The Common seals in the Dollard

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1. Introduction

Since 1993, the Seal Rehabilitation and Research Center (SRRC) in Pieterburen regularly monitors the seal population in the Dollard area, to gain constant information on the reproductive success, the status and the health of seals in the wild. During the last 15 years of observations and counting in the Dollard area, an increase in the number of seals of more than three times has been registered. The status of the seals of this area is of great concern because of the intensive industrial activities carried out in the estuary and because of the critical water quality of the Eems river, which may affect the entire food web. This is even more important for a top predator such as the harbour seal.

The present study will focus mainly on the effects of human activities on the haul out behaviour of the seals.

In the last 15 years, it has been observed that the haul out behaviour of the harbour seals of this area was affected not only by the natural cycles of the tides and severe weather conditions, but also by human activities such as fishery industries or recreational activities.

The various types of disturbances have changed over the last years. The Dollard area is a protected area and no vessels are allowed to enter. Besides rare cases, the disturbance caused by vessels does not happen so frequently anymore. However, the tranquility of the seals in the area are being affected by new disturbances, which are furthermore being esplored by investigation.

This is why during the observations of the summer 2008, like the former study of Bakker & de Vries of 2007, the research was not only focused on the haul out site behaviour and the mother and pup bond, but also on the different type of disturbance and how they affected the behaviour of seals during the nursing period.

1.1 Seal Rehabilitation and Research Centre (SRRC)

The present study was carried out by the Seal Rehabilitation and Research Centre (SRRC, also known as “Zeehondencrèche Lenie ‘t Hart”).

The SRRC was founded in Pieterburen in 1971, and it started as a simple “crèche” for young seals who lost their mothers and then developed into a real seal hospital. During the summer, mainly harbour seal orphans are recovered. In Dutch, these orphan seals are called “huilers” which means “criers”. During winter periods the majority of seal pups which are rescued are grey.

The Centre’s facilities include quarantines for the intensive care, intermediate departments, outside pools for the final rehabilitation stage before the release, a laboratory for blood analysis and parasites identification, a radiology department, necropsy laboratory and more research equipment. All the rehabilitated seals are released, as soon as it is possible, into the wild, after a period of several weeks, to a few months; and it also depends on the overall health condition of the recovered seal. The seals are not trained or kept in the centre to be shown to the public. The SRRC follows established protocols and has an ISO 9001-2000 quality certificate.

In the first instance the SRRC is a rehabilitation centre, and a large amount of seals, which have recovered are sick animals with concerning issues, it is of a great interest for this centre to gain information on the status, conditions and conservation issues of the seals in the wild, since it is important to establish the main problem and their causes seals encounter the main causes of the seals problems, and to find possible solutions. That is why the SRRC carries out postmortem analysis on stranded seals and other marine mammals, genetical, virological, toxicological analysis on sick animals; other methods include aerial surveys over the Dutch coasts, and field research. The SRRC, also cooperates with different research institutes in the Netherlands and abroad to give training by sending advisors and also cooperates with other rehabilitation centres in the world.

As a non profit organisation the Centre carries on information and education programs in the visitors centre but also around the country to inform the public on seals and environmental issues.

2. Material and method

2.1 Research area: Dollard

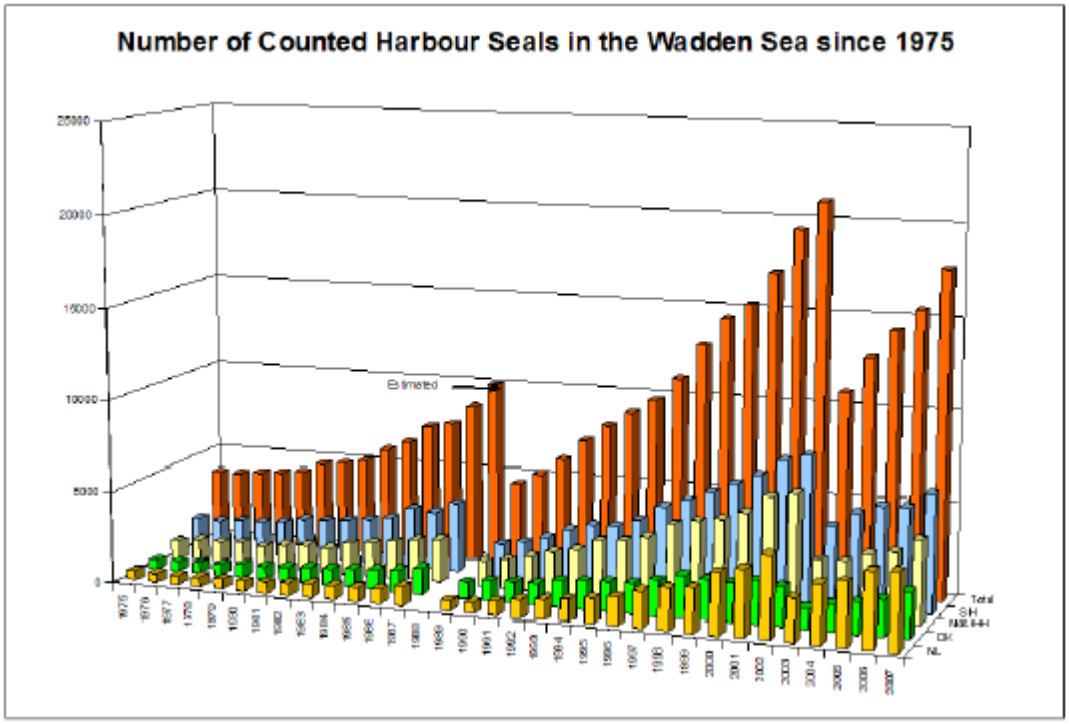
The Dollard area is part of the Dutch Wadden Sea and is the tide estuary of the Eems river on the boundary between Germany and the Netherlands. Tides and river deposits influence the geographical morphology and the ecosystem of the area. Fresh water and sea water are mixed, while sand, silt, organic matter in suspension and large floating materials sediment and deposits to form the sandbanks. The dynamism of the tides and the estuary streams affect the shape and the position of each sandbank, which changes every year. Also, the composition of the sand can be different on each sandbank: some of them are sandy and others are more muddy. In the tide estuary, the length of the low tide may vary because they are affected by strong winds, its direction or by the entity of the river flood.

In this brackish water area, the salinity vary from 6‰ in the winter to 25‰ in the summer. On the 41 species of fish, 9 diadromous migrate in this area at different times of year. Since the coasts of the Netherlands are separated from the sea by dikes, sluices and locks, many diadromous fish species struggle to migrate to fresh water, but the Dollard area is still an open estuary, where the fish can swim to the other side of the dike (Kleef & Jager, 2002).

This ecosystem is rich in nutrients and primary production, therefore fish and crustaceans are abundant. Some fish like eel (*Anguilla anguilla*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*), plaice (*Pleuronectus platessa*), flounder (*Platichthys flesus*), smelt (*Osmerus eperlanus*), stickleback (*Gasterosteus aculeatus*) and the brown shrimp (*Cragon cragon*) use this area for reproduction. This high biomass and biodiversity attracts thousands of migratory birds, between 6 to 9 million costal birds have been recorded, in the whole Wadden Sea (AAVV 1991 a and b, Kleef & Jager, 2002). In the Dollard thousands of birds were registered, of which 40.000 were geese. The Dollard also has the largest colony of avocets (*Recurvirostra avosetta*) in North West Europe (www.waddenvereniging.nl).

Looking at the abundance of some fish, some are constantly present in the area while some others are seasonal. For instance, the smelt is endemic to the area. However, flounder fish stock increases between May and July and the eel is more abundant during June and July. This is an advantage for the seals living in this area. Even if there is no shortage of fish, the quality of fish may not be the best; according to the Wadden Sea Society, there is a high level of dioxin in the fish, the Dollard, which may affect the condition of the seals (www.waddenvereniging.nl). Nevertheless, further studies have not been carried out.

In the Dollard, there is a growing population of seals, for instance, in the same observation area from 1993 the number of seals increased to a maximum of 77 seals (Selvaggi, 1999). It has augmented to 240 individuals in 2007 (Bakker & de Vries, 2007). This is consistent with the overall data for the Wadden sea area (see graph 1).



Graph 1: Number of counted harbour seals in the Wadden Sea since 1975 from http://waddensea-secretariat.org by the Trilateral Seal Expert Group.

This research includes the Dutch side of the Dollard near Punt van Reide. In this area fishing and sailing are not prohibited from the 15th of May to the first of September. Large ships and boats pass regularly right out of Punt van Reide into the main channel of the Eems estuary. On the German side of the Dollard there is a busy cargo harbour named Emden. From there wood, paper, liquid gas, liquid crayon, building materials, iron and steel products, grain and feeding stuff also different bulk goods and part load goods, especially automobile and spare parts are shipped in containers (www.emden.de/de/wirtschaft/engl/port.htm).

Recreational activities are not allowed in the study area, but on the dike people can walk and observe nature, birds and the seals. On the inland side of the dike, there is a road open to pedestrians and bikers, but is closed to normal car traffic, only some cars are allowed to use it. Between the old and the new dike there is a wetland, the Breebaart Polder, with paths all around it and to observational point, where tourism and farming activities are carried on.

Since 2002, a water inlet was dug and a siphon let the salt water pass from the estuary into a constructed wetland through the dike, so that migrating birds can rest, feed, nest and be easily observed by visitors from observation huts. There are also “stairs” to let the fish (especially sticklebacks) reach freshwaters. Close to Punt van Reide, there is a visitor centre run by the Groningen Landschap association (for more information: www. groningerlandschap.nl/ Beleef_het_Groninger_landschap/Onze_gebieden/Dollard).

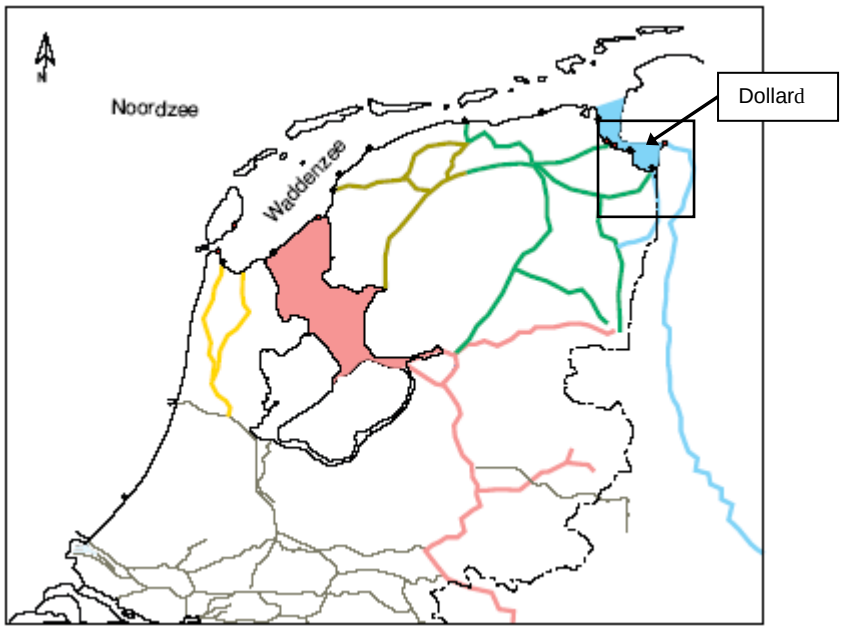


Fig.1: The tide estuary of the Dollard in the Netherlands.

2.2 Harbour seal as research species

In the Dutch Wadden Sea two species of seals are present, the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina*). The grey seal is more frequent in open seas. A population has settled between the islands of Vlieland and Terschelling, inbetween Terschelling and Ameland and near Texel. The harbour seal distribution is abundant in shallow waters between the islands and the coast. Sometimes, it is possible to observe both species on the same sandbank, but no grey seals have been recorded in the Dollard from present and former studies (Bakker & de Vries, 2007; Selvaggi, 1999).

Since 1500 the grey seal has disappeared from Dutch waters because of the seal hunt, but since the first sighting in 1955-56 and after 1962, when seal hunting was stopped in the Netherlands, the grey seal population in the Wadden Sea increased (Hart ‘t et al., 1988).

Other species may occasionally be registered in the Wadden Sea: the ringed seal (*Pusa hispida*), the harp seal (*Pagophilus groenlandicus*), the bearded seal (*Erignathus barbatus*) and the hooded seal (*Cystophora cristata*) (‘t Hart, 2007).

The harbour seal is the most abundant species of seal in the Wadden Sea. They haul out in large herds, during low tide in the summer period, between May and September. They rest, give birth, lactate and moult (King,1983, Pauli & Terhune, 1987, Thompson, 1993,Venables & Venables, 1955, Wilson, 1978).

During lactation, the mother and pup pairs lay as long as possible on the dry banks for suckling, and when it is high tide the mothers stay close to the haul out area with the pup. Since the harbour seal is a specie adapted to areas affected by tides. Seals give birth on intertidal sandbanks, which will be submerged. New born seals do not have lanugo (Oftedal et al., 1991); they moult before birth, and are able to swim with the mother (King, 1983). According to Wipper (1975), the first 8-14 days the pup needs to be on the sandbank to suckle. Then, when they are able to dive for longer time they may also suckle underwater (Venables & Venables, 1955). After three to four weeks, thanks to the 43% of fat milk, the pups triple their weight. The approximate mean of a newborn is 10 kg and is more than 30 kg for weaned pups (Wipper, 1975). Adult harbour seals opportunistically catch different kinds of fish. After weaning, pups start to feed mainly on shrimps (*Cragon cragon*) (Bigg,1973; Havinga, 1933).

The maximum number of seals on the sandbanks occurs at the height of the reproduction period when the mothers haul out with the pups the sandbank, where also sub-adults and males are present. After the nursing period begins the mating season, the adult seals moult, therefore the number of hauled out seals slowly decreases (Selvaggi, 2001).

During the moulting season, the seals need more vitamin D and can only be obtained when seals are exposed to the sun (Watts, 1992). Subadults shed during the nursing season, while adults do so after the mating season.

The pelage of the seals is a sort of trap for sun rays. The skin of a seal is dark in order to capture the heat and they also have blubber to insulate their body. The seal thermoregulates its temperature by using their head and an intricate web of blood veins and arteries laying very close to each other (rete mirabile) in the flippers. This explains the position of the seals, with head and tail up, when they are partially submerged by the rising high tide (Van Wieren, 1981).

One more reason for seals resting such a long time out of the water, is to save energy by avoiding the heat loss which in the water is 25 times higher (Watts, 1992), since the ratio surface-volume is higher in small animals, and the blubber layer is thinner in young seals (Kvadsheim & Aasseth, 2002) this is a good reason for pups and young seal to haul out as long as possible.

2.3. Research method

This research is a continuation of the one conducted last year (Bakker and de Vries, 2007), which took place from the 21st of May until the 9th of July. The same methods were applied in order to keep continuous data and observe any differences through the years. The observation work took place in the same place: the Dollard area, in the Wadden Sea, which is the natural habitat of a colony of only common seals (*Phoca vitulina*). It started from the 26th of May until the 31st of July.

The weather conditions were recorded each day at the beginning of the observations. Any change of the former was registered as well.

Two observers (authors of the report) were present during the survey days (See table 1 for the observation days). This research contains less days of observation (29 days) than last year (32 days). A telescope and binoculars were our tools of study.

The observation started approximately 4 hours before low tide and observed up until a couple of hours before high tide, depending on weather and sea conditions. The observation time stopped when no more seals were seen on sandbank 1.

The point of observation was located on land near the Punt van Reide restricted area. We first used, for a couple of days, the sea side of the dike. It protected the observers from the strong wind coming from land. No seals were seen, at time, near the water inlet, so this did not cause any disturbance. The dominant observation point was on the stairs, by the fence which are located on the top of the dike, this is were the rest of the entire study was conducted. The seals did not seem to react when we remained on this spot. The gate provided a sort of a camouflage as seals do not see clearly and are scared of vertical moving objects (King, 1983). Moreover, it provided a good point of view on the five sandbanks of the study.

Table 1: Days of observation

2007 (Bakker and de Vries, 2007)

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	

2008

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

The days of observation are coloured in grey.

Three fields of research were studied for this report: the distribution and abundance of common seals, the disturbance on seals and the mother-pup bond behaviour.

2.3.1 Distribution and abundance

The main part of this study was to investigate the use of sandbanks used by common seals throughout the area and the research period. The number of seals on each sandbank was therefore recorded every 15 minutes. A distinction was made between pups and the other seals (adults, yearlings, and sub-adults). When the pups are smaller and are still suckling, they are always accompained by their mothers. They are easily recognisable. During the last two weeks of the study, seal pups that were weaned were not easy to identify compared to the yearlings. They were not as identifiable because their size did not differ much from the yearlings. Once they were not observed suckling anymore and were lying alone on the sandbank they were included in the category others. Seals swimming in the water were not recorded. Each day, the haul out sites on all the sandbanks used by common seals were noted on the map (See Fig.2) of the area.

From the observation point mainly four sandbanks were visible, and the edges of the water inlet that reaches the dike were visible. Sandbanks were marked with the same numbers like in the former study of Bakker & de Vries (2007). In the present study, the larger sandbanks have been further divided into different haul out sites that were marked with letters of the alphabet.

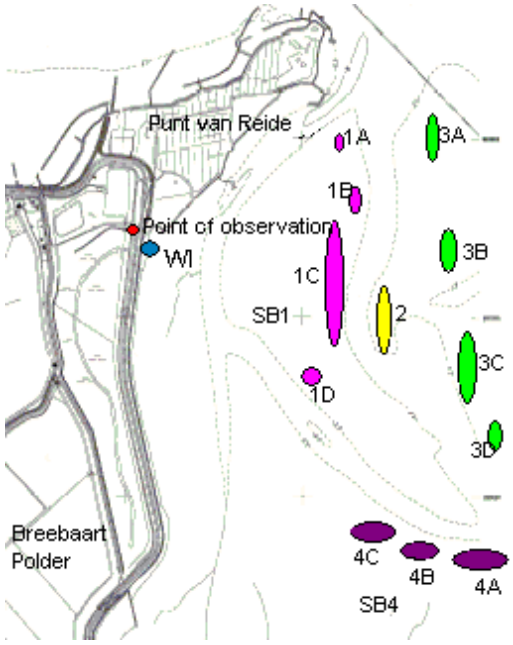


Fig. 2: Map of the area with haul out sites

Sandbank 1 (SB1) is a long tong of sand which reaches the mouth of the protected area near Punt van Reide, it can be identified on maps as Reiderplaat. This sandbank stays dry for around 7 hours, less than SB3, SB4 and WI. This sandbank has been subdivided in four parts, A, B, C and D. **A** was the outer part of it, in front of Punt van Reide, and it is dry for shorter length of time. **B** and **C** can also be assumed as a whole haul out site awhere a large number of seals were spread, and also the seals which were on the opposite side of the sandbank in respect to the observers was included. **D** is a small haul out site and is on the opposite side of B/C in the inner part of the area.

Sandbank 2 (SB2) is a thin sandbank between SB1 and SB3, but, during the low tide, only stays dry, for 3 hours, shorter in comparison to the other haul out sites.

Sandbank 3 (SB3) is the farthest sandbank from the point of observation but the seals lay on the slope at the side of the observers. On the map this is called Herringsplaat. It has also been divided into two haul out sites A,B,C. This sandbank stays dry longer, especially on the inner part C (9 hours).

Sandbank 4 (SB4) is further in the southern part of the observation area, and hard to see on very hot days or rainy days. Also, this sandbank was divided in three different haul out sites.

Water Inlet (WI) is a man made channel which can be usead by the seals to reach the beach close to the dike. This haul out site last longer than any other. For this reason even after all other sandbanks where submerged, there where seals on the beach very close to the dike and can easily be observed depending on the responce distance and disturbance. This is why the point of observation was 150 m further than the nearest place on the dike which is right above the water inlet. Since the seals were so close it was possible to observe the mother and pup bound, to recognise some individuals, to see if they had tags, or alternatively if they had some kind of health issue like blindness, skin problems, wounds and underfeeding

2.3.2. Disturbance

The prevalence of disturbance occurring in the Dollard area was examined. Two types of disturbance were differentiated: the potential and the actual disturbance. Potential disturbance corresponds to all the events that happened during the day; those which had an effect plus other types which did not. Actual disturbance relates only to the events that had an effect on seals. All the events, that did not engender any effects, were not classified in the actual category of disturbance.

Any disturbance that occurred during our observation period was registered. The times of each observed disturbance, the sandbank observed during the occurrence, the nature of the events and the factors that triggered the disturbances were noted. Thus, when the categories “agricultural vehicle”, “horse”, “car”, “cyclist”, “farmer”, and “person” occurred, the observers focused their observation on the water inlet. “Airplane”, “boat”, “ship”, and “jet fighter” have the potential to disturb all sandbanks. Most of the time, we observed the sandbank the closest to the disturbance factor.

Disturbance was split into various categories. We used the same ones defined by Bakker and de Vries, 2007 (see Table 2). However, we slightly modified some definitions considering the effects observed. First of all; the category “horse” was added; that is, any horses moving along the dike, that caused a large disturbance to the common seals likely due by the sound of horseshoes on the asphalt. It is certainly an isolated case, but the effects were such that it is important to include it. Second of all, we observed that cyclists at the landside of the dike triggered effects on seals. Second of all, we observed that cyclists, which travelled across the cattle grids, initiated disturbance towards the seals from the water inlet. Consequently, the category “cyclist” also concerns the cyclists behind the dike. Finally, regarding the category “car” in the previous study did not notice any actual disturbance when a car driving without a trailer was moving behind the dike. However, it was observed that it generated disturbance to the seals, which was recorded.

Table 2: Definition of the different types of disturbance (modified from Bakker & de Vries, 2007)

Recorded events	Description
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.

These diverse events provoked effects on seals. During this investigation,, the definitions used are the same ones described by Bakker & de Vries (2007) (see table 3). The number of effects that were observed on the sandbanks plus the total number of seals examined were noted.

Table 3: Definition of the various effects of disturbance on seals (Bakker & de Vries, 2007)

Recorded effects	Description
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.

2.3.3. Mother-pup bond

The relationship between mothers and pups was monitored. This section is only based on observations. Six main types of information were recorded. These involve the mother-pup pair, the suckling behaviour, the mothers alone, the orphaned pups, the weaned pups, and the case studies. Indeed, a couple of seals were identified due to a couple of specific physical signs. These distinct marks will be described in chapter 3.3.6. The interactions of the mother and her pup include their swimming activities, the "who follows who" behaviour, as well as the vocalization and physical communication between the two. These interactions also comprise the ones with the other seals of the rookery. Another very important part of the nursing period is the lactation process. This was also reported. Unfortunately for some seals, the pair was eventually separated. In that case, the mothers on their own were registered. Indeed, the lone mothers had different behaviours in terms of their swimming and haul out movements, her interaction with the other pups, the fostering behaviour and the time spent looking for her pup. In case of separation, the pup was also wandering about and this was observed, along-side different interactions with others as well as swimming and haul out behaviour. Towards the end of the research the pups finally weaned and this behaviour was also noted.

3. Results and analysis

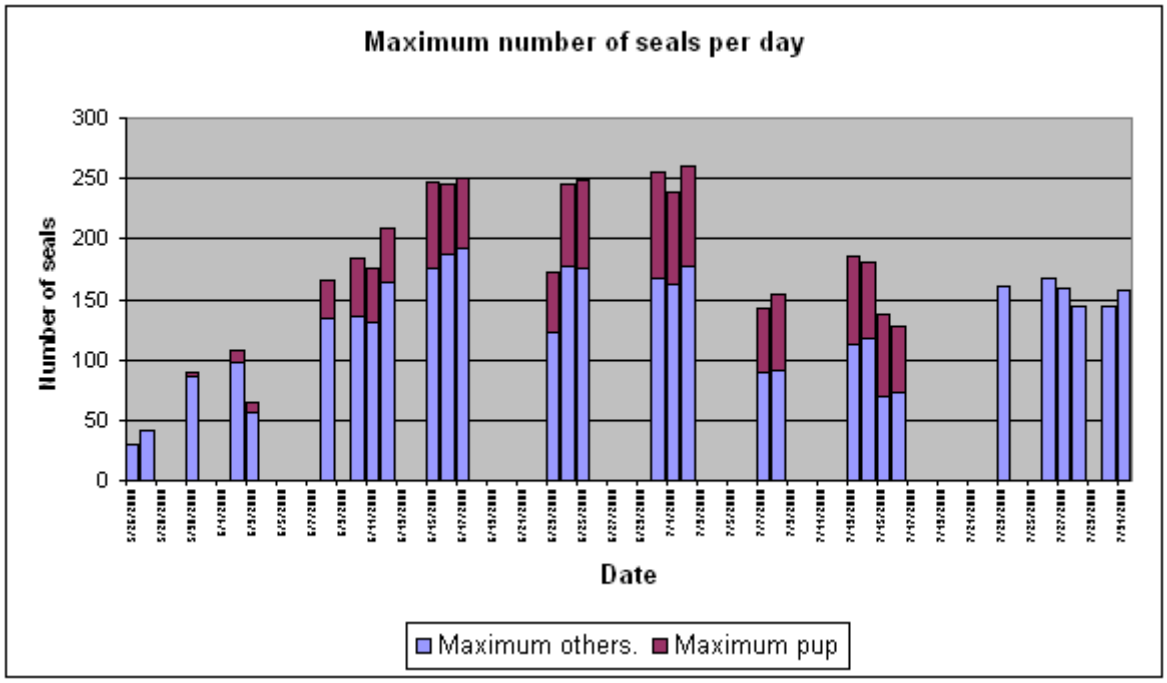
This chapter includes the results of our study. The observation data were analysed using the Excel (2003) program.

Distribution and abundance will be described followed by the disturbance, and finally mother pup bond behaviour. The mother-pup relationship concerns the observations surveyed in between the counting research.

3.1 Distribution and abundance

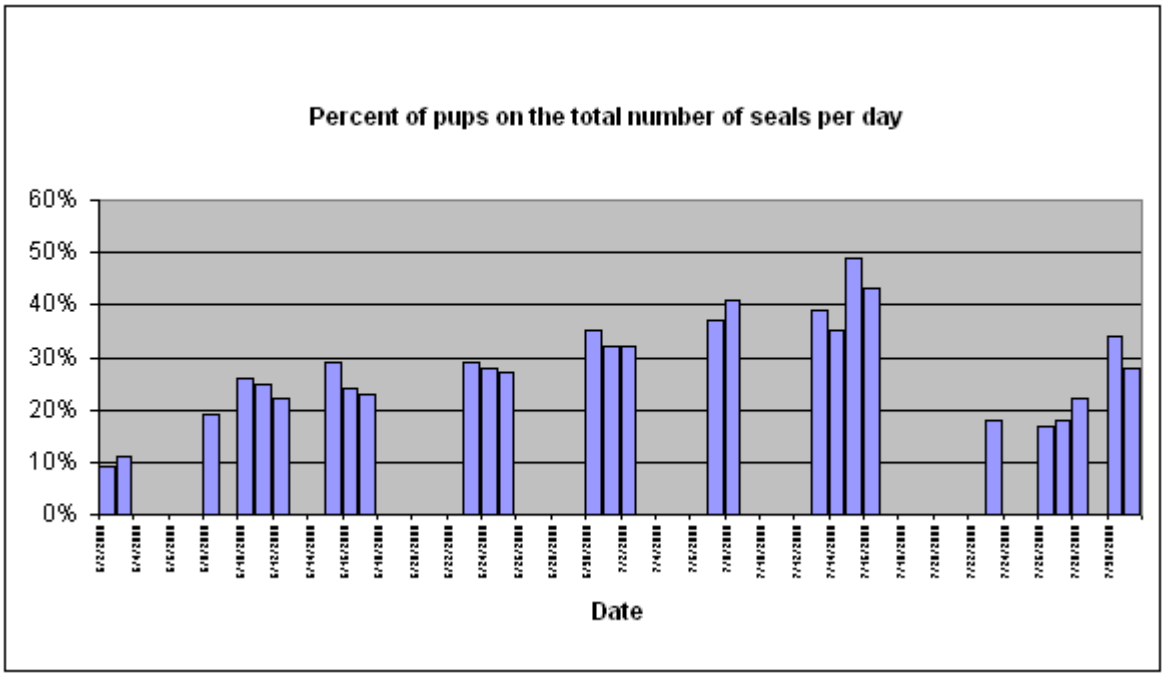
During the whole observation period, between the 15th of June to the second of July, on average, the maximum number of seals peaked at 250, apart from an isolated occasion where 261 individuals were counted (including pups and non-pups).

The first pup was observed on the 30th of May, previously, the year before, the first pup was observed on the 27th of May (Bakker & de Vries, 2007). In 1993 the observation started in august, and the nursing period had already begun, therefore we compared the maximum number of seals observed in the summer 1993 (77 on the 15th of August) (Selvaggi et al, 2001), and the maximum of summer 2008 (261 on the 2nd of July). In the last 15 years, it is apparent that there has been a shift in advance of the nursing season of 44 days (about 6 weeks).



Graph. 2: Total number of seals hauled out during the study period

During the whole observation period, if we look at the highest number of hauled out seals and the total percentages of pups resulting from the total number of seals, we see that the highest percentage of pups occurred during the nursing period between the 8th of June to the 16th of July. The first pup was seen the 30th of June and the last suckling ones were seen on the 16th of July.



Graph 3: Percent of pups on the total number of seals on all the sandbanks during the study period

3.1.1 Distribution and abundance on each sandbank

Within the haul out sites the majority of the seals counted were on sandbank 1 (SB1) and sandbank 3 (SB3) with peaks of around one hundred of seals. On the other sandbanks and the Water Inlet (SB2, SB4, WI) the seals abundance reaches around 30 seals. In 1993 the seals

hauled out almost on the same sandbanks, in particular sandbank 1, the only difference is that the water inlet did not exist yet and sandbank 4 was not observed.

In general within the sandbanks there is a main difference in how they were used by the seals:

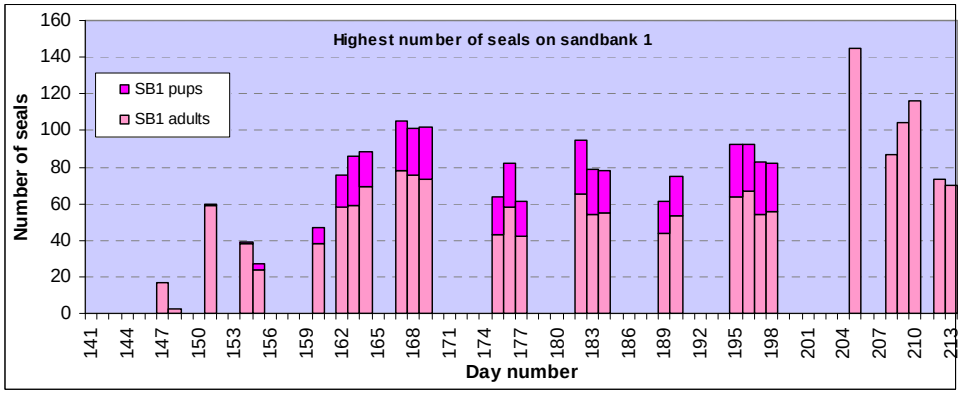
- Sandbanks where the seals rest for the central part of the low tide period (SB1, SB2 and SB3) and
- Sandbanks where the seals haul out mainly at the beginning and at the end of the low tide period (SB4, WI and 1D).

Sandbank 1 During the observation period there is a constant abundance of seals on the first sandbank and in general, looking at this sandbank as a whole, there are no differences during the whole observation period, except for an increase at the end of the season. In the central part of the low tide period there is a decrease in the number of seal, however, before high tide, it is registered the maximum. This may be due to the fact that the seal lay on the opposite site from the observation point and in the central part of the low tide period they may move lower on the opposite side and may be hidden by the sandbank. Anyway there is a difference between single haul out sites on the same sand bank. At the beginning of the nursing season a small amount of seals (less than 20) was hauled out in **1A** during the central part of the low tide period. The percentage of pups on the total number of seals is 35% along the whole period (for comparison with other sandbanks see table 4 page 16).

1B is close to the main haul out site where the largest numbers of seals rest. This is not where the highest number of seals were observed after the nursing period. Just a few seals haul out there, even though it is not an everyday occurrence, anyway it is interesting that mainly mother and pups haul out here mainly at the beginning of the nursing season (42% pups).

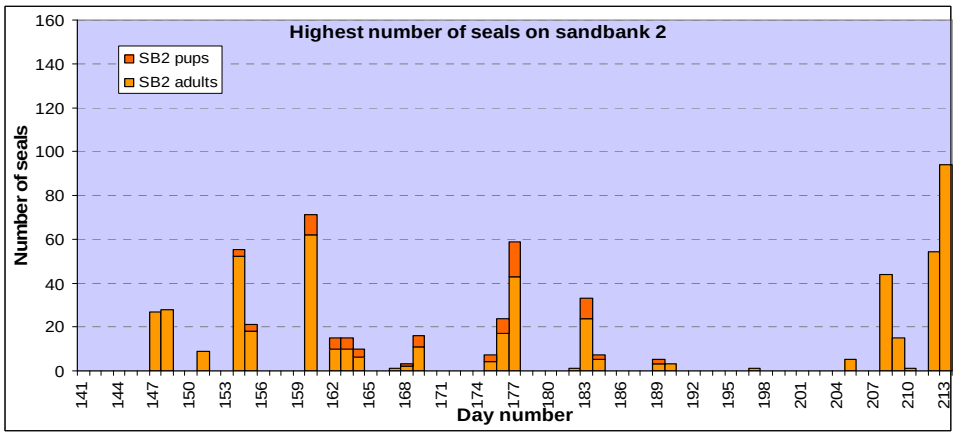
1C is the most important haul out site, this is were the highest number of seals were usually observed (around 100), as well as after the nursing period. On this site, the percentage of pups decreases to 25%.

1D is on the opposite side of 1B and 1C in front of the WI, usually there are seals at the beginning and at the end of the low tide period, in this site one on out of three seals is a pup (33%).



Graph. 4: daily maximum number of seals during the whole period of observation on SB1

Sandbank 2. This is a small sandbank and only remains dry for three hours, there is not a differentiation between haul out sites. It was being used at the beginning of the nursing season and by the end, the percentage of pups was then lower than 24%. When the sea is really calm the seals, mainly adults, can stay on the bank even if partially submerged in the characteristic head up back up position; while during periods when the waves are high the seals cannot keep dry and leave as soon as the sandbank is submerged.



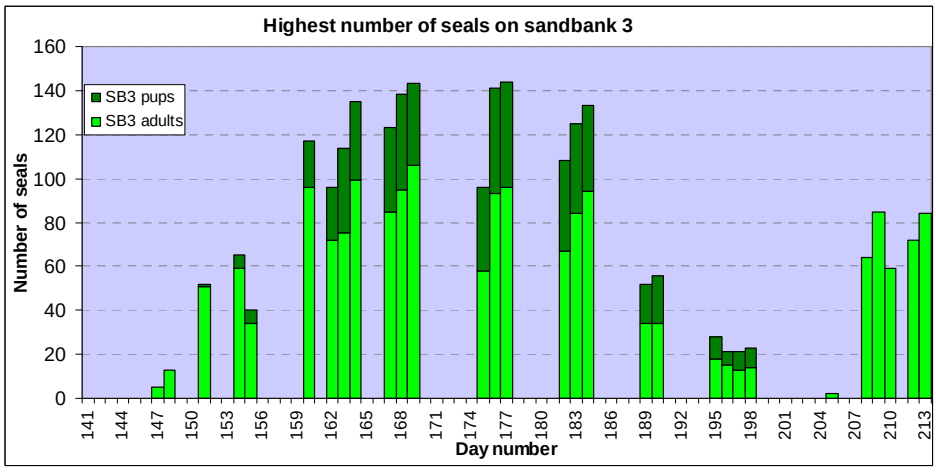
Graph. 5: daily maximum number of seals during the whole period of observation on SB2

Sandbank 3. This is a large sandbank and has been also divided in four main haul out sites and there are seals almost everyday. As a whole it registers the largest number of hauled out seals, especially during the nursing season. At the end of the nursing season there are also seals but less than in SB1 and SB2. In relation with the low tide period the number of seals decreases slightly in the central part of the low tide period and increases soon before the upcoming high tide, as it happens in SB1. In this case, seals can be hidden from the observer's sight.

In **A** only a few single seals were hauled out, mainly adults (27% pups) and not every day.

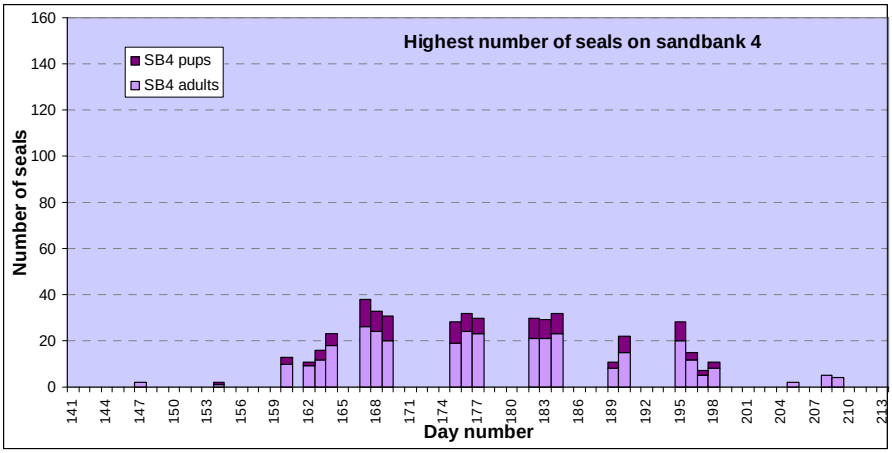
B and **C** are separated by a little stream and large debris. B is in front of sandbank 2, and since C is more on the inner part of the area it is the last part of the sandbank to be submerged, furthermore, there is not a huge difference with C. In C the number of seals is constant during the entire low tide period, while in B there is a decrease in the central part of the low tide period and an increase right before the sandbank is submerged. The percentage of pups is 31% in B and 29% in C.

D is not always frequented, there were seals present in the beginning of the study period and at the end, they were mainly weaned seals (40%).



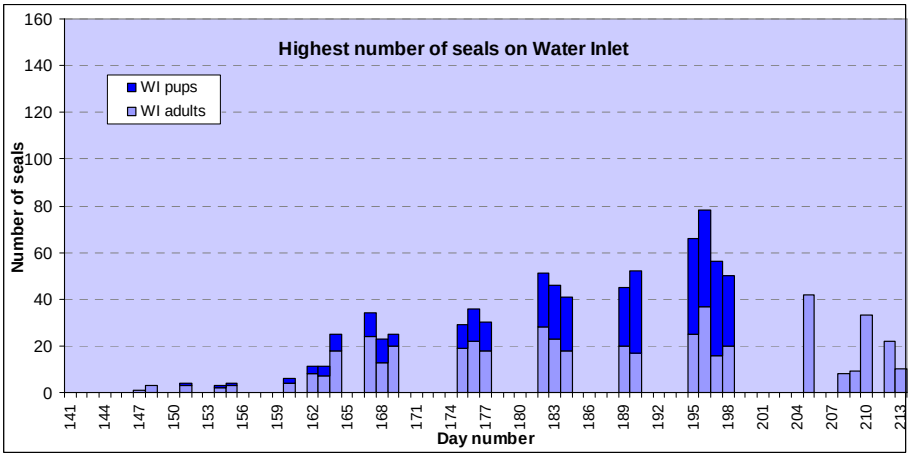
Graph. 6: daily maximum number of seals during the whole period of observation on SB3

Sandbank 4 is frequented mainly in the nursing season, but slightly later than SB3 (1 week), referring to the tide, there were seals mostly at the beginning and then they decrease during the central part of the low tide period, and do not increase at the end. The percentage of pups is lower than other sandbanks (29%).

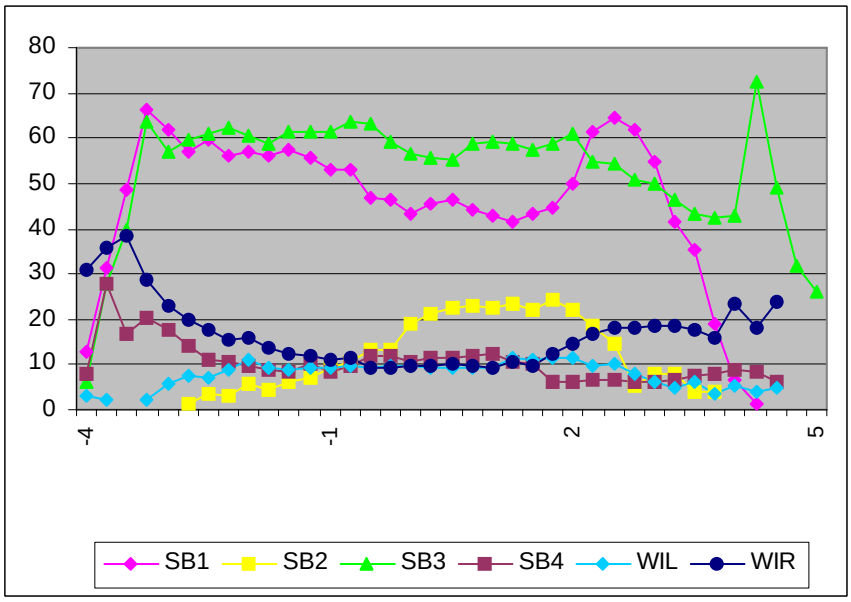


Graph. 7: daily maximum number of seals during the whole period of observation on SB4

Water Inlet (WI) The seals haul out on both edges, and it is possible to distinguish three main haul out sites, two on the outer part of the sand flat, on the right and on the left, and the inner part on the right (WIR) just under the dike. In this study, it has been distinguished as only right and left. (WIL and WIR). This haul out place remains dry for longer periods than any other sandbank, but the edges of the channel become very steep during the central part of the low tide period, then in the central part of the low tide period it becomes very difficult to climb on to the dry or to enter the water, especially for young seals. At the beginning of the low tide period there are hauled out seals in WIR (inner part), which, as the sea level decrease, move on the other part of the sand flat WIR (outer) and WIL where they stay for the entire central part of the low tide period or will move again. At the end of the low tide period, when the other sandbanks are partially submerged, seals haul out again in this site, first on the outer part then in WIR. During the whole period of the study seals were hauled out almost everyday. The total number increases from the beginning to the end, even if the number of adults is nearly constant. In fact the number of young seal constantly increases from a initial percentage of 33% to 70% and more after weaning. During the whole period we have an average of 52% for the WIR and 40% for WIL that is anyway the highest of any other haul out site.



Graph. 8: daily maximum number of seals during the whole period of observation on WI



Graph. 9: Number of hauled out seals on each sandbank in relation with the low tide, from four hours before to five hours later.

There is also a difference between haul out sites on the larger sandbanks: 1A and 3A have been used mainly at the beginning of the study period and for the central part of the low tide period, in particular on 1A hauled out mainly mother and pups (35% of pups), while in 3A there were mostly a few adult seals. On sandbank 1, we registered a higher percentage of pups on 1A, 1B and 1D. 1B was not used so often but it registers an high percentage of pups (42%), that suggest that some mothers prefer to be on the same sandbank as the whole herd, but at a certain distance. 1D (33% of pups) does not have a lot to make with the rest of this sandbank and, being more on the inner part of the area, it is more similar to WI and SB4.

Table 4: Average percentage of hauled out pups on the total number of seals on each site during the period from the 26th of May to the 31st of July.

Haul out site	1A	1B	1C	1D	2	3A	3B	3C	3D	4A	4B	4C	WIL	WIR
% pups	35	42	25	33	24	26	31	29	30	28	28	31	40	52

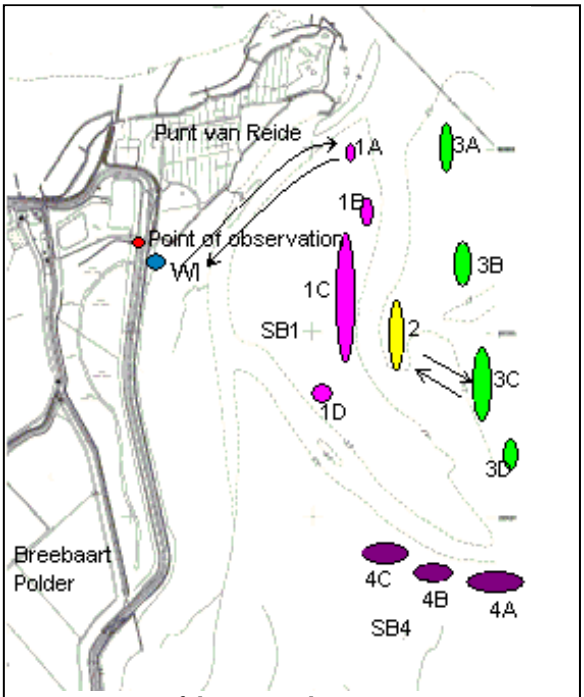


Fig. 3: Map of the area with movements between the sandbanks

3.1.2. Movements between haul out sites

It has been possible to see and recognise the seals which were first in WI and that moved from the right side to the left side and then towards 1A and back. This suggests that there is a cyclic pattern of movements from the inner haul out sites to the outer ones.

The movements between the Water Inlet and sandbank 1 and back where registered, this was mainly at the beginning of the observation period, while on larger sandbanks (SB1, SB2, SB3) 17 days on 30 there have been registered movements, between the 10th and the 23rd of June, when most of the pups are less than two weeks old, no movement are registered.

In the last part of the observation, when all the pups were weaned, it was possible to see the groups moving together and waiting for each other.

From the daily graphics (see appendix) it is possible to see when the number of seals decrease on one sandbank and increases on the other and vice versa. On the larger sandbanks, the main movements are:

1 ➔ 2 ➔ 1
1 ➔ 3 ➔ 1
3 ➔ 2 ➔ 3
1-3 ➔ 2 ➔1-3
1➔ 2 ➔ 1 ➔ 3

This pattern explains the decrease in the central part of the low tide period in SB1 and SB3, the increase of SB2 and the presence of seals in the WI and SB4 at the beginning and at the end of the entire low tide period.

Day	Before	Low tide	After		Before	Low tide	After	Most of sandbanks submerged
26 May						2	1C	
27 May								
30 May	WI	1A	WI		1C	3	1C	
2 June		1A	WI		1C 3	2		
3 June	WI	1A	WI		1C 3	2	1C 3	
8 June	WI	1A	WI		1C 3	2	3	
10 June								
11 June	WI	1A	WI					
12 June	WI	1A	WI					
15 June	WI	1A	WI					
16 June								
17 June								
23 June							1C 3	4 WI
24 June								
25 June					1C	2	1C	
30 June								
1 July					1C	2	1C WI	
2 July					1C	?	1	
7 July							1C 3	
8 July						3	1C	
13 July								
14 July							3	4
15 July	WI	?	WI					
16 July								
23 July						?	1C	
26 July					1C 3	2	1C 3	
27 July	WI	1A	WI		1C	2	1C	
28 July								
30 July	WI	1A	WI			2	1C 3	
31 July					1C 3	2	1C 3	

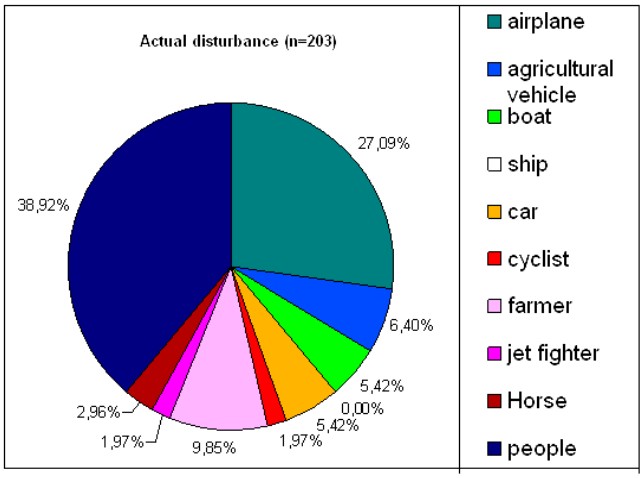
Table 5: Summary of when cyclic movements between the sandbanks occurred in relation with low tide. Movements between the haul out sites between Sandbank 1 and the Water Inlet and between Sandbank 1 and Sandbank 3 are on two different columns.

3.2. Disturbance

The various human interferences, which occurred during our observation period are represented in this chapter.

3.2.1. Disturbance and their effect

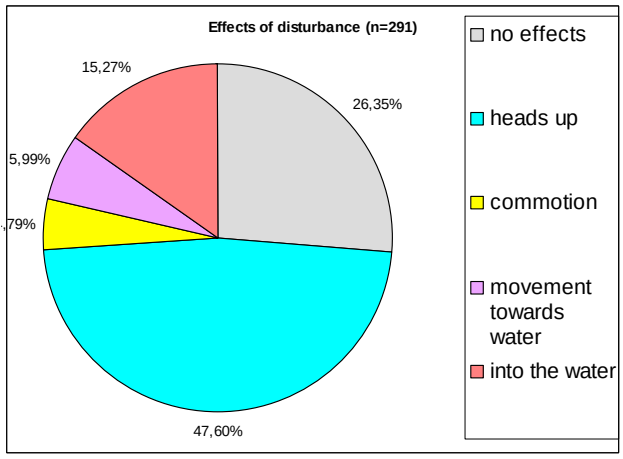
Disturbance had many effects on the common seal of the Dollard area. The total number of recorded disturbances is 291 of which 203 events were actual disturbance. Disturbance was categorised into 10 types of events (see methods, paragraph 2.3.2). The four main potential events that occurred during the observation period are “airplane” (34,71%), “people” (33,68%), “farmer” (8,25%), and “car” (7,90%). In terms of actual disturbance (see graph 10), the category “people” comes first with a value of 38,92%, followed by “airplane” (27,09%), then “farmer” (9,85%) and finally “agricultural vehicle” with 6,40%.



Graph 10: Percentages of the registered actual disturbance

The graph shows the different values of the various categories.

Disturbances can have either small effects or large effects. The proportion of each effect of disturbance was also classified (see graph 11). The first consequence of these different events is “head up”. It is the main reaction of seals with a value of 47,60% and 26,35% of the time, they did not respond to these events. However, compared to the percentage of commotion (4,79%) and movements towards the water (5,99%), which is relatively low, seals running into the water is of a greater share: 15, 27%.

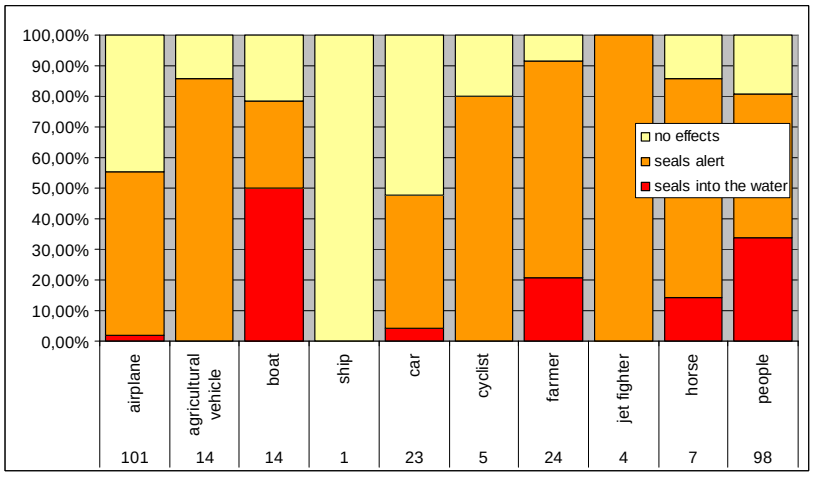


Graph 11: The share of the effects on seals

This graph presents the proportion of the five types of reactions on seals.

Another interesting approach of disturbance is to evaluate the portion of events with one of the effects caused by the former (see graph 12). The category “seals alert” combines three others: “head up”, “commotion”, and “movement towards water”. The different events

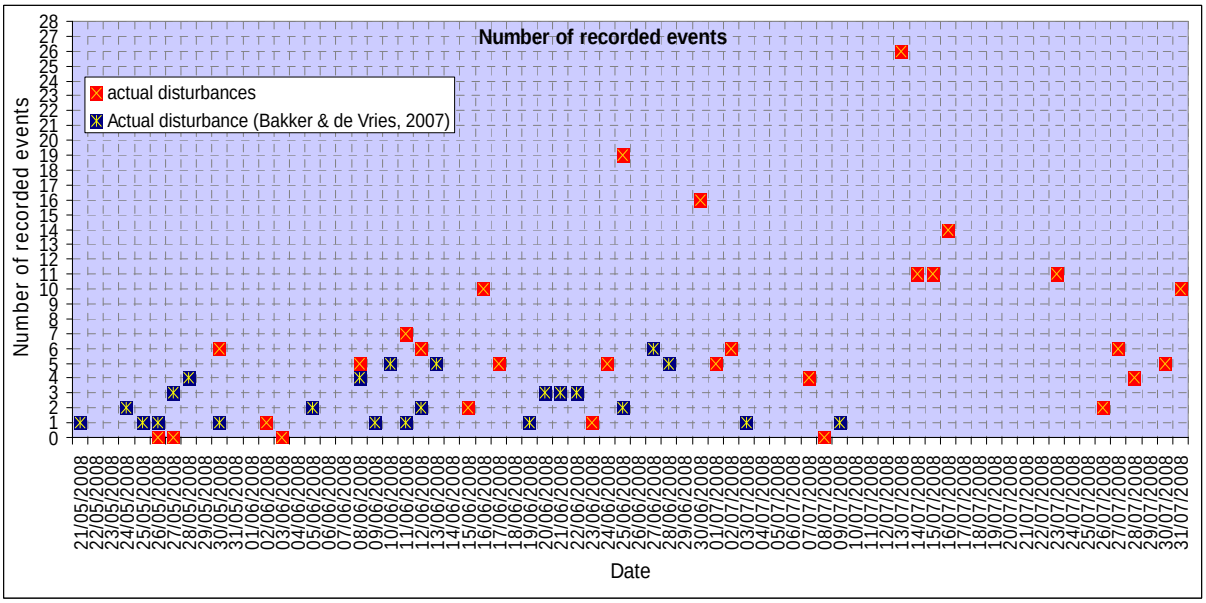
had a certain amount of effects on seals. It was observed that “boat” was the main event causing 50% of the seals to run into the water. This number is quite important as only 14 boats in total were registered. “People” was the second group which triggered the “into the water” effect with 33,67%. The farmer’s car and horses had also quite an effect with respectively 20,83% and 14,29% of seals into the water. The other categories had a proportion less than five percent.



Graph 12: Percentage of the various effects caused by each event
This graph shows the share of three types of effects on seals by the different causes.

3.2.2. Disturbance and consequences

The number of recorded events was studied throughout the various days of observation (see graph 13 below), including last year observations of disturbance.

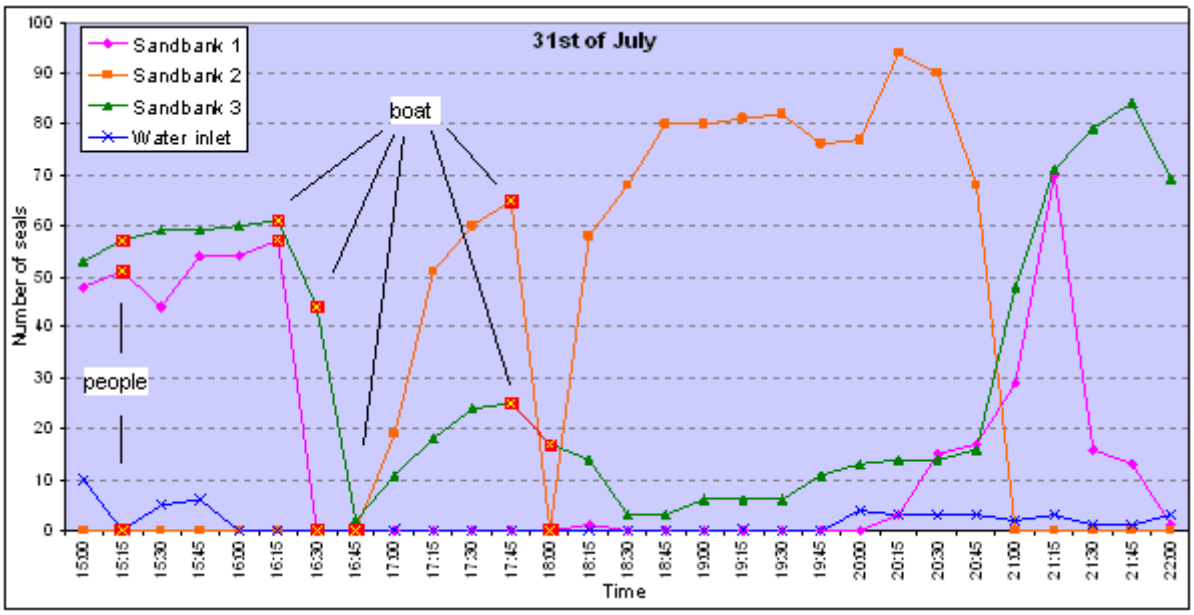


Graph 13 : The number of recorded events through the dates of observation.

It can be observed that the numbers of events were very different throughout these dates. It is logical human disturbances are random events. In terms of actual disturbance, it seems that the various events had different effects on seals depending on days. Although there is a very slight increase, we would have expected disturbance to have a stronger impact on seals behaviour during the peak of the nursing season (period from 15th of June to the second

of July). Overall, Bakker & de Vries (2007) observed less actual disturbance throughout their study.

Another approach to consider is the change of the use of sandbanks when human interference occurs (see graph 14).



Graph 14: Records of disturbances on the 31st of July

The red squares correspond to the time of disturbance. Only the effect 'in the water' is reported on this graph. The category "people" only affected seals located on the water inlet. However, the number of seals on sandbank 1 decreased just after this event. The sandbank1 and the beach are quite distant from each other. This could be coincidence. A decrease is indeed observed. On this date, the category "boat" concerned all the sandbanks as it sailed between the different haul out sites. Seals from sandbank 1 disappeared from our sight. Many of them deserted the sandbank; however, it is possible that some stayed on it. As explained before, sandbank 1 is not entirely visible. The number of seals on sandbank 3 also dropped. An interesting occurrence happening is the large increase of seals seen on sandbank 2. Most of the seals from sandbank 3 and 1 hauled out on this sandbank away from the boat. Nevertheless, not all seals returned on the haul out sites. Later, as the boat left the Dollard via the restricted area, it passed behind sandbank 2 causing the whole group to run and jump into the water. A couple of minutes later, seals came back on sandbank 2 until it disappeared as the water rose again. The rest of the day was quieter in terms of disturbance. Disturbance caused seals to switch sandbanks but not all of them reappeared on the same sandbank.

3.3. Mother pup behaviour

The next chapter portrays the various observations of the relationship between mothers and pups. The mother-pup pairs will be first described; then, the suckling behaviour followed by the mothers alone, the orphaned pups and finally the weaned pups.

3.3.1. Behaviour of mother and pup pairs

Interactions with others

Mothers and pups haul out on sandbanks to rest and lactate. The longer they can stay the better. Unfortunately, some factors may disturb them. Their rest may be disturbed by human activities, by the tides or by severe weather conditions. Normally during the nursing period the whole group rests and they do not interact very well with each other. However,

within the group of hauled out seals, sometimes interactions with other seals that caused interferences. For instance, some seals coming onto a sandbank move back and forth on the surface splashing and sliding on the mud. Lone mothers try sometimes to approach other females' pups. They smell the pup, but usually the real mother starts fighting with the adult and/or tries to keep her pup away. Moreover, orphaned pups trying very often to suckle from indiscriminate mothers, play an important role, as well as bothering the pair. Mothers tend to be quite protective to their pups. They defend their pups against orphaned pups and adults. A couple of these situations have been observed during our research. On the 30/05/08, hostile comportments were noticed between a mother and her pup and an adult. The adult started to push the pup with its snout. The mother slapped the water and the mud with her fore flipper and she growled. The adult left. The same event also happened on the 25/06/08. A mother and her pup were swimming to the water inlet when another adult approached them. The adult sniffed the mother's snout. The mother attacked the other adult by pushing it away with her snout and flippers, whilst with growling synchronically. The adult therefore pushed her pup and they both fled into the water. All three ended up in the water. Mothers are not only standing against other adults. They also have to keep orphan pups away. The 14/06/08, a mother chased an orphan trying to suckle. She sniffed it and then started to bite its tail. She followed it and pushed the orphan away. Mothers either use the hostile manners towards the others, or they escape from them. On the 24/06/08 an orphan pup was following a mother and her pup. She tried her best to keep them separated from each other by lying between the two. The orphan was coming back all the time. The mother started to show aggressive attitude. She tried to push away and to bite the orphaned pup. After a while, she moved towards the water with her pup followed by the orphan. They hauled out further from the place accompanied by the orphan. This chase lasted for a long time. Neither of the pups had the chance to be fed. Such events were seen many times during the study. A couple of times, the observers saw a pup which showed aggressive behaviours. For instance, on the 14/06/08 a pup scratched the adult with its fore-flipper. It pushed the adult away by lying on the side, and moving the flippers very fast. It is not known whether or not this adult was the mother since a couple of aggressive behaviours were noticed between pups and mothers.

Mother-pup swimming behaviour

In the water, mothers are also very protective. A couple of swimming behaviours have been recorded. The pup climbed on the back of its mother in a piggy back riding manner. It stood on the back; she turned her head backwards to muzzle her pup. Then, she started swimming away. If the mother wanted the pup to dive, she climbed on top of it. They dived and re-emerged together. Sometimes the pup followed her mother; in that case, she was constantly alert making sure the pup was always there. If the distance increased, the mother swam in the direction of the pup. On the 17/06/08, a mum and a pup were sunbathing on a sandbank. Then the pup started to play in the water. It was rolling in the water and splashing its mum. The mother kept an eye on it although she stayed still. The pup was swimming back and forth from its mother increasing the distance at each go. She was still watching. After a while, the pup disappeared from the surface. The mum panicked and fled to the water looking around for her pup. She swam and dived for a couple of meters. The pup finally re-appeared several minutes later near the sandbank where they were resting earlier. She smelled it. They swam together till the ridge. The mother pushed her pup towards land.

Vocal and physical interactions

Vocalization between mothers and pups is a very important process to keep in touch. A pup at a distance from its mother will cry so that she comes to it. The mother swims towards the pup and muzzles it to recognize the pup. Moreover, mothers also call their pup. For instance, on the 23/06/08, the mother with the old neck wound left the water inlet and went to the water. The pup did not follow. She stayed in the water, calling for her pup for it to come. She kept calling. Due to high tide, the edges of the sandbank were too steep for her to climb back to her pup. After a while, the pup and the mother finally reunited.

The physical interactions are also part of the recognition between the mother-pup pair. Muzzle, flipper and snout rubbing are performed very often. These physical interactions are also important to stop the suckling process (the mother pushes the pup with her flipper), or to help the pup move, or suckle. On the 12/06/08, for instance, a pup was playing around its mother on the water inlet. It was sliding all around her and entered a very muddy "pool". The pup was sort of stuck on the mud. The mother pushed the pup out with her snout and body. Moreover, the pup after the second week starts to be more independent and can show resistant behaviour to its mum. On the 17/06/08, a pup was recorded to scratch its mum with its flipper when the former muzzled it. The pup suckled after a while, which proves that they were a pair.

Who follows who

Fig. 4: left The mother hauled out first; right: the pup hauled out afterwards

Fig. 5: The pup hauled out first, the mother stayed in the water close to it

During the first two weeks, the mother was leading the hauling out movements. She was the one choosing the sandbank and the pup followed (see fig 4). The mother always made sure that her pup could climb. Otherwise, she moved back to the water and chose a less steep one. Sometimes, she waited for her pup to crawl on the sandbank while she stayed behind partially emerged in the water before hauling out (see fig 5). It happened that the mother remained in the water letting her pup suckle from its dry place. The mother was moving depending on the tide. The pup followed her everytime she departed. During any disturbance (human or environmental), the mother tried to not leave her pup. It was observed on the 30/05/08 during

a human interference (people on the Punt van Reide area), that the three adults present on the sandbank fled to the water while a pup stayed on land. The pup was sleeping and did not react. The mother remained near her pup but in the water. She tried to make him move without success. It appeared that she was struggling between protecting her pup and leaving the sandbank. The mother was extremely alert looking back and forth to her pup and the people. As soon as the disturbance stopped, the mother hauled out again followed by the two other adults. Around the third week, pups become more self confident. They play around the mother, take the initiative of leaving a sandbank, and of swimming away. In these cases, the mother follows the pup, reach it and convince the pup to come back on the sandbank. She climbs on top of it to make it dive.

3.3.2. Suckling behaviour

Lactating duration

From the observation study the observers noticed that during the first two weeks the mother presented her teats to the pup. She would haul out with the pup and move on one side in order for the pup to suckle. The pup always stayed very close to its mother. The first pup was observed on the 30/05/08. The mother was laying on the side. The pup was not able to find immediately the teats. The pup suckled all over the mother's body. The pup was suckling on the upper part of the mother's body. She pushed it towards her tail with her flipper. The pup arrived at the right place, and started to suckle milk. From the third week till the weaning process pups were the ones initiating the suckling session. They would push the mother's body with their snout or their flipper until she finally surrendered. For instance, on the 16/06/08 a pup was really hungry. It kept pushing the mother with its snout. She would not move. The pup tried to suckle anywhere it could but she did not allow it. Then, the pup rubbed its mother with its flipper. She was really not reacting. The pup ultimately climbed on the mother's back a couple of time. She eventually capitulated and the pup could feed. Furthermore, it was also noticed that pups became more independent and distant to their mother. Pups started to play and swim around the mother before hauling out. Thus, they suckled less from the mother. They also spent more time sleeping.

3.3.3. Behaviour of mothers alone

Swimming and haul out behaviour

A mother who lost her pup swims back and forth looking on the haul out sites that usually are frequented, but also on other sandbanks. They may even haul out on sites without seals. She tended to approach other pups.

Mothers alone and other pups

Mothers alone kept searching for their pup and approached pups that were alone or pups which still had a mother. Whenever the mother noticed an orphaned pup, she would approach and smell it. Once, she realised it was not hers she continued her desperate search. On the 16/06/08, a mother alone hauled out on the water inlet. A group of orphaned pups was on its own apart from a mother-pup pair. The female without a pup went directly towards one of the pup. She smelled it and fled to the water. The pup followed even though she did not wait for it. The observers also encountered a fight between a female and a mother with her pup on that same day. The mother without her pup tried to separate the mother-pup pair by pushing the pup towards the water. The mother of the pup reacted aggressively using her snout and flipper. She growled at the intruder and tried to keep the latter away from her pup. The mother kept fighting until the female was gone.

Fostering and accepting abandoned pups
Fostering is described by Boness (1992) to be the care given to the young in replacement of that given by its mother, this is associated with the separation of the mother and the pup. Most of the time mothers chased away abandoned pups, and tried to escape from them either by not showing their teats or by fleeing to the water in order to feed their own pup. Orphans tried really hard to reach another mother's teats to suckle. A case of accidental fostering however happened on 1/07/08. Two pups were suckling the same mother. Both of them were using either one of the two teats that were available. The orphan was fatter than the mother's pup. She did not chase the impostor at first. She would rest and stay on the side. Her pup was closer to her head, therefore, each time she smelled it she would not react as it was her pup. Once, she smelled the orphan and started to move. However, the intruder was faster as well and could always find a way to suckle from her. She changed haul out site. When she arrived on the other one and let her pup suckle again, the orphan started to feed before her pup which was still climbing the edge of the sandbank.

Time spent searching for her pup
One interesting observation involving a mother looking for her pup, was on the 16/06/08. A female without a pup hauled out on the water inlet. She smelled the mud, and started to scratch the ground. She was pushing something with her snout. The observers could not see it yet. After a couple of minutes, a shape of a seal appeared. A pup was lying on the ground covered with mud. The animal was dead and the seagulls had already started to pick on the eyes as blood was noticed. The mother tried to move it, and to wake it up. The body was recovered for post-mortem analysis. The seal pup was a dead born. The mother was swimming back and forth the water inlet for approximately seven hours.

3.3.4. Behaviour of orphaned pups
Swimming and haul out behaviour
Orphaned pups swam for hours to find their mother again. The longest search was approximately seven hours long. They cried when their head was above the surface, and the sound disappeared once they dived. They swam back and forth between the different sandbanks, especially the water inlet channel. Orphaned pups do not follow the tide ebb and flow in terms of haul out site movements. Indeed, they stay on one place until high tide. On the 23/06/08, one orphaned pup hauled out on the water inlet. The others had already left earlier to another sandbank. The pup was deeply sleeping until two adults swam towards the pup area. They rose their heads in its direction the way they do before hauling out. At high tide, the sandbank is high and the edges of the water inlet are very steep. Thus, the adults did not haul out. The pup woke up and tried to join them. Once in the water, no interactions were observed. Usually once sleeping, the orphaned pups were not easily disturbed.

Interaction with others

Pups had a tendency to follow any adults or even pups. The former was observed a couple of times (16/06/08, 23/06/08). An adult hauled out on the water inlet where an orphaned pup was laying. When the former went back to the water, the pup followed it. Also, when the pup was swimming it would follow the adult nearby. The adult would smell the pup and dive to escape from it. On the 17/06/08, two pups were swimming in the water inlet crying for their mothers. Sometimes, they crossed and one of them started to climb on the back of the other the way they do with their mothers. However, they swam together in an infrequent manner sometimes together and sometimes apart from each other. Therefore, there might not be any relationship between the two orphaned pups. On the 23/06/08, two pups were seen suckling each other. Orphaned pups suckle anything they find (observations of seals in captivity at the SRRC). A pup followed an adult even when the latter showed aggressive behaviour, escaped or refused any interaction. On the same date, a pup and an adult were close to each other. The adult was moving on the sandbank splashing and jumping onto the pup. The pup crawled away from it. They bit each other. The adult tried to push it into the water. They both ended up into the water. The pup swam in a piggy back ride manner on top of the adult. Then, the pup was left alone in the water.

3.3.5. Behaviour of weaned pups

Weaned pups like orphaned pups do not have the same haul out site movement behaviour as adults have. They tend to stay on one sandbank until the water rises again. In that case, they leave the ridge to the water. A couple of weeks later, they formed a group on the sandbank. They did not seem to interact with each other. They sleep and leave the haul out site at high tide. On the 23/07/07, a small group of weaned pups was observed during hauling out. They swam very close to each other, at the same time and very fast, splashing, and sliding on the mud. Each individual looked at each other before leaving the place. The group resembled together. Seals were interacting with each other.

3.3.6. Case studies

Wounded neck

It was an easily recognisable female seal with a deep scar around her neck. This seal was observed during most of the time of observation. Her behaviour was observed carefully, and she showed a unique care and a strong attachment to her pup. She was the first mother to be seen with a pup during the observation period (30th of May). The pup was estimated to have an age of maximum three days old. At the beginning the pup was not able to reach the teats, but the mother helped the pup. The pup followed its mother during her movements between a sandbank to the other since the first day. Till the 8th of June, they stayed within the water inlet and sandbank 1A, but this did not happen daily. It is possible that the mother and her pup went to different sandbanks. The wounded neck mother and her pup stayed together till the 5th of July. Until this date, they were seen together even when the pup was not seen suckling anymore. They still had lot of interaction with each other such as swimming, muzzling each other, hauling out or resting nearby. On the 5th of July, the pup had followed her mother to sandbank 1a. They rested together till the sandbank was submerged, and then they swam together to the water inlet, where a few abandoned pups were crying and looking for a mother. The wounded neck mother was immediately followed by a couple of orphaned pups as soon as she hauled out with her own offspring. In the confusion, she suddenly left the sandbank to the water and did not come back. Two days later she was observed alone on the water inlet resting. She continued to haul out on this place until the end of the observations. Her pup was not only the first born in the area, but one of the last to wean (about 5 weeks). In

case of disturbance, she was one of the first seal to enter the water. She was always waiting for her pup, and in two cases (described earlier) she had to wait for her pup.

Fig 6: Wounded neck mother with pup on the 2nd of June

Fig. 7: Wounded neck mother with pup on the 23rd of June

Red head

A female with quite a light spotted body and a red head was observed. She hauled out on the water inlet during the whole period of observation, but not everyday. At the beginning, she often had fights with other seals and sometimes she approached pups of other seals. She was seen with a pup for the first time on the 23rd of June and her pup was seen suckling till the 8th of July, but not after the 15th of July (about 3 weeks).

Fig. 8: Red head with pup and two orphans

Fig. 9: Red head mother and pup

Red body seal

It was a male seal. He was rounded and short. His pelage on the whole body was bright orange with lighter spots on the back. He was observed almost everyday during the whole observation period and he hauled out near the females with pups. He hauled out on the water inlet less frequently during the last days of observation. He was resting all the time and stayed on the sandbanks until the high tide submerged him. On the 16th of June, he displayed porpoising in the water inlet.

Fig. 10: Red body seal (11th of June)

Blue eyes

The blue eyes seal was a large male of a very dark red-ish colour. He was only seen 4 times during the observation period and mainly during the last days. He also displayed very impressive shows, with splashing, porpoising, rubbing his belly and his back on the sandbank. After hauling out, he could not stay still and it seemed to be always alert. He was probably blind on both eyes. He had a light green tag.

Fig. 11: first image: see green tag on the hind flipper

One eye seals

1. The last days (26th July to 30th July) a young seal, probably a subadult, with a missing right eye was observed. This seal also has a scar on the muzzle.

Fig. 12

2. On the same date as above, another seal with only one eye was recorded. It was missing its left eye. However, the loss was fresh when the observer registered it. The wound was still red. It seemed healthy in terms of body shape.

Fig. 13 

Red Back seal

Within all the seals observed, there are a few with a red pelage. In this case, only the back of the seal was red coloured. It was seen from the 25th June to the second of July.

Tagged seals

Unfortunately it is hard to see a little tag on the hind flippers of a seal in the wild even from so close. It depends on the position of the seal (if the seal stretches and opens its flipper), the light, or the timing, etc. A seal with a red tag was observed on the 15th of June, and another one with a light green tag (the cited above "blue eyes" case) was seen twice (26 and 27th of July). The wounded neck mother should also have a tag, because she recovered from her injury at the SRRC. However, the observers never spot it. A seal marked on its back was also recorded on the 24th of June. This technique is called freeze branded (Härkönen & Harding, 2001). The observers detected large letters, which could be R5.

Male displays

Male seals were seen splashing and porpoising from the 10th of June till the last days of observation. They seemed to have been more active during the nursing period. In one case (15th of June), one mother with her pup followed the male into the water; and on another occasion a seal was observed following a male into the sea. They stayed for a while in the water splashing. Then, the male came back on land and started to hop back and forth on the sandbank. The other seals did not pay attention to him.

4. Discussion

The observations of this report were influenced by the environmental conditions. Indeed, counting the seal was extremely difficult in case of rain. Rain drops would make the observation through the lens of the telescope slightly indistinct. Nevertheless, in case of heavy rain, the study was stopped throughout the rainstorm. This explains a couple of gaps during the observation survey. Also, during high wind, the telescope trembled too vigorously in order to properly observe the seals. Moreover, a couple of days were biased by the mist surrounding some sandbanks. In that case as well, some data is missing. Besides, the photospheric oscillations, observation of sandbank 3 was difficult. The shimmering of the sun provoked a haze around that sandbank. Therefore, the counting was complicated. Furthermore, the distance of sandbank 3 from our observation point was far and thus reduced the visibility of the latter. The distinction between pups and adults was complex on sandbank 3. Additionally, it happens that seals lay behind each other on the sandbanks. Then, the zoom was used to distinguish them, but the process was delicate and not possible on sandbank 3 for the reasons described above. It is also important to keep in mind that the 15 minutes interval of recording is enough for seals to leave or come back from the sandbank. The number of seals changes constantly, especially during disturbance periods.

This chapter will focus on the distribution patterns of the harbour seal in the Dollard area, and the disturbance and on mother-pup behaviour.

4.1 Difficulties encountered during observations

The observations of this report were influenced by the environmental conditions. The counts were extremely difficult in case of rain. Images observed through the lens of the telescope seemed indistinct due to raindrops. Nevertheless, in case of heavy rain the study was stopped throughout the rainstorm. This explains a couple of gaps during the observation survey. Also, during high wind the telescope trembled too vigorously in order to properly observe the seals. Moreover, a couple of days were biased by the mist surrounding some sandbanks. In that case as well, some data were missing. Besides, the photospheric oscillations would make observation on sandbank 3 difficult. The shimmering of the sun provoked a haze around that sandbank, which complicated the counting. Furthermore, the distance of sandbank 3 from our observation point was too far and thus reduced the visibility of the latter. The distinction between pups and adults was thus complex. Additionally, it happens that seals lay behind each other on the sandbanks. Then, the zoom was used to distinguish them, but the process was delicate and not possible on sandbank 3 for the reasons stated above. It is also important to keep in mind that the 15 minutes interval of recording is enough for seals to leave or come back from the sandbank. The number of seals changes continually, especially during disturbance periods.

This chapter will focus on the distribution patterns of the harbour seal in the Dollard area, on the disturbance and on the mother-pup behaviour.

4.2. Distribution and abundance

In general, since the first study was carried out in the Dollard in 1993 the number of seal has increase, from 77 to 261 of 2008, following the trend of the rest of the Wadden Sea, even if the virus outbreak in 2002 affected the increase of the seal population (http://waddensea-secretariat.org).

Seasonally the maximum amount of seals occur during nursing and moulting season, between May and August in the Dollard area. Within the group all age classes are present however, if the predominant reason to haul out is for nursing the pups, is not clear why males are also present on the same sandbanks and display visually and acoustically in the same area in order to attract the females, which eventually restrict their foraging activities (Thompson, 1993).

There are differences in the hauling out behaviour of harbour seal depending on the study areas. There are many studies carried out on the haul out behaviour of harbour seals in different areas in Europe and in North America. The haul out sites may vary from rocky ledges, coastal island, intertidal areas, and estuaries.

During the present study, it was possible to follow some individuals, site fidelity has been observed (see case studies), as former described by (Härkönen & Harding, 2001).

In the present study, cyclic movement between sandbanks were observed depending on the tides. This behaviour has not been registered earlier along the coast of the Netherlands, besides in a former study of the Dollard area in 1993 (Selvaggi, E., 1999), but it has been recorded by Thompson 1993 who explains them with the necessity of haul out and the availability of sites due to the tide and the characteristics of the sandbanks.

In fact in estuary areas, the shape of the sandbanks and how long each individual hauls out for on each site, indicates some are dry for different lengths of time. While along the

coast, the sandbanks are perpendicular to the upcoming and outgoing tidal floods, which submerges the haul out sites almost at the same time.

Then the haul out behaviour vary between the different areas of study and may be influenced more on diurnal or tidal factors (Thompson, 1993). In estuary areas, where the tides influence the availability of hauling out sites, the haul out pattern follows the tide cycle (Pauli & Terhune, 1987, Thompson, 2005). According Pauli & Terhune, 1987, the seals prefer to haul out on steep sided rocks at the beginning of the low tide and then move to lower profile ledges when the level drops. This is also the case of the Water Inlet, that has steep edges during the central part of low tide and Sandbank 1 which has a low profile.

Also the diurnal cycle affects the presence of seals on the sandbanks with an increase of 20% in the afternoon as observed by Thompson (2005) and (Watts, 1991) and in the Dollard of 33% as mentioned in a former study (Selvaggi, 1999). Other factors that may influence the choice of the haul out site are food availability and predators (from sea and from land) (Thompson, 1993). In the Dutch Wadden Sea threats of predators are absent, and also seal hunting is not allowed (‘t Hart, 2007).

4.3. Disturbance

The different effects of disturbance were mainly observed on the water inlet. This place was more affected by the various events in comparison to the other sandbanks, therefore it was easier to disturb the seals.

Moreover, the various strollers passing by had a greater tendency to climb up the dike when the researchers were present to ask questions about the investigation so therefore caused distraction from observation. Additionally, on the 8th of June 2008 obvious signs were placed to educate the public to prevent disturbance towards the nursing mothers and pups. However, half of the time it had the reverse effect. It attracted attention of passer-by who did not know of the existence of seals in the region. Most of the time, the observers aroused curiosity and therefore their presence involuntarily allowed people to stay close to the proximity of seals.

The results of disturbance of 2008 varied from 2007. The events which had most effects on seals (“into the water”) this year are “boat”, “people”, “farmer” and “horse”. Last year, it was: “jet fighter”, “car”, “boat”, and “people”. In terms of effects, last year results showed that “no effect” happened 81% of the time, while “head up” and “into the water” are next with less than 9%. This study found that most of the effects engendered were the category “head up” with a share of 48%, followed by “no effect” (26,35%) and “into the water” (15,27%). The actual disturbance is also different from the previous study. They noticed that the main categories were: “people” on the dike with 50% of real disturbance, “agricultural vehicle”, and “airplane” as well as “boat” contributed to the other events triggering effects with less than 14%. This report exposes that people (39%), airplane (27,09%), and farmer (9,85%) were the major ones this year. The main categories involved as well as their percentage are different from the preceding analysis. Disturbance is based on visual and audible observations. The only invariable parameters from years to years are the definitions of the various events as well as the definition of the effects obtained. Thus, observers may either have observed more disturbance cases from the preceding year or have different perceptions of disturbance. As both studies registered all disturbances, it supports the former possibility. Furthermore, our awareness of disturbance is also different from the one of a seal. For instance, seals are less aware of airborne sounds than human (<10 KHz) (Richardson, 1995). Also, sandbank 1, 2, 3, and 4 are very far away from the observation point. Not all audible harassments are perceived by the researchers. Therefore, not all disturbance events are recorded, although the authors think most of them are.

Disturbance is determined by random events. It would be very rare to have the same event happening at the same time, date and place a couple of years in a row. It is very possible

that the number of occurring disturbance events has increased in one year. The disturbance events this year was higher than the past years. People wandering about in the Dollard area, boats, airplane traffic and other factors have probably amplified. This aspect should be kept in mind for further research in the Dollard as human activities are expanding.

This research and the one from last year have demonstrated the disparity of effects that have been triggered by an event. This usually depends on one individual seal and time. Other studies have come to the same conclusions. For instance, Terhune and Almon (1983) (in Suryan, 1999) reported that the response to disturbance was different from group to group. Suryan (1999) described that the reactions were influenced by the "different levels of tolerance among age, sex, or reproductive status"; and they diverge "within and among regions". Moreover, Born (1999) found that the probability for a seal to run into the water depends on "the time of day, the relative direction of the wind and the wind chill". Seals are more apt to enter the water during high wind condition and in the afternoon when the temperature is the highest (between 14h00 and 18h00) (Born, 1999). Suryan (1999) also noticed that they were more readily to escape during afternoon haul out period, as well as during high temperature (not bearable for the seals) and during rain.

Another factor is pupping season. Indeed, Newby (1973) (in Suryan, 1999) noted that a female harbour seal with a pup was "constantly alert and nervous". Also, Suryan (1999) observed that seals were more disturbed at a pupping site. Mums may have a greater tendency to escape to the water with her pup during disturbance. This research aspect should be investigated. Further studies in the Dollard could investigate this phenomenon.

Disturbance is known to have a severe impact on seals during the moulting season and also on pups during the pupping season (Suryan, 1999). In fact, the energy expenditure is firmly increased by human disturbance. A pup leaving to the water with its mother has an shortened time suckling and encounters an energy loss from swimming (Suryan, 1999; Bowen, 1993).

Recovery of seals after harassment would be interesting to measure. Suryan (1999) detected that seals would all come back before low tide. In their study, he found that only 39% of all harassment encountered full recovery. Some seals were more tolerant, while some left the area where the disturbance had occurred. They also noticed that seals which had stayed or which hauled out again during the first disturbance were not as disturbed by a new harassment (Suryan, 1999).

"Head up" is a category which may not be as reliable to determine disturbance. Indeed, seals naturally lift their heads up when stretching or when they wake up. Thus, it is important to establish the extent to which it is disturbance. Therefore, a control should be obtained by calculating the mean of "head up" counts on different days and different times when no disturbance is observed. Also, a "head up" should only be counted (if possible) when the seal is actually looking at the disturbance. Stirling (1991) (in Suryan, 1999) observed that vision would trigger the escape response. It can be assumed that in order to be alert ("head up") a seal has to visually detect the disturbance.

Further studies need to examine the various aspects of disturbance in the Dollard area.

4.4. Mother-pup bond

One aspect of the observation of behaviours is the fact that seals were not always differentiated. Therefore, the mother-pup pairs observed were not always distinguished the days after the observations. Also, it was often unclear which pup belonged to which female, especially during the last weeks when orphaned pups constituted a large group.

The nursing period seems to differ from places to places for the common seal (*Phoca vitulina*). In Shetland, Venables & Venables (1955) found that it last 28 days, while Oftedal *et a*l (1987) stated 21 days. King (1983) recorded the period to be four weeks. It seems to be in the line with what we observed, although one of our case studies weaned after five weeks.

Wilson (1974) noticed that mothers and pups were always together but stayed segregated from the rest of the colony. This is what we observed. For instance, the water inlet was a place mainly occupied by females and pups. The mother-pup pair stayed together the whole nursing period. When a pup was on its own, the mother was never seen to come back. Moreover, Renouf (1983) discovered that the pup following the mother fit the general imprinting model and that this behaviour led to the constant proximity of the mother and her young. Wilson (1974) however, observed that the mother was always responsible for maintaining the close relationship with her pup. A third aspect of the subject was the one of Oftedal *et al* (1987), who explained that the bond between mother and pup was formed immediately due to nosing and vocalization. This approach seems to corroborate the one of Peterson & Bartholomew, and Evans & Bastian (1969) who considered "muzzle contact, flipper touching and rubbing" very important. The observations of this research surveyed many physical contacts between the pair. These interactions were present in all activities. Furthermore, mothers tend to protect their pups all the time. Renouf (1983) discovered as well that the mothers were controlling the situation if required and were not tolerant to other pups.

In terms of suckling behaviour, the mothers appeared very fat at the beginning of the study and very skinny towards the end. Also, the mothers never left the pups alone. Therefore, it was deduced that the mothers encountered fasting during lactation. This is what was assumed by Bakker & de Vries (2007) on the same area. In addition, Oftedal *et al* (1987) found that most of phocids experienced fasting. Besides, the observers noticed that both mothers and pups were initiating the lactation process. This is also what Deane (1983) estimated. He observed that both mother and pup initiated and terminated suckling bouts. However, Wilson (1974) found that the mother was always initiating nursing. The former seems true for this research. Another interesting occurrence perceived in this research and calculated by Wilson (1972) is that throughout the nursing period there is an increase of the distance between the pair. The suckling behaviour described by Oftedal *et al* (1987) is the same observed in the Dollard region. The pup initiated the nursing time by approaching, muzzling the female and pushing her side. The mother initiated the feeding time by showing her teats to her pup. The pup suckled one teat for a short period and switched to the other one and so on (Oftedal *et al* 1987).

Accidental fostering is a new discovery in the Dollard. Boness (1992) found that most cases of fostering occurred when the mother had lost her pup. This was essentially caused by the next factors: "high female density, poorly developed mother, female aggressions, and environmental factors (tide, weather)" (Boness 1992). It also resulted from confusion (Boness, 1990). He evaluated this event to happen mainly among young and inexperienced female in the case of elephant seals. Boness (1992) considered fostering to "enhance maternal performance and presumably maternal fitness". Therefore, nulliparous and primiparous females benefit from this (Boness 1992). However, most of the studies concerning fostering show that it has a cost for the parents engaged in it and it is maladaptive (Pierotti 1980, Hebert 1988, Rohwer 1986 in Boness 1990). Accidental fostering was observed only once in the Dollard area this year and not seen at all last year (Bakker & de Vries, 2007). It is therefore a very rare event. Fostering behaviour is not considered to be usual behaviour of the seals of this area.

A couple of orphaned pups were observed. They were looking for their mothers for hours. They would swim from sandbanks to sandbanks and cry all the way as well. This definitely had an energetic cost.

Furthermore, Boness (1992) found that there was a significant relationship between the occurrence of separation and the maternal body size. As the weight increases, the probability to loose her pup before weaning decreases. Also, young females have more risks as well.

Weaning is mostly described as a very abrupt and sudden process (Wilson 1972, Deane 1983, Oftedal *et al* 1987). Oftedal *et al* (1987) stated that weaned pups either remained on the rookery and fasted for several days or weeks, or they left immediately. It was observed for a couple of days that weaned pups lye on a sandbank for the entire tide period. The question whether the weaned pups in the Dollard fast or not should be explored in further studies. It was noticed as well that weaned pups did not interact with each other at first and then started to do so. Wilson (1978) noticed this type of behaviour in Washington. She thought this behaviour was favourable because it allowed them to obtain some foraging guidance from the juveniles. She concluded by suggesting that post weaning movements and social affiliations of pup groups depended on local suitable food and other age groups in the post-weaning period. She also observed that weaned pups tend to stay in the vicinity of the area where they were born (Wilson, 1978).

Conclusion

Throughout the duration of 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 tide cycles. There is a slight difference between haul out sites in terms of percentage of pups on the total number of seals.

Mothers and pups showed a strong attachment, carefully maintained by the mothers using constant physical and vocal interactions. The many occurrences of disturbance clearly demonstrate the effects humans have on this group of seals, which are dependent on this area for the successful rearing of their pups. The separation of mothers and pups caused by disturbance has an impact on the pup survival. This is an important factor to consider in terms of conservation management in order to increase the pup survival and to minimize the suffering of individual seals.

Recommendation

This area is ideal to carry on research on seals as well as for people to learn about seals. However, it is important to avoid human disturbance. Since the seals are so close to the dike, they are easily reachable. This forces the seals to abandon the site; this is especially true during the suckling period. Informing and explaining this problem to the visitors is essential in order to prevent any causes of disturbance.

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Appendices

Movements patterns

On the daily graphics it is possible to see how on certain sandbanks all at once the number of seals decreases and before high tide increases again. At the same time on an other sandbank the number of seals increases during the central part of the low tide period and decreases soon after. This does not happen randomly, but it is repeated with the low tide.
For instance, the following daily graphics that can be compared with table 5: