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Original Investigation

Response of common seals (*Phoca vitulina*) to human disturbances in the Dollard estuary of the Wadden Sea

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We dedicate this paper to the memory of our colleague Renske Hekman (1981–2011) who studied the seals in the Dollard in the summer of 2010.

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ABSTRACT

The Dollard area is a core breeding area of common seals, *Phoca vitulina*, in the Dutch Wadden Sea. Seals mainly use this area in the birth season, and it is at this time that mother and pup pairs are prone to disturbance. Seals in the Dollard lie on sandbanks close to the dyke area which exposes them to various human activities on land and in the coastal waters.

The colony of common seals on the sandbanks of the Dollard has increased from 77 individuals in 1993 to 332 in 2010. Observations were made during the pupping and lactation seasons in 2007, 2008, 2009 and 2010. In total, 692 h of observations were made over the last 4 years, and a total of 1329 potential disturbances were recorded. Human activities were more frequent on land than on water or in the air. In total, most disturbances were also recorded as arising from land. Actual disturbances of seals were recorded 344 times; seals were alerted 249 times and seals escaped into the water 95 times. An escape response was observed for 81 of the 1037 (7.8%) recorded land activities, 6 of the 92 (6.5%) recorded water activities, and 8 of the 200 (4%) air activities. These percentages of escape responses did not differ significantly between the land, water and air activities.

The construction of a culvert in the dyke in 2001, and the building up of sand ridges along the water flow towards the culvert, provided the seals with an extra place to haul out. Land activities only affected seals resting on these sand ridges which are at a distance of 50–200 m of the dyke. Boats have the potential to disturb seals on all sandbanks of the study area. They affected the highest number of seals per disturbance, with up to 117 animals fleeing into the water. Flying at lower altitudes appeared to cause more disturbances of seals. Therefore, the effect of flying at low altitudes (150–300 m) warrants further investigation.

Disturbances which lead to fleeing into the water create the potential risk of separating pups from their mothers. This may contribute to the high incidence of orphaned pups found in the Dollard region. Yearly numbers fluctuated between 13 and 24 orphans representing a substantial proportion of the seals born in this area (with highest pup counts of ca. 100). In addition to separation, disturbances may also impact the condition of pups if they occur repeatedly during suckling.

The results of this study demonstrate that disturbance is caused by various human activities to a colony of seals using sandbanks close to the mainland. As these disturbances pose a risk that pups become orphaned or are impacted in terms of their body condition, efforts should be made to minimise the effects of human presence.

Introduction

Common seals, *Phoca vitulina vitulina*, typically inhabit coastal waters and are, therefore, prone to human activities. One of their core breeding areas in the Dutch Wadden Sea is the Eems-Dollard estuary (Ries 1999). The sandbanks in the Dollard are located close to the mainland, where various recreational and land management activities take place. Seals in the Dollard are therefore not only exposed to activities on the water or in the air, but also to human presence on the dyke. The peak in recreational use of the Wadden Sea coincides with the birth season of the common seal. Disturbance often results in seals fleeing in to the water, with the potential risk of separation of mothers and pups.

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Both common seals and grey seals, *Halichoerus grypus*, are indigenous to the Wadden Sea, but only common seals haul out in the Dollard area. No observations of grey seals have been recorded in the Dollard from present and former studies (Selvaggi 1999). The colony of common seals in the Dollard has increased from 77 individuals in 1993 (Selvaggi 1999) to 332 in 2010 (current study). The number of seals in the Dollard area is highest in the months of May, June and July, which corresponds to the birth season of the common seal in the Dutch Wadden Sea (Van Haaften 1983). The pups shed their lanugo before birth and are immediately able to swim with the mother (Venables and Venables 1955). Pups must acquire adequate fat reserves during the lactation period of four weeks (Venables and Venables 1955; Drescher 1979). Common seals use the land to rest and lactate. The mother and pup pairs typically lie as long as possible on the sandbanks at low-tide, thus maximising the total daily nursing time. Mating takes place after the birth season in July–September (Venables and Venables 1957; Van Haaften 1983).

Various human activities take place on the Dollard dyke. These are mainly for recreational purposes and involve pedestrians, cyclists and horse riders. Further, cars and agricultural vehicles use the dyke area. In addition, some disturbances originate from water and air, such as from boats and airplanes.

Anthropogenic disturbance adversely affects seals. Seals are timid animals, and close approach by man, although benign in intent, disturbs them (Bonner 1982). Common seals are most vulnerable during the birth and suckling period when females with their pups are constantly alert and nervous (Newby 1973). At a sign of danger, the mother, usually followed by her pup, will abandon the haul out site and flee into the water. Disturbances can lead to panic-driven rushes to the water by all mothers and pups, in which they are susceptible to become separated. A separated pup will eventually starve.

Stranded seals in distress are admitted for rehabilitation to the Seal Rehabilitation and Research Centre (SRRC) in Pieterburen, the Netherlands. The SRRC stranding network covers the entire Dutch coast (451 km coastline), with the exception of the island of Texel and a stretch of the mainland adjacent to Texel. At present, approximately 300 common and grey seals are admitted to the centre in each year. The seals that undergo rehabilitation are orphaned pups as well as animals which are sick or injured. We record below that between 13 and 24 orphaned pups are stranded along the Dollard coast (Termunterzijl to the German border) and admitted to the SRRC in each summer.

The aim of this study was to investigate the impact of different disturbance factors on a colony of seals which uses sandbanks close to the mainland. All disturbance events were recorded to identify the main sources of disturbance and the effects they have on the seals.

Material and methods

The Dollard area is the tidal estuary of the Eems River located in the northeast of the Netherlands. The estuary is the natural boundary between Germany and the Netherlands. The Eems and the Dollard are separated by a peninsula named 'Punt van Reide'. The Dollard area covers an area of approximately 100 km^2. Several sandbanks are located in the southwest of the Dollard, southeast of the peninsula (Fig. 1a). The northern area of the Dollard has a busy shipping lane for the harbours of Germany.

The study area in the Dollard includes several sandbanks which are submerged at high tide (Fig. 1a). The peninsula of Punt van Reide is a protected area with no access. There is, however, open access to the Dollard dyke area for pedestrians, cyclists and horse riders, and limited car access. Cars and agricultural vehicles mainly use the road on the landside of the dyke, but they occasionally drive over the top of the dyke to reach the seaside. Pedestrians and cyclists frequently use the top of the dyke. There is a small path seaward of the dyke which pedestrians or cyclists use occasionally.

A culvert has been built in the dyke 150 m south of the peninsula. Since 2001, the culvert allows access for tidal water from the Dollard into a reconstructed wetland behind the dyke. As a consequence of the tidal current, sand ridges have developed along the water flow towards the culvert (Fig. 1b). These are connected to the mainland and seals have started to use them to haul out on. In this study, these areas were called 'sand ridges' to distinguish

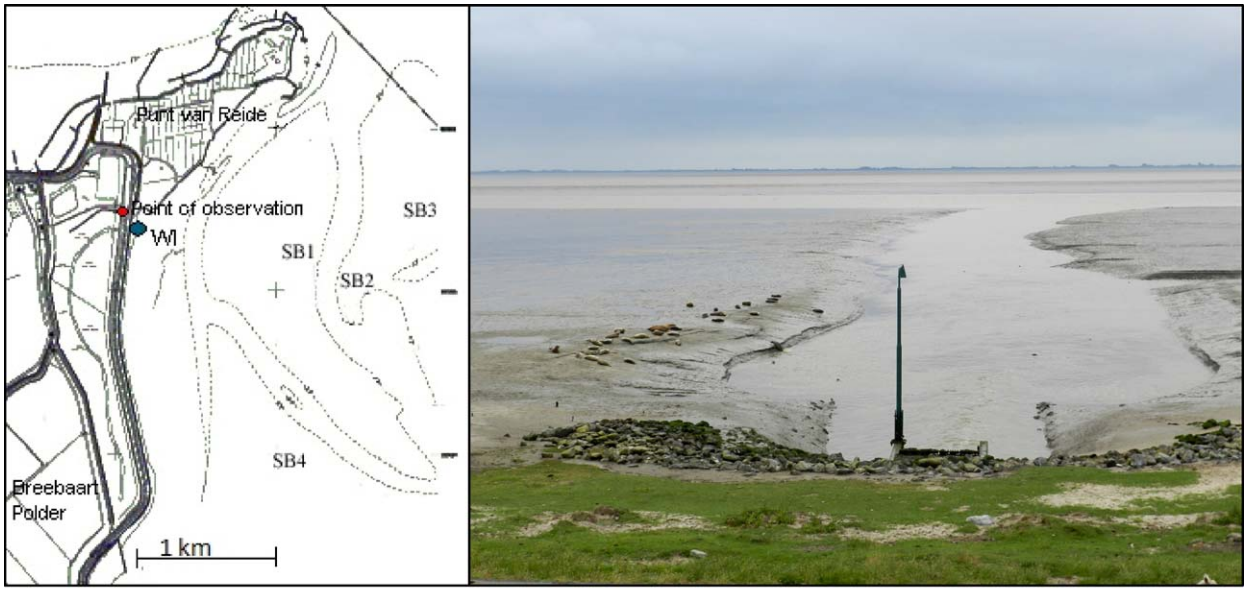

Fig. 1. (a) The Dollard area. Several sandbanks submerge in the study area with low-tide (SB1–SB4). The point of observation is located in the north western corner of the study area. The distance between the observers and the water inlet with culvert (WI) is 115 m. There is a road west of the dyke and a path east of the dyke. (b) The view from the dyke (point WI) on the sand ridges that have developed along the water flow towards the culvert. The distance of the culvert to the nearest seals on the sand ridges is 50 m.

them from the original sandbanks which are surrounded by water (referred to as 'sandbanks').

Part of the Dollard waters is a protected area (Natura-2000 legislation). This area is called Kerkeriet and covers the sandbanks on which the seals haul out. Access is not allowed between May 15th and September 1st. Despite the protected status, small boats sometimes entered the area to sail between the sandbanks. Boats and larger ships also sailed in the shipping lane located north of the study area, but no disturbance effects were detected, and these were not included in the study. Air traffic is allowed above the Dollard area at a height of above 1500 ft (450 m), with a limited number of licences for flights at 500 ft (150 m).

This study combines four years of data collection during the pupping and lactation seasons. Observations were carried out over at least two days a week in the years 2007 (May 21st–July 9th), 2008 (May 26th–July 31st), 2009 (May 30th–July 19th) and 2010 (May 18th–July 18th). Observation was conducted from the top of the dyke 115 m north of the culvert (Fig. 1a). This site provided a good view on the sand ridges and sandbanks included in the study. The distance of the observation point to the nearest seals on the sand ridges was about 120 m. At fixed time intervals (15 min for 2007 and 2008, and 30 min for 2009 and 2010), the distribution and numbers of seals on the sandbanks was recorded. The data were entered on standardised observation forms and excel sheets. In addition, photographic and video records were made. The observation started approximately 4 h before low tide and continued until no more seals were seen on the sandbanks. Total observation time per day was about 7 h. The seals were observed using a telescope and binoculars. Weather conditions were recorded at the beginning of each observation day and every time conditions had changed. The same methods were applied in each year, although used by different observers. The observers remained hidden from the seals and caused no apparent disturbance. For each potential disturbance event, the following parameters were recorded: date, time, category of disturbance, location of disturbed seals, the effect on seals (no effect, alert or going into the water), and the number of seals affected. For sandbanks furthest away from the observation point, it is possible that not all disturbance events were recorded as not all disturbers may have been noticed by the researchers. The calculated levels of disturbances should, therefore, be considered as a minimum estimate.

The actual disturbances were divided into three categories: those originating from land, from water, and from air. The land disturbances were further divided into those resulting from pedestrians, cyclists, horse riders, cars or land management activities (Table 1). Only small boats entered the waters between the sandbanks of the protected area. The observed aerial vehicles were propeller and jet aircrafts as well as helicopters.

Disturbances lead to two levels of effects on the seals: they become alert or they enter the water. Alertness includes various behaviours: head lifting, agitation and movements towards the water. If one disturbance event led to seals escaping into the water with an additional number of seals becoming alert, then the most serious disturbance (seals into the water) was recorded for this particular event. When a potential disturbing agent was detected, the observers focused on the seals closest to the event. Aerial vehicles and boats can affect seals on all sandbanks, whereas land activities particularly affect seals on the sand ridges along the water flow to the culvert. If groups of pedestrians, cyclists, or horse riders were seen, disturbance was recorded per group of persons and not per person.

Data analyses was performed to study: (1) the frequency of disturbance per disturbance category (2) the effects on seals (seals becoming alert or entering the water), (3) the number of individual seals disturbed per event, and (4) differences between the four years of study. Suggestions for preventative measures were formulated using the results.

Results

There was a strong seasonal fluctuation of the numbers of seals present in the Dollard. Their numbers were highest during the pupping season and peaked in the second half of June. The numbers fluctuate over the observation days and were highest around low tide. The highest total number of seals (adults, juveniles and pups) observed in this area was 246 in 2007, 261 in 2008, 282 in 2009 and 332 in 2010 (Table 2). The highest number of pups observed in the area was 82 in 2007, 89 in 2008, 103 in 2009 and 67 in 2010. A portion of the seals in the Dollard use the sand ridges which originated along the water flow to the culvert.

Effect of different types of disturbance

692 h of observations were made over 2007–2010, and a total of 1329 potential disturbances were recorded. 344 actual disturbances of seals were recorded: seals escaped into the water 95 times and were alerted 249 times. Thus, disturbances frequently led to seals entering the water (0.14 disturbances/h) or being alerted (0.36 disturbances/h). This means that as a result of disturbance, seals entered the water once every 7.3 h and were alerted once every 2.8 h. The highest incidence of disturbance was recorded in 2008 (Table 2).

Of all human activities, those on land most frequently led to an escape of seals into the water (81 of 95; 85.3%; Fig. 2). Of the 1037 recorded land activities that potentially could disturb the seals, 81 (7.8%) actually led to seals entering the water (Fig. 2). Seals were alerted 153 times (14.8%) and no effect on the seals were observed in the remaining 803 cases. Land activities only affected seals on the sand ridges, and therefore, have the potential to disturb up to about 80 animals (Table 2). The actual number of seals that fled into the water per disturbance event was on average 5, reaching a maximum of 36. Similarly, an average of 4 seals (max. 31) became alerted.

Table 1
Definition of the different types of disturbances.

Categories of disturbance	Description
Land	
Pedestrians	People who walk, stand or sit on the top of the dyke, on the landside of the dyke, on the seaside of the dyke or on the protected area of 'Punt van Reide'
Cyclists	People cycling on the landside of the dyke, or on top of the dyke
Horse riders	Any person riding a horse on the landside of the dyke
Cars	Cars and cars with a trailer driving on the landside of the dyke, or on the top of the dyke
Land management	Any type of agricultural vehicles such as grass mowers, tractors and vehicles (larger than a car) with a trailer driving on the landside of the dyke, or on top of the dyke
Water	Boats sailing near to the area of the sandbanks
Air	Airplanes including propeller and jet aircraft and helicopters

Table 2
Comparison of the four survey years.

	2007	2008	2009	2010
Highest number of seals observed in Dollard area	246 (June 22)	261 (July 2)	282 (June 20, July 14)	332 (June 22)
Highest number of pups observed in Dollard area	82 (June 20, 22)	89 (June 30)	103 (June 20)	67 (June 17)
Highest number of seals on sand ridges	49 (July 9)	78 (July 14)	68 (July 14)	47 (June 22)
Highest number of pups on sand ridges	18 (July 4)	41 (July 13, 14)	30 (July 14)	26 (July 8)
Frequency of seals going into the water (disturbances/h)	0.11	0.26	0.080	0.086
Frequency of seals alert (disturbances/h)	0.20	0.85	0.14	0.21
Orphans stranded in Dollard	16	23	13	24
Orphans stranded along Dutch coast (excl. Dollard)	67	65	58	89

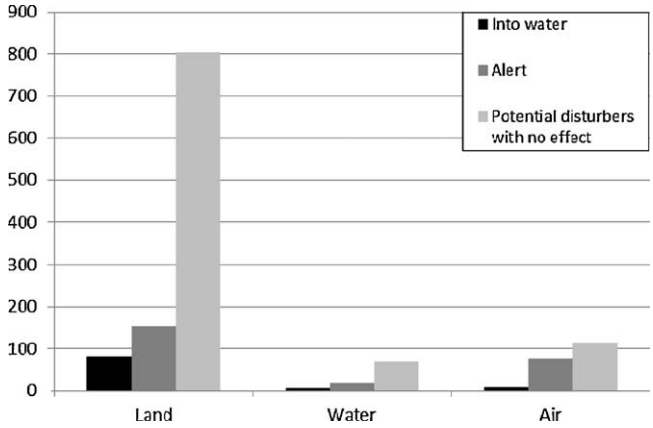

Fig. 2. Total number of disturbances per category (2007–2010).

Of the land activities, pedestrians most frequently led to an escape of seals into the water (65 of 81; 80.2%; Fig. 3). Pedestrians walking on top of the dyke are at 50–200 m from seals on the sand ridges. These pedestrians often, but not always, caused disturbances. Those walking on the path, seaward of the dyke can approach the seals to a distance of less than 50 m, and always caused disturbance. Pedestrians sometimes walked in groups on the dyke but their number was not related to the number of seals disturbed. Land activities only affected seals resting on the sand ridges and had no impact on animals on the sandbanks, these are at a distance of more than 800 m from the dyke. The observations also revealed that sudden movements by pedestrians, as well as loud noise, are likely to increase the effect on the seals.

Another category of land activities, the cars and agricultural vehicles disturbed seals when driving over the top of the dyke. Also driving over the cattlegrids in the roads on the landside of the dyke lead to loud noise and disturbed the seals.

Disturbance from the water comes from (yachts and) small boats sailing in between the sandbanks of the study area. Of the 92 recorded water activities that potentially could disturb the seals, 6 (6.5%) actually lead to seals entering the water (Fig. 2). Activities on the water have the potential to disturb the seals on all sandbanks, that is up to about 330 (Table 2). The actual number of seals that fled into the water per disturbance event was on average 23 with a maximum of 117. Similarly an average of 10 seals (max. 132) became alerted. Thus, water activities can affect a high number of seals.

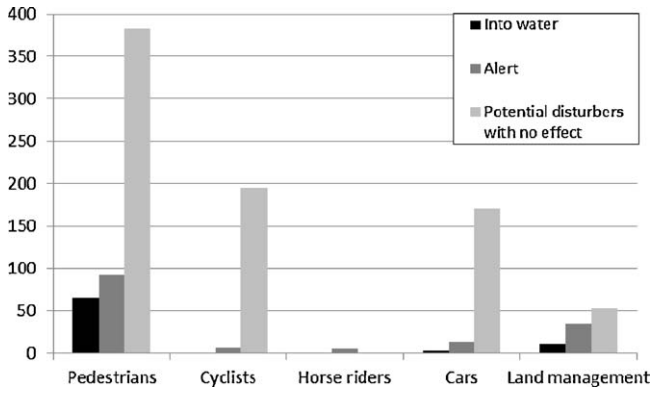

Fig. 3. Total number of disturbances from land per category (2007–2010).

Of the 200 recorded air activities that potentially could disturb the seals, 8 (4.0%) actually lead to seals entering the water (Fig. 2). Activities in the air have the potential to disturb the seals on all sandbanks, that is up to about 330 (Table 2). The actual number of seals that fled into the water per disturbance was on average 12 with a maximum of 28. Similarly, an average of 5 seals (max. 125) became alerted. From the observations, it appeared that flying at lower altitudes caused more disturbance of the seals. The only incidental data available on the effect of flying height is that of aerial surveys of the SRRC in the summers of 2009 and 2010. Surveys were conducted at a flying height of approximately 300 m. No effects on seals were detected by the observers on the dyke, other than alert behaviour of a limited number of seals.

In the Dollard, human activities on land were more frequent than human activities on the water or in the air. Consequently, disturbances of seals in the Dollard most often originate from land. No difference was found for these three categories in the rate of escape into the water (overall, 4.0–7.8%).

Yearly fluctuations

The highest recorded level of disturbance was in 2008 (Table 2) when seals escaped into the water at a rate of once every 4 h (0.26 d/h), and were alerted almost once every hour (0.85 d/h). The number of seals hauling out on the sand ridges was also highest (78) in 2008.

Discussion

The maximum count of seals using the Dollard area increased over the four study years. The number of pups was highest in 2009. The highest pup counts are likely to be an underestimate of the total number of pups born in the Dollard area, since the pupping is not fully synchronous and some pups may have been missed. According to Venables and Venables (1955), the pupping season for common seals on Shetland (UK) is extended over three weeks. An underestimate may also be due to pups stranding and being admitted for rehabilitation, thus reducing the total number of pups present. Seals in the Dollard area are mainly mothers and pups. It is interesting to note that on the days with the highest counts on the sand ridges (July 13 and 14, 2008), there were more pups than adults. This is most likely an aggregation of weaned pups at the end of the lactation period. In all four years, males were observed to arrive in the beginning of July.

Effect of different types of disturbance

Most disturbances in the Dollard came from the land. Land disturbances are mostly due to pedestrians who unintentionally disturb the seals. This also occurs in other parts of the world where people can walk close to haul out sites, e.g. for common seals in Glacier Bay, Alaska (Lewis and Mathews 2000) and harp seals (*Phoca groenlandica*) in the Gulf of St. Lawrence, Canada (Kovacs and Innes 1990).

The distance of the event from the seals has been observed in other studies to be an important factor in the response of the seals. Human activities closer than 100 m caused common seals at Bolinas Lagoon, California, to leave the haul out sites more than activities at greater distance (Allen et al. 1984). Our study shows that pedestrians at a distance less than 50 m from the nearest seals always led to disturbance, those at 50 to 200 m frequently, but not always, led to disturbance and those at a distance of more than 800 m had no impact on the seals.

Disturbances by boats are not frequent in the Dollard due to its protected area status. However, if boats do enter the area, they have the potential to disturb many seals (up to 100). In 1993, before the protected area had been established, fishing boats frequently disturbed seals in the Dollard, with seals being disturbed into the water, on average, once every three observation days (Selvaggi et al. 2001). For many areas in the world, boats are the main cause of disturbance to common seals, e.g. for San Juan Islands, Washington, USA (Suryan and Harvey 1999), Yellow Island, Washington State, USA (Johnson and Acevedo-Gutiérrez 2007), the Gulf of Maine (Lelli and Harris 2001), Métis Bay, Saint Lawrence Estuary Québec, Canada (Henry and Hammill 2001), Bolinas Lagoon, California (Allen et al. 1984). Boats are also one of the main causes of disturbance in the unprotected areas of the Dutch Wadden Sea. Reijnders (1981) reported that seals in the Wadden Sea are often forced to leave the tidal flats when disturbed by boats. Studies of common seals in the Oude Lauwers (eastern Dutch Wadden Sea) concluded that boats used for professional purposes were the main cause of disturbance in 1978 (Doornbos 1980) and boats used for recreational purposes the main cause in 1979 (Van Wieren 1981).

Disturbances by aerial vehicles are not frequent in the Dollard. They appear to disturb seals by the sound they produce rather than by the visual observation of the vehicles. Born et al. (1999) found the escape response of ringed seals (*Phoca hispida*) to be related to the type of aircraft, with a stronger response to helicopters than to fixed-wing aircraft. Their results also indicated that the risk of scaring seals into the water can be substantially reduced if small helicopters do not approach them closer than 1500 m, and small aircrafts not closer than 500 m. We found that small aircrafts flying at a height of 300 m does not lead to seals leaving their haul out. The effect of flying at altitudes of 150–300 m warrants further investigation.

Yearly fluctuations

The highest frequency of disturbance was recorded in 2008. This could be caused by the high number of seals hauling out on the sand ridges, and consequently a high number of seals being exposed to activities on land. It is interesting to note that the number of orphaned pups found in the Dollard area was also high in 2008, suggesting that more disturbance leads to higher stranding rates of pups.

The level of recreational activity varies between years and may have influenced the level of disturbances. The weather conditions are an important factor for the level of recreational activities, but also the school holiday planning could be of importance. Furthermore, observer difference may have played a role, for example, influencing the recording of the number of alerted seals. It is considered unlikely that observers missed a disturbance which caused seals to enter the water.

In the spring of 2009, drilling activities started in the harbour of Eemshaven, at the entrance of the Eems-Dollard area. Brasseur (2007) suggested that the drilling might influence the migratory behaviour of seals. If this occurs in the Eems-Dollard it should be detectable in the number of seals on the sandbanks during summer months. However, the number of seals observed in the summer of 2009 and 2010 were higher than in earlier years.

Mother–pup bond

A continuous mother–pup bond was observed in the current study. Mothers and pups remain close to each other, both when on land and in the water. We did not observe any mothers swimming away to forage, and thus leaving their pups on sandbanks. This is consistent with earlier studies in the Wadden Sea (Van Wieren 1981; Doornbos 1980). The behaviour of the mother and pup during the lactation period seems to vary among common seals in different habitats. On the one hand, there are populations showing a very strong and continuous bond between mother and pup; these include the populations in the Humboldt Bay, California (Knudtson 1975), the Shetlands (Venables and Venables 1955) and New foundland, Canada (Renouf et al. 1983). On the other hand, there are other populations in which the mothers leave their pups on the haul out and move out to sea to forage. This has been observed in Maine, USA (Wilson 1978). The strong mother–pup bond of common seals in the Wadden Sea may be explained by the geo-physical properties of the area. The Wadden Sea is a shallow sea with strong currents and sandbanks which are submerged during high tide. There is simply no place to temporarily leave the pup.

Impact on seals

Each disturbance implies a risk of separation for mother and pup pairs. This is probably more likely to occur when disturbances lead to panic-driven rushes to the water of many mothers and pups. The current study showed that in cases of disturbance, mother and pup pairs are the first to flee into the water. The actual moment of separation between mother and pups could not be observed because disturbances usually lead to panic of seals and the quick disappearance of the animals. The seals are difficult to distinguish individually and can only be seen for a short time once in the water. Because of the strong tidal currents between the sandbanks, mothers and pups can become well separated within a short period of time.

In the Dollard region, pups were regularly observed without their mothers. Lone pups vocalize and move on to land or swim in a circular pattern. They tended to haul out mainly at the sand ridges. Lone pups were observed for multiple hours before they were rescued, and no examples of reuniting with the mother were observed. Mothers only allow their own pups to suckle (although it was observed incidentally that pups suckled by other sleeping mothers). Orphaned pups were never taken care of by other mothers in the area.

The number of orphans admitted to the SRRC from the Dollard region (Termunterzijl to the German border) has fluctuated between 13 and 24 animals per year. This is a substantial proportion of the seals born in this area, with highest pup counts of about a hundred animals. The orphaned seals from the Dollard also comprise a substantial proportion of the total number of orphaned seals admitted for rehabilitation which along the whole coast has fluctuated between 71 and 113 seals annually for the period 2007–2010. The average weight of seals admitted for rehabilitation was 11.9 kg ($n = 76$), which is just above the average birth weight of 8.7 kg (Härkönen and Heide-Jørgensen 1990). Pups of this weight depend

on their mother for nutrition and would starve to death if not rescued.

The Eems-Dollard estuary is an important region for the common seal population, since it is one of the core breeding areas in the Dutch Wadden Sea. We did not find an adverse effect of the scale of human disturbance on the growth of the number of seals in the area over the studied period. However, it needs to be considered whether such an effect could have been masked by the rescue and release of stranded orphans, which has a positive effect on recruitment levels and population growth (Osinga and 't Hart 2010).

In addition to separation, repeated disturbance will have negative energetic consequences and may be detrimental for the condition of pups. The survival chance of pups depends largely on an undisturbed nursing period, and/or the nutritional status at the end of the time (Drescher 1979). For the German Wadden Sea, Drescher (1979) found that disturbances particularly impact young seals. Because of frequent disturbance, mother and pup spend much time in the water at low tide, during which only limited time is available for suckling and resting of pups on land. Also Reijnders (1981) wrote that disturbance by boats in the Wadden Sea results in less time for nursing and resting. Disturbances on harp seals by tourism in the Gulf of St. Lawrence (Canada) were found to decrease the time females spent nursing their pups and to decrease the resting time of the pups (Kovacs and Innes 1990). We observed that seals were reluctant to haul out again after being disturbed, and that usually there was only a partial recovery of the numbers on the sandbanks. Selvaggi et al. (2001) found that in the Dollard during the birth season in 1993, 75% of the seals that had left the sandbank did not return during the same low tide period. Although it is possible that seals will eventually haul out on a different sandbank, such movements will certainly reduce the time available for suckling and resting. It is uncertain whether seals can compensate for the loss of lactation time by additional suckling in the water. Hewer (1974) and Venables and Venables (1955) have observed suckling in the water during the initial days after birth and have related this to the difficulty for small pups to come ashore on the rocky coast. We have never observed any suckling behaviour of pups in the water in the Dollard region; small pups also appear to have no difficulty in coming ashore on the sandbanks. Uncertainty exists about the seals behaviour at night, although we assume seals can haul-out undisturbed during the low tide periods at night.

In contrast to common seals, grey seals give birth further away from the coast, usually on sandbanks in the tidal outlets between islands. Grey seals give birth in the winter when recreational pressure is low. Therefore both the location and the season of birth of grey seals, implies a much lower level of human disturbance than for common seals. However, grey seal pups are vulnerable to severe weather. With extreme weather conditions the sandbanks on which grey seals pups (with lanugo) are born become submerged. Mothers and pups, as well as lone pups, are then washed up on, or move to the beaches of the Wadden Sea islands where they are frequently disturbed by pedestrians and cars.

Protection of the site

As a consequence of the construction of the culvert in our study area in 2001, the developing sand ridges along the water flow provided the seals with an extra place to haul out. Generally, seals prefer to haul out on sites with direct access to deep water, permitting an easy escape. The sand ridges indeed provide this. Another advantage of the sand ridges is that they are submerged for a much shorter time at high tide, giving the seals a longer time for resting and lactation. However, human presence on the dyke area creates a substantial pressure on seals using these sand ridges. The building of the culvert has therefore indirectly increased the level of disturbances on seals. Furthermore, there is an increased risk of disease transmission between seals and other mammal species on the sand ridges connected to the mainland. We have observed both sheep and foxes on the sand ridges.

Management actions to minimize disturbance should be taken. Pedestrians never intend to disturb the seals, and are usually unaware of their potential effect on seals. We hereby list a number of recommendations to minimize disturbance of seals. First, we propose closing the seaside of the dyke area for the pupping and lactation period. The placing of an observation screen on the dyke could then provide people the opportunity to observe the seals. Second, we propose to minimise land management activities during the pupping and lactation period. Third, we suggest a speed reduction for cars and agricultural vehicles driving over the road at the landside of the dyke. Boats have the potential to disturb many seals if they enter the protected area and sail in between the sandbanks. This finding stresses the importance of maintaining the protected area. The effect of flying at altitudes of 150–300 m warrants further investigation.

Conclusion

The results of this study reveal the effects of human presence on a colony of seals close to the mainland. Seals hauling out on the sand ridges close to the mainland are most vulnerable to disturbances, especially to those resulting from pedestrians on the dyke area. Future management actions should reduce the impact of human presence. Undisturbed mother–pup resting and suckling is of utmost importance for successful rearing of young common seals. Improved conservation of seals in the Dollard area will have a positive effect on recruitment levels and population growth and will prevent the suffering of orphaned seals in distress.

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