 1 meter from the adult seal.
- 13th of July, 12.47; One adult followed by 2 pups came out of the water at the left side of the water inlet. When they are on the sand both the pups moved to the belly of the adult seal but she moved first to another pup that was hauling out on the sand. The adult seal attacked the pup which moved towards the water. After that she moved towards the 2 pups that were following her, when the pup that was hauling out came closer the adult seal attacked again and even bit the pup. The adult seal turned towards the other 2 pups, thereby the attacked pup could reach to the belly of the adult seal which caused a third attack. After that the 2 pups started to suckle together (figure 21) and only 30 second later the adult seal was shortly touching noses with the pup she attacked earlier. One minute later, one of the pups that was allowed to suckle hit the other pup with his front flipper, this caused the same reaction of

the adult seal towards this pup. They moved all a little bit after which both the pups started to suckle again. 3 minutes later, one of the pups stopped suckling and moved away, the adult seal was looking but did not move. The second seal stopped suckling 2 minutes later.

- 14th of July, 12:00; Adult seal (with a read coloured head) on the left end of the water inlet together with a pup.

  12.08; the adult seal moved towards the dyke, followed by 2 pups, one of them starts to suckle. After a minute the adult seal moved again and was touching the nose of the pup that was suckling, pup start to suckle again.

  12.12; The adult seal moved in to the water, followed by 2 pups. She is coming out of the water half way the left side of the water inlet, now followed by 3 pups, one a little bit later. At least one of the pups starts to suckle (adult seal with her back towards the observers, not everything visible), she moves back in to the water after 5 minutes.

  12.23; Adult seal and 3 pups back on the left side, one pup starts to suckle, second pup is coming closer but attacked by adult seal when it came to close. Adult seal moves again towards the dyke, followed by 3 pups, one pup started to suckle.

  12.30; pup stopped suckling, one moment later 2 pups are suckling at the same time, not certain if one of them is the pup that was allowed to suckle all the time (figure 21) After 12 minutes one of the pups stopped suckling, the other pup stopped 25 minutes later.
- 16th of July, 8.54; One adult seal with a pup on the right side of the water inlet, pup is suckling. After a couple of minutes a second pup came out of the water and went straight to the adult seal. The first pup moved away from the adult seal and the second pup started to suckle. When the first pup moved to the water, the adult seal followed the pup, followed by the second pup.
- 16th of July, 9.10; An adult seal together with a pup came out of the water on the right side of the water inlet, followed by a second pup. The first pup started to suckle while the second pup came closer. When the second pup arrived the first pup moved away, the second pup tried to suckle but the adult seal followed the first pup.

  9.18; one pup suckling, other pup was hauling out 7 meters away from the adult, but came closer after 4 minutes. The first pup stopped suckling after which they all haul out.
- 16th of July, 14.50; One adult seal together with a pup on the left side of the water inlet, pup is suckling. 2 other pups came closer, one of them started to suckle when the first pup stopped. The adult seal attacked the second pup when she saw her own pup.

Appendix 6: Observation pup alone/reunited with mother

- 14th of June, 9.15; After all the seals left the water inlet 3 pups stayed behind close to the dyke, 1 of them was not moving at all, the other 2 looked fine.
    - ❖ 9.30; An adult seal came out of the water close to the pups and one of the good looking pups followed her back in to the water. The adult seal and pup were swimming together, which was the last observation.

  The other 2 pups stayed alone, one of them was still not moving and the good looking pup started to suckle on a stone so the decision was made to bring them to the SRRC.
- 15th of June, 6.45; 4 pups alone
    - ❖ 9.00; 2 adult seal with their own pup moved in to the water from the water inlet, 2 of the pups that were alone went in to the water, short after the other seals, where already 3 adult seals were swimming. The last observation of the pups was swimming together with one of the adult seals that was in the water.
    - ❖ 10.05; One of the pup that was alone moved in to the water where an adult seal was swimming, they were swimming away together.
    - ❖ 10.10; the last pup that was alone also moved to the water but the pup stayed at the bottom of the water inlet next to the water.

      11.15; An adult seal came to the pup at the bottom of the water inlet, the pup followed the adult seal in to the water. They moved to the left end of the water inlet, the pup was on the back of the adult seal. When they arrived on the sandbank the pup started to suckle immediately. Hauling out together was the last observation.
- 16th of June, 8.00; 3 pups alone
    - ❖ 10.22; one of the pups was crying for a while, an adult seal was swimming in the water inlet and climbed out of the water close to the lamp post. When she was on the sand she moved to the pup that was crying, the pup followed the adult seal back in to the water and they were swimming together to the end of the water inlet were they haul out together.
    - ❖ 11.00; The 2 pups that were still alone moved together in to the water where 3 adult seals were swimming. One of the adult seals is aggressive to one of the pups, later the pup was swimming together with one of the other adult seals. The other pup is swimming on the back of one of the adult seal, after 15-20 minutes they are both alone and crying. At 12:00 they are together on the right end of the water inlet.
- 18th of June, 11.00; 3 pups alone
    - ❖ 12.57; An adult seal was coming out of the water, touching the pups that are alone after which the pups followed the adult seal back in to the water. But the adult seal left the water of the water inlet without the pups.
- 19th of June, 10.45; 3 adult seals and 5 pups stayed behind on the right side of the water inlet.
    - ❖ 11.35; An adult seal came out of the water at the water inlet, she moved to the pups and 2 of them followed the adult seal in to the water. It was not visible if they stayed together.

- 20th of June, 13.03; Due to a disturbance by sheep, one pup lost its mother. The adult seal came back in at most 2 minutes and they left together.
- 22nd of June, 14.42; 6 pups alone on the right side of the water inlet.
    - ❖ 14.56; 3 of the 6 pups moved together to the water, close to the water one of the pups moved towards an adult seal which attacked the pup. The other 2 pups moved to the water where an adult seal was coming out of the water, the adult seal was touching one of the pup and they moved in to the water together. The other pup went also in to the water, the last observation was that the adult seal and one of the pups were swimming together, the other pups was swimming alone.
- 30th of June, 8.00; big group of pups without mother, possible weaned pups, 2 pups crying.
    - ❖ 8.38; An adult seal came out of the water close to the big group of pups. Two pups are following the adult seal, one of them follows her in to the water. In the water the adult seal and pup were short together and touching noses but the pup went back on the sand.
- 5th of July, 14.28; pup alone on the right end of the water inlet.
    - ❖ An adult seal came out of the water and went to the pup, they were touching noses 3 times in a row. The pup followed the adult seal in to the water, the last observation was swimming together and touching noses in the water.