

Green light to birds

Investigation into the effect of bird-friendly lighting



NAM LOCATIE L15-FA-1

DECEMBER 2007

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Management summary

May 2007, the external radiating light sources on gasproduction platform L15, have been exchanged for a special made light source - low in spectral red. L15 is situated in the North Sea, about 20 km Northwest of the island Vlieland.

The environmental effectiveness has been determined during the bird autumn migration, between October 5 and 8, 2007. Dense flocks of songbirds, wader birds and ducks were observed. Also some co-migrating owls were seen. Weather conditions, to assess the impact of the new lighting were extremely favourable: light fog and almost complete cloud cover.

The observed species and numbers were compared with assessments from previous years. Periods of comparable weather conditions were selected and the same observer was employed in order to assure full comparability of assessment techniques.

Based on this comparison it is concluded that 2-10 times less birds are negatively impacted (circling around the installation for a prolonged period of time) by the new light source as by the original standard white (tube lights) and orange (sodium high pressure lights) lighting. Also the number of birds actually landing on the platform was decreased.

The negative impact on birds therefore was significantly reduced.

For technical reasons, a limited number of light sources was not yet replaced during our observation period. The presented results are underestimating the effect if all external lights would have been replaced.

It is also concluded that a North Sea wide approach would be needed and that application of this new light source could reduce the number of impacted birds from about 6 million to less as 600.000.

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1 Introduction

Over the course of the last fifteen years, the Dutch natural gas producer NAM (Nederlandse Aardolie Maatschappij) has commissioned various studies into the reactions of birds to gasproduction installations. These studies have been conducted both on land and at sea. The research shows that birds respond to these installations in many different ways. At sea, some species benefit from them. For example, they provide a place for sea-gulls, Eider ducks and scoters to rest and gather. Moreover, a lot of food can be found around the platforms, which is why sea-gulls, Auks, Cormorants and seals are often seen fishing there, both in the day and at night.

The platforms can also have a negative influence, especially on songbirds, waders and a number of ducks, which results in flying around the platforms during the autumnal migration. Most of the species are migrating at night. In the autumn of 2000, the cause for this circling was determined experimentally at NAM platform L5-FA-1, by actively switching off and on the lights on the outside of the platform. After the lights were switched on, birds accumulated around the platform in the thousands within 20 minutes; after switching off, all circling birds (several thousands) left within a few minutes. No further influence on the birds' behaviour could be found. This proved that artificial light causes the birds' nocturnal circling around platforms (1). This behaviour is mainly – if not only - observed during nights with fog and/or >80% cloud cover.

The impact of lighting was estimated to extend to 3-5 km around the installations. Based on the density of platforms in the North Sea, it is virtually impossible to cross without encountering 2-10 platforms (see Figure 1). Based on the weather conditions during migration, this concerns for the North Sea about 6 million birds and worldwide several billions.

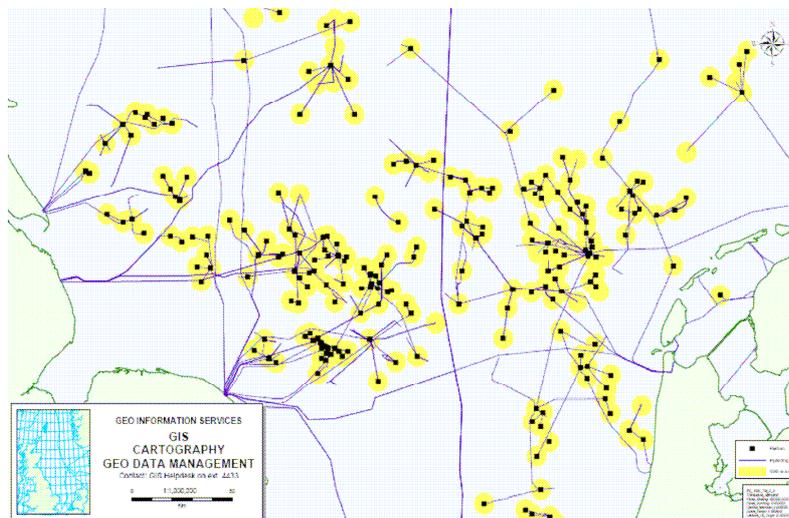


Figure 1. Map of the southern section of the North Sea with existing production platforms (2007). Also indicated the potential impact zone of 5 km (in yellow).

Considering birds respond differently to different colours of light, research looked at whether some primary colours could decrease the number of circling birds. This study was done on the eastern point of Ameland and in Germany. It showed that the birds' geomagnetic compass is upset by the red part of the spectrum (2). This at last explained why birds do not accumulate around platforms during clear nights, but only during cloudy nights and with fog. It also explained why birds leave the platform at the first onset of dawn.

With the outcome of the research, NAM contacted Philips. In close cooperation, both companies jointly developed an effective new type of lighting. They had to take into account the birds sensitivity for this part of the spectrum, but also the human safety conditions on the platform. It took 2 more years of tests on the NAM land-gasproduction site on the coastal island Ameland, to determine the most promising spectrum for

offshore application. This included taking into account significant contrast with the future helideck perimeter lighting. Finally, in May 2007, many of the lights shining outwards at NAM production platform L15-FA-1 (some 20 kilometers northwest of Vlieland) were equipped with these specially designed lights with a low-red spectrum (see Figure 2).

The effect of this new lighting on migrating birds was assessed over the course of three nights in the autumn of 2007, viz. Friday 5 October to Monday 8 October 2007. The results of this study are discussed in this report.

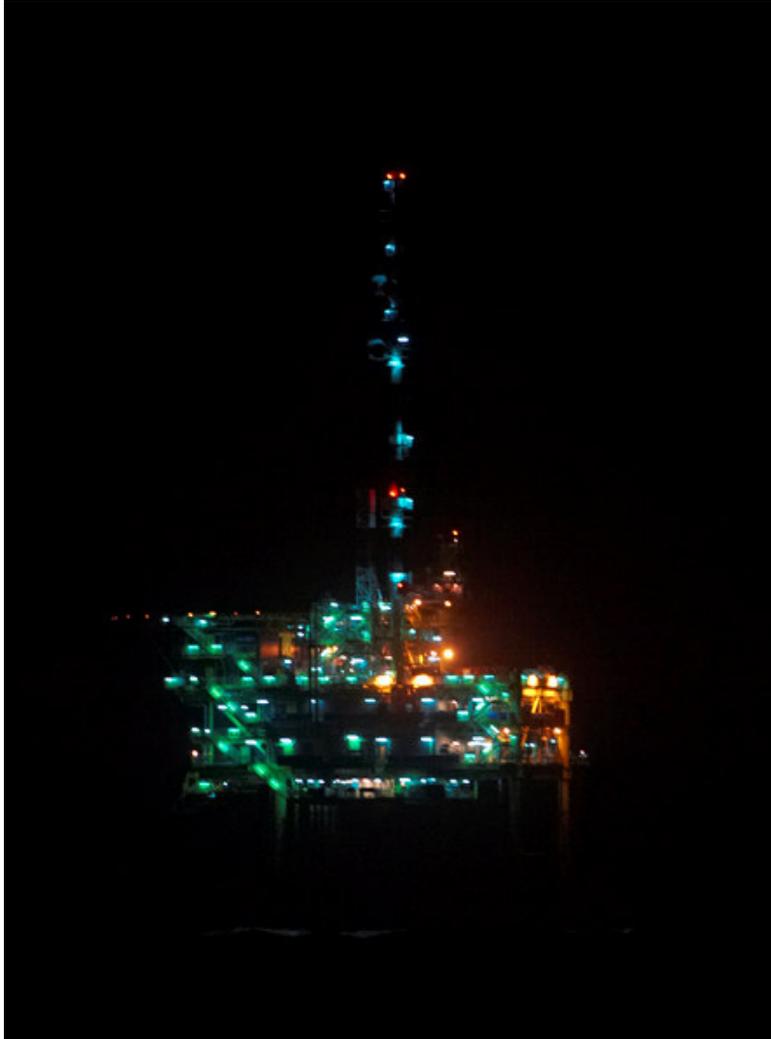


Figure 2
A photograph taken from a ship of the platform L15 (August 2007). The two sets of floodlights on the outside of the main deck were switched off during this study. The lighting not yet replaced in the centre of the plant and on the lowest deck is visible.
Photograph Johan Krol

2 Influence and description of light and sound

2.1 Consequences of circling for the birds

The time individual birds spend circling a platform is usually hard to determine, but it tends to range from a few minutes to several hours. The average time birds spend circling a platform is probably around 15 minutes.

It is virtually impossible to cross the North Sea without encountering a platform. The number of platforms birds meet on their crossing is between 2 and 10, depending on their flying routes.

A small number of birds normally actually lands on a platform. There are usually no or only very few birds perched on the platform. In times of intensive migration, however, the number of birds per platform quickly runs into several hundreds a night and an installation can become rather covered with birds. A small number of these birds continue on quickly, but many stay for hours or even days.

The most important adverse consequences of this for the birds are:

- Energy wasted while circling the platform:
 - A lack of energy prevents the birds from crossing the North Sea;
 - Birds that spent time on a platform have less energy left when they arrive on land (is weaker), so it will have to take longer to replenish its energy levels for further migration to the wintering grounds (autumn migration) or breeding grounds (spring migration);
- Some birds smash into the platform and die or land and stay around for a very long time. These animals likewise usually die, as there is no drinking water or food.
- Birds become prone to predation.
 - Bird flocks are often accompanied by birds of prey and are an easy catch. Sea-gulls are experienced hunters in daytime. Birds that leave the platform at dawn or during daytime are an easy prey.

2.2 Effects dependent on the level of brightness

The research of 2000 showed that the degree in which the birds responded to the light was not just dependent on the weather, but also on the amount of light. The table below (table 1) outlines the correlation between the intensity of the light and the influence on the behaviour of birds. It shows that a limited amount of light that is not directly visible has little effect. If a similar amount of light is placed where birds can immediately see it, the influence clearly increases (see also figure 1). The influence increases dramatically once the intensity of the light exceeds a certain level.

Table 1. Comparison of levels of brightness and influence on birds.

INTENSITY OF LIGHT	NUMBER OF BIRDS	INTERPRETATION
Beacon and obstruction lights (300 W)	None	This level of brightness is inconsequential
Light in crane (1500 W)	Small number	Bright lights shining outward, albeit to a limited extent, has some influence on birds
Light in crane, beacon and obstruction lights		
Light in crane, on helicopter landing platform (160 W) and beacon and obstruction lights	Limited numbers	Lights in a place clearly visible to birds has a marked, but limited influence
All lights on the helicopter landing platform (incl. landing lights: 480 W)	Numbers clearly increase	Quite a lot of light in a place conspicuous to birds has quite a considerable influence

INTENSITY OF LIGHT	NUMBER OF BIRDS	INTERPRETATION
All lights switched on (30 kWh)	In times of intensive migration, large to very large numbers	Standard lighting of a location has a marked, considerable and prolonged influence

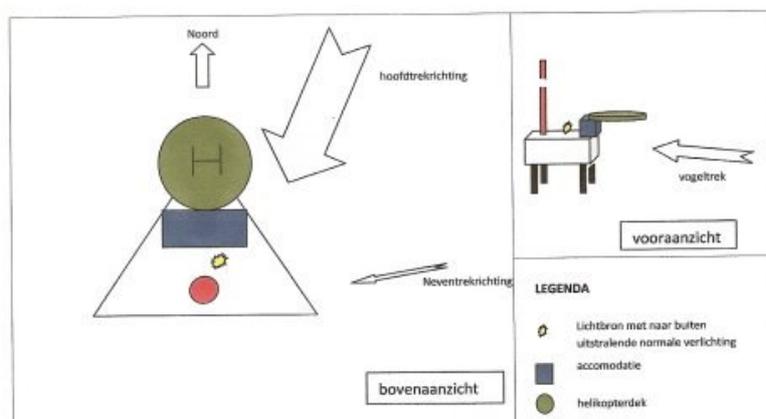


Figure 3
During light experiments at L5-FA-1 (night of 7-8 November 2000), the lights of the crane and floodlights were aimed at the main deck, "hidden" for the birds behind the accommodation.

2.3 New colour of light at the platform during the study

In the course of the study, a total of 152 fluorescent luminaires on the outside of the platform were equipped with the specially designed Philips lights, which have a spectrum low in red. This left still 21 fluorescent luminaires (partly) shining outward in the old/normal colour, as are the lighting on the helicopter landing platform (8 fluorescent luminaires and 20 bulbs), two HPI floodlights aimed at the main deck and one HPI floodlight at the free fall life boat. During the study, the other floodlights of the platform were switched off, and the 8 fluorescent light fittings of the helicopter landing platform were covered most of the night of 8-9 October (see Figure 2, Table 2 and Figure 4).

Table 2. Overview of the lighting of the plant during the study.

Name of deck	Regular lighting (not changed yet)		New lighting
	(partly) shining outwards	aimed inwards	
7 - mast	None	none	10 double fluorescent lights (2*36 W)
6 - Helicopter landing platform	8 double fluorescent lights (2*20 W) 20 low-energy light bulbs	none	4 double fluorescent lights (2*36 W)
5 - Utility deck	2 floodlights (approx 1500 W)	8 double fluorescent lights (2*36 W) light in motor hold crane	5 double fluorescent lights (2*36 W)
4 - Top deck	2 double fluorescent lights (2*36 W)	12 double fluorescent lights (2*36 W)	37 double fluorescent lights (2*36 W)
3 - Main deck	2 double fluorescent lights (2*36 W)	6 double fluorescent lights (2*36 W)	30 double fluorescent lights (2*36 W)
2 - Cellar deck	-light from compression and generator room (via open doors) -4 double fluorescent lights (2*36 W) -floodlight at free fall life boat (400 W)	none	30 double fluorescent lights (2*36 W)
1 - Lowest (subcellar) deck	13 double fluorescent lights (2*36 W)	none	24 double fluorescent lights (2*36 W)
TOTAAL (lamps)	27 double fluorescent lights (2*36 W) 20 low-energy light	26 double fluorescent lights (2*36 W)	140 double fluorescent lights (2*36 W)

Name of deck	Regular lighting (not changed yet)		New lighting
	(partly) shining outwards	aimed inwards	
	bulbs 3 floodlights (400/1500 W)		
TOTAL (Watt)	Around 6150 Watt	1872 Watt	10080 Watt

* No wattage is mentioned on the lights, but they are 36 watt fluorescent light.

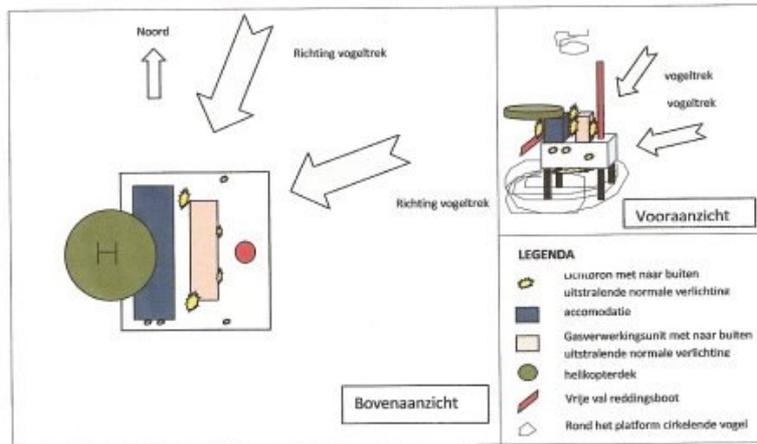


Figure 4
During the research into the newly developed colour of light at L15-FA-1 early October 2007, there was still a fair amount of normal lighting shining outwards.

2.4 Noises from the platform

No prior studies at sea have ever shown a clearly negative or repelling effect of continuous noise from a gas production platform.

3 Influence and description of the weather

3.1 Influence of the weather

Millions of birds cross the North Sea during the spring and autumn migration. The exact moment of crossing depends largely on the weather. The wind direction and wind-force are very important in this respect. When the head wind is very strong, very few birds, and only the strongest flyers, undertake the crossing. In strong winds or even storms, however, there may still be many birds over the North Sea.

On quiet nights, many hundreds of thousands or even millions of birds, of many different species, may be crossing the North Sea simultaneously. There are moments at which even the smallest of migratory birds, such as the Goldcrest, make the attempt.

The migration takes place both in the day and at night. For songbirds, however, flying in the day is much more dangerous than it is at night: the risk of being killed by a sea-gull, for instance, is much higher in the day. Moreover, the weather is more stable and quiet during the night, which benefits migration.

When birds that fly at night pass a source of light, some end up circling that light source. The numbers vary greatly, from none at all to some tens of thousands of birds per night per platform! Prior studies have shown that the numbers that start circling depend as much on the numbers migrating as on the weather. When the sky is clear and visibility is good very few birds respond at all, while thick clouds and limited visibility (only a few kilometres) maximise the response.

Considering the importance of the weather and the major differences in the way birds respond, a precise description of the weather during the study follows.

Description of the weather

Friday 5 to Saturday 6 October 2007

This night, a substantial high-pressure area passes the northern part of the North Sea, moving from the north-west to the east-southeast.

Wind There is a mild wind early in the night. In the course of the night, it subsides to (nearly) completely calm. The wind shifts from E-NE, via the east, to E-SE during the night.

Clouds The cloud cover is complete for most of the night. By the end of the night, there are some breaks in the cloud every now and then.

Visibility Clear all night. By morning, visibility slowly worsens.

Precipitation It is a dry night.

Temperature Friday is a fair and rather warm day at about 17 ° C. After sunset, temperatures drop quickly to some 14 ° C, remaining constant throughout the night. Saturday is again very fair with temperatures reaching 20 ° C.

Saturday 6 to Sunday 7 October 2007

The high-pressure area that passed last night slowly moves from Denmark to north Germany this night. During the day on Saturday, a cold front approaches from the south-east, running from Scotland via the North Sea to all of Sweden. This front passes Sweden and Norway in the day on Sunday.

Wind A mild wind from E-NE in the evening, shifting to SE in the course of the evening. Around 2 AM, the wind subsides but does feel cold. In the course of the night, the wind light but cold wind shifts to the east.

Clouds A dull sky in the evening. The clouds quickly gather and around 9 PM the cloud cover is complete. From 1.30 AM the cloud cover shows the occasional gap, with the odd star peeping through. From about 4 AM, about half to three-quarters of the sky is clouded.

Visibility Visibility is about 4 kilometres in the evening due to a light fog. Around midnight, visibility temporary worsens, to about 2 kilometres. From 2 AM, visibility is 4-5 kilometres, and remains this way for the rest of the night. It clears around half an hour before sunrise (7 AM).

Precipitation It is a dry night.

Temperature When the sun sets after a beautiful day, temperatures quickly drop to about 14 ° C. Just after midnight, they drop even further to about 9 ° C for a couple hours, only to go up again to 12 - 13 ° C. Sunday is yet again a fair day with temperatures reaching 20 ° C.

Sunday 7 to Monday 8 October 2007

In the course of the night, the cold front passes the southern part of the North Sea from north to south. After it passes, a new high-pressure area approaches, which reaches the area between Scotland and the south of Sweden by Monday afternoon.

Wind It is nearly completely calm in the evening, while later in the evening the wind is light from the north-east. In the course of the night, the wind slowly picks up to a moderate force, and shifts towards the NW around sunrise.

Clouds The evening starts off with a dull sky. After sunset, the clouds gather until the sky is partly clouded. Around 5 AM, the cloud cover is complete and will remain so for the rest of the night into the morning.

Visibility The light is hazy just before the sun sets. It clears up quickly, and stays that way until morning. Around 5.45 AM, visibility decreases a little due to some local rain.

Precipitation It is a dry night. Around 5.45 AM, it starts raining, briefly and lightly at first, soon followed by an almost continuous light to moderate rain. From about 7.30 AM it is dry again.

Temperature In the evening, the temperature drops to about 13 ° C. In the course of the night it drops even further, only to go up again. By morning, it is about 12 ° C.

3.2 Birds: observations and numbers

A description of all bird and sea mammal observations is shown below.

Bird and sea mammal observations

Friday 5 to Saturday 6 October 2007

10 to 12 PM: Some ten sea-gulls, mainly Herring gulls, but also Common, Lesser and Great black-backed gulls, are foraging around the platform and regularly catching fish. Seen and heard the odd Redwing, but these are not circling around the plant.

12 PM to 2 AM: A Robin lands, a Blackcap keeps flying. Various Redwings and Song thrushes and the odd Blackbird are circling. Some Redwings and Robins may be flying on without any obvious circling. A Common seal, fishing.

2 to 4 AM: During virtually all of this time, a Great bittern is circling the platform, as are some ten Skylarks and several dozen Turidae (Song thrush, Redwing, Blackbird and Fieldfare). The quick changes in species ratio indicates that the birds are circling the platform only for a short period of time per individual. A Wheatear, a Eurasian woodcock and a few waders are only circling for a very short time. A Dunnock and about fifteen Goldcrests land almost immediately on arrival. A Peregrine falcon, which is clearly familiar with the platform, arrives at 3.38. Possibly due to the arrival of this Peregrine, the circling birds quickly disappear. At 3.50 AM about 10-15 circling birds (some Skylarks and Song thrushes, a Common teal and a Wheatear).

4 to 6 AM: Just after 4 AM the cloud cover breaks a little, which causes a few stars to peep through. Can see and/or hear a Turidae type or a Skylark every now and then (a couple dozen an hour), but no birds clearly circling the plant. Every now and then, a bird flaps about a little near the plant.

6 to 8 AM: The situation does not change for the first half hour. Around 6.30 AM, a Turidae type could still regularly be seen and/or heard, but various Turidae and Skylarks were also circling. Towards the end of the period, a homing pigeon lands. Looked around for perched birds: 3 Goldcrests and 1 Robin. 3 Song thrushes pass and keep flying towards the S-SE.

8 to 09.10 AM: Various Common seals and a Peregrine foraging, 2 Harbour porpoises passing close to the platform. 8 Fieldfares, 4 Skylarks, 1 Song thrush and a female Sparrowhawk passing towards the south-east at some metres over the water. Two Greenfinches and a Chaffinch flying south to south-east land on the platform and fly away immediately. Just after 9 o' clock a Blackbird is chased by a Herring gull. The Blackbird manages to get away at first, but after several other Herring gulls and Black-backed gulls join in the chase, it is forced into the water and eaten.

Saturday 6 to Sunday 7 October 2007

5 to 6 PM: 7 Song Thrushes, 7 Blackbirds, 3 Robins and 5 Fieldfares passing low over the water towards the south, S-SE.

6 to 8 PM: 2 Skylarks and 2 Bramblings perching, found a dead Willow warbler and a dead Garden warbler. There is a Lesser whitethroat perched on the helicopter landing platform.

8 to 10 PM: Immediately after 8, several Redwings, Blackbirds, Song thrushes, Skylarks and a Meadow pipit start flying back and forth at the helicopter landing platform, not (clearly) circling. Heard, but did not see, a Dunlin and a Common snipe. The Peregrine starts hunting from the platform. From 9.27 PM, some 40 (between 35 and 50) birds are circling, including one Short-eared owl.

10 to 12 PM: The number of circling birds changes quickly, and fluctuates between 40 and 200 until 11.10. These are mostly Redwings and Song thrushes, with the odd Fieldfare and 2 Short-eared owls. From 11.10 the number increases to 500, with a peak around midnight of approximately 650. These are mostly Redwings, but the group also includes Song thrushes, Blackbirds, Fieldfares and a few dozen Starlings. The species ratio seems to change very rapidly.

12 PM to 2 AM: The number of circling birds stabilises at around 500 (mostly Redwing, with Song thrushes, Fieldfares, Blackbirds, 2 Short-eared owls and the odd Wheatear). After 0.51 AM I no longer see the owls. The number of circling birds and the ratio of circling species change quickly, which seems to indicate that there are continuously birds joining and leaving.

2 to 4 AM: The number of circling birds steadily decreases in this period. Around 3 AM, the number is fluctuating between 220 and 300. Half an hour later around 180 and by the end of the period only 110 to 120 left. The cloud cover is breaking apart at this time, going from (virtually) complete cover to semi-cloudy. While the ratio keeps changing, the species remain the same. By the end of the period, a Goldcrest takes off from the plant with a near sheer rise. The (new) moon rises as a dark red sickle.

4 to 6 AM: The number of circling birds further decreases from approx. 85 around 4 AM to some 50 around 4.30 and 17 by the end of the period. Otherwise, the same as last period.

6 to 8 AM: The last circling birds have left by 6.48, and the orange glow of the rising sun is clearly visible above the clouds. A Goldcrest leaves the platform only to return soon after. There are 20 Redwings, a few Song thrushes, Blackbirds and Starlings and a Goldcrest on the sub-cellar deck. 3 Song Thrushes, 8 Redwings, 3 Blackbirds, 3 Meadow pipits and 1 Woodcock passing the platform going south to south-east, mostly at a height of about 30-40 metres.

Sunday 7 to Monday 8 October 2007

4.30 to 6 PM: Found a Firecrest and a Skylark dead on the deck. A Wheatear flying away from the plant is chased by a male Sparrowhawk. The Wheatear lands on the lowest deck, the Sparrowhawk keeps going towards the south. Heard a Redwing around 5.23.

6 to 8 PM: A Herring gull killed a Blackbird. Heard a Redwing just after eight and a Robin arrives straight from the north and lands.

8 to 10 PM: No bird sightings (with the exception of the odd gull).

10 to 12 PM: No bird sightings (with the exception of the odd gull).

12 PM to 2 AM: A Robin arrives and flaps around a little towards the north of the platform. Have not seen it since. A Seal naps a little under the platform, dives under every once in a while, and catches a large flatfish.

2 to 4 AM: A few Common guillemots are fishing under the platform.

4 to 6 AM: The clouds gather around 4.30. Around 4.45, the cover is complete and some birds start circling the plant (3 Ducks, 1 Brambling, 1 Turnstone, 1 Redwing and 1 Skylark). A Common seal, fishing at leisure. This remains the same until 5. Then, a Goldcrest passes and a second Seal arrives. A little past five, the amount and species ratio of the circling birds start changing rapidly. The species numbers stay limited to 13 at most. The species observed are Fieldfare (2), Brambling (about 6), Dunlin (2), Redwing (20-30), Blackbird (2), Skylark (4), Turnstone (3), Blackcap (2), Robin (1), Goldcrest and Firecrest (some 6 total), and some species of wader (4).

6 to 8 AM: for a large part of the first hour, there are some 35 to 70 birds circling. Mostly Redwings, with the odd Blackbird, Song Thrush, Robin, Dunlin, Fieldfare and a Common Teal. After that, the numbers dwindle slowly, until only a few Song Thrushes and Redwings are left circling. At 7.20 AM, the last 6 birds gain height over the gas production platform and resume their journey. 8 AM, end of study.

4 Assessment of the intensity of bird migration

4.1 Radar observations and coastal bird counts

In order to assess the influence of the light of a platform, it is important to know how many birds actually pass that platform. However, it is not easy to assess the actual migration intensity at that exact location during studies offshore.

Radar may give a fairly accurate value. However, the birds observed on a radar are usually birds passing at great(er) heights, whereas it is likely that birds passing low over the water are particularly affected by the lights of a platform. This is supported by past studies suggesting that when a large group of birds was detected by radar, the researchers at the platform often saw barely any at all, and vice versa.

There are a number of other possible ways of assessing the migrating numbers. One of these is listening to the sounds of birds passing at a distance. Another is interpreting data of various migratory bird counts, which take place all over the Netherlands (which may be found at www.trektellen.nl). There are two types of observation data, namely visual counting of passing birds, and counting data collected in ringing birds.

This report does not draw on radar data for this research period. Considering the enormous noise generated by the processing of extracted gas (around 120 dB(a)) it was impossible to listen to birds passing at a distance. Also, there were no visual migration counts at an appropriate place near the research location during the study. Fortunately, birds have been ringed both on Vlieland and on Schiermonnikoog during this research period. The data of these counts have been included in annex 1, which also includes the ring data from Vlieland and Schiermonnikoog collected during the 2000 study into the causes of circling.

4.2 Interpretation of the ring data

Birds that travel at night tend to land in the course of the morning. At that point they usually start looking for food right away. In ring studies, these birds are then caught in so-called mist-nets. The interpretation of the ring data rests on the assumption that the number of birds being ringed depends on the number of birds actually present: many are ringed when the migration intensity is high, and few when there is no migration.

A notable advantage of using these count data is that they concern mostly birds that were caught after they had landed and went looking for food, or birds that pass at low altitudes. Far fewer birds that pass at great heights are caught in the nets (so these data match the situation at sea, as opposed to the radar data).

Interpretation of the ring data shows the following:

1. The 2000 study identified a markedly increased number of birds ringed on Vlieland on 3 November (especially Redwings) and 9 November (Robin, Blackbird, Redwing and Song thrush). There was no ringing done on Vlieland on 8 November, while the largest number of birds in the research period, which ran from 2 to 13 November, was ringed on 9 November. There was a sharp peak in ringed numbers (Blackbirds and Redwings) on Schiermonnikoog on 4 November.

These data suggest that there must have been a very intensive to extremely intensive migration near the research location in the night of 8-9 November 2000, and a fairly intensive migration in the night of 2-3 November. The sharp peak was only observed in Schiermonnikoog, so it seems likely that the birds did not travel as far west as the

research location. This also makes it likely that the migration took place mostly from north to south (and much less from east to west).

2. During the 2007 study, both the observations on Vlieland and on Schiermonnikoog show a marked increase in bird numbers on 6 October (Blackbird and Goldcrest), 7 October (Blackbird, Blackcap) and 8 October (Winter wren and Redwing). The peak in early October 2007 is on 2 October. During the research period, large numbers of birds were ringed on Vlieland every day, while the numbers on Schiermonnikoog are average to fair for this period.

On the basis of these data, it is likely that there was a reasonably intensive to very intensive migration near the research location in the night of 5-6 October, and a reasonably intensive migration in the nights of 6-7 and 7-8 October. The data do not suggest a clear direction for the migration. Considering the mild weather, however, it is likely that birds crossed the North Sea both from north to south and east to west.

4.3 Summary of bird observations

Birds were observed every night in the course of the study (see chapter 2). These observations have been summarised in the table below (table 3).

Table 3. Summary of numbers of birds observed on and around the plant during the study.

	Peak number Circling	Total number circling	Number of birds landing
5 → 6 October	10 – 15	150 - 200	20 - 25
6 → 7 October	650	1500 - 2500	30 - 40
7 → 8 October	35 – 40	150 - 200	5 - 10

- The first column shows the peak number of birds observed that night;
- The second column shows an approximation of the total number of birds observed that night and
- The third column shows the number of birds that landed on the plant.

Table 4. Summary of all observations of circling birds during prior studies. The observations have been arranged by month, so the years appear to be in the wrong order.

Research period	Date	Location	Total number circling	Approximate number passing
1 – 12 Oct. 1999	06-10	D 15	150 - 250	Several 1,000s
8 – 17 Oct. 1998	09-10	N 7/3	650 – 700	1,000s to 10,000s
	9-10 in the day	N 7/3	≥ 6,000	10,000s
	11 – 10	N 7/3	100	Several 100s
	13 – 10	N 7/3	50 - 75	100s to 1000s
	14 – 10	N 7/3	25 - 50	100s to 1000s
26 Oct. – 23 Nov. 1992	27 – 10	TEN-1	1,000 – 1,500	1,000s to 10,000s
	29 – 10	TEN-1	300	Several 1,000s
	31 – 10	TEN-1	200	1,000s to 10,000s
2 – 14 Nov. 2000	03 – 11	L 5	40 - 50	A few dozen
	04 – 11	L 5	250 - 350	Several 100s
	05 – 11	TEN-1	45	A few dozen to 1,000s
	05 – 11	L 5	Approx. 250	Several 100s
	06 – 11	L 5	2,250 – 2,750	Several 1,000s
	07 – 11	TEN-1	15	Several 100s
	07 – 11	L 5	80,000 – 110,000	Tens of thousands
	08-11	TEN-1	14	Several 100s
	08-11	L 5	15,000 – 20,000	≥ 10,000
	09-11	TEN-1	20	Several 100s
	09-11	L 5	10	Approx. 10
	10-11	L 5	15 - 20	A few dozen
	15-11	TEN-1	40	100s to 1,000s
	16-11	TEN-1	450	Several 1,000s
	17-11	TEN-1	45	100s to 1,000s
	22-11	TEN-1	10	Several 100s
2 – 13 Dec. 2000	02 – 12	L 15	Indirect observation	≥ Several 1,000s
	03 – 12	L 15	100 - 150	Several 1,000s
	06 – 12	L 15	Approx. 100	100s to 1,000s
	07 – 12	L 15	Approx. 10	A few dozen
6 – 17 Feb. 1993	08 – 02	TEN-2	Approx. 10	A few dozen
	13 – 02	TEN-2	75 - 100	Several 100s
Total number of nights: 87	Total number of nights: 30	Total number of research locations: 7	Average number of birds counted: 3570 - 4790	Several 10 – 100s: 10 100 – 1,000s: 14 ≥ 1,000 – 10,000s: 6

Converted to all the nights in which observations were made, this means that:

- 65.5% of all nights, (virtually) no circling birds were observed;
- 11.5% of all nights, there were several dozen to several hundreds;
- 16.1 % of all nights, there were several hundreds to thousands;
- 6.9 % of all nights, there were several thousands to tens of thousands.

5 Conclusion and recommendations

A large number of the lights shining directly outwards were replaced in the course of the study by the new colour of light (approx. 10 kWh of the approx. total of 18 kWh). Approx. 6 kWh of the regular or yet to be replaced light shines (partly) outward. The normal colour of light also shines through the perforated floors underneath. The fluorescent lights of the helicopter landing platform were covered nearly the entire second night of the study.

The first night of the study shows a reasonably intensive to very intensive migration of birds, the second and third nights show a reasonably intensive migration. All important groups of species are represented in the research period, including the small songbird species. Due to weather conditions, the influence of the light was considerable for nearly all of the first night. The influence reached its peak during the second night. The influence of the light was minor during the first part of the third night due to the weather, but considerable for the last part of the third night.

Table 5, below, summarises the bird data collected in this study. It includes a column with an estimation of the peak amount of birds that would have circled during the time of the study at 100% normal lighting. These estimates are based on prior counts, weather conditions, bird species sighted and ring data.

Table 5. Summary of expected and actually observed numbers of birds.

	Approximate numbers passing	Expected numbers circling at normal lighting	Actual total numbers circling	Expected peak numbers circling at normal lighting	Actual peak numbers circling
5 – 6 October	Several 1,000s to 10,000s	Several thousands (1.500-2.500)	150 - 200	400 to 1000	10 to 15
6 – 7 October	Several 1,000s.	Several thousands (3.000-5.000)	1500 - 2500	1,000 to 1,500	650
7 – 8 October	Several 1,000s.	Several hundreds (750-1,500)	150 - 200	200 to 500	35 to 40

- The first column gives an estimation of the number of birds that passed the location in fairly close proximity during that night;
- The second column gives an estimation of the total number of birds that would have circled all night at normal lighting;
- The third column gives the actual number of circling birds;
- The fourth column gives an estimation of the maximum number of birds that would have circled all night at normal lighting;
- The fifth column gives the actual maximum number of circling birds.

From the perspective of bird protection, it is recommended to prioritise the exchange of all external white and orange lighting for light sources low in red spectrum as tested on L15.

For a more precise assessment of the efficiency it is important to replace the remaining original lighting: the lower subcellar deck; the TL lights of the helideck and the sodium HPI floodlights. Also some luminaires on the second subcellar deck and the main deck need some final adjustment.

New additional observations only are meaningful after the above replacement. The outcome, however, will not change the conclusion of this report of a minimum reduction of impact by 50%.

Based on the knowledge of partial lighting (table 1), it is expected that a reduction of 90% of impact could be achieved.

6 Summarising conclusions

This study took place between 5 and 8 October 2007. Bird migration passing the production platform every night was reasonable to very intensive. Many species of songbirds, various types of waders and ducks as well as a few owls were observed. The weather conditions were very favourable to the study. It was mostly completely clouded with even a light fog for part of the period. Prior studies have shown that these are the conditions under which birds respond to light the most.

On the basis of the intensity of the bird migration and the weather conditions, 2-10 times fewer birds displayed circling behaviour than could reasonably have been expected based on migration and weather conditions. Likewise, the number of birds landing on the plant was markedly smaller than under normal lighting conditions. The disturbance of birds has therefore decreased significantly. A number of lights had not yet been replaced at the time of the study. It is likely that replacing these lights will lead to a further lessening of the disturbance.

Applying these measures all over the North Sea could lower the number of birds disturbed from around 6 million to fewer than 600,000.

The following, more detailed remarks provide the foundation for the above conclusion.

1. There was a considerable bird migration over the North Sea at the time of the study. This is apparent from the researcher's own observations, the ring data of the migration stations and from air force radar observations. A fairly large number of birds and a large number of species passed the platform during the study.
2. The weather conditions were such that the largest possible influence on the birds could reasonably be expected: complete cloud cover and fog during most part of the nights. On the basis of years of observation, one might have reasonably expected tens of thousands of birds. At these times, the influence of lighting is at its most disturbing.
3. A significant number of the lights shining outwards have been replaced with lights with a new spectrum composition without red: another portion (30% of the total capacity, 20% of the fluorescent lights) that shines outwards has not yet been replaced, and therefore retains the regular colour of light. It is likely that the number of birds affected will drop even further when these last regular lights, which are white and orange, have been replaced with lamps with the new spectrum. On the basis of research on production platform L5, which was conducted in 2000 (Table 1), it has to be concluded that the remaining, yet to be replaced lights must have had a significant influence on the effectiveness of the measures. Nonetheless, the numbers of circling birds have decreased by a factor of 2-10. The total number of birds circling in the night decreased considerably as compared to the number which could reasonably have been expected based on prior observations, the intensity of migration at that moment and the weather conditions. The peak amounts are likewise much lower than might have been expected.
4. The lighting shining outwards is not just aimed upwards, but there is also still a fair amount of regular light shining down underneath the platform. Many of the birds crossing the sea at night tend to fly closely over the surface of the water. The birds circling an plant also tend to fly close to the sea (between a few and a couple dozen metres over the water). It is therefore likely that the lights shining down through the grid of the floor onto the surface of the water has an enormous influence on the birds.

5. The decrease in the number of birds circling at any given time during the night seems more marked than the total decrease of the number of birds affected: the changes in numbers and ratio of species of the circling birds seem greater than with full regular lighting. Therefore, it is likely that the average time a bird spends circling the platform has also decreased substantially (However, it is extremely difficult to determine exactly how long a bird keeps circling.).

7 Acknowledgement

I am greatly indebted for the support and help of the crew of the NAM gas production platform L15 during my stay, especially Niek van den Heuvel and Joop van de Kamer for installing the lighting. I thank Joop Marquenie for his help with the English version of the report and the opportunity to return to the platform and to enable me to make this comparison with my earlier offshore observations. I am grateful to my wife Marlies, for allowing me to go offshore, so very close for the birth of our daughter Loes.

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ANNEX 1 Ring data from Vlieland (2000 and 2007) and Schiermonnikoog (2000 and 2007)

Ring data Vlieland 2000

DATE	2-11	3-11	4-11	5-11	7-11	9-11	10-11	11-11	13-11
SPECIES									
Winter Wren	1	2	3	1	3	1	2		2
Dunnoek					2	1			
Robin					15	36	11	1	4
Ring Ouzel						1			
Blackbird	8	14	38	20	38	99	19	4	4
Song Thrush	1	9	8		10	6	1	1	
Redwing	8	77	49	10	13	18	3		1
Blackcap	3		1	2	3	4	1	1	3
Pallas's Warbler									1
Chiffchaff				3		3			1
Goldcrest	2			1	7	1	1		1
Blue Tit	1								
Short-toed Treecreeper									
Brambling			1		1		3		
Chaffinch	2	3	1		1				
Number of Species	8	5	7	6	10	10	8	4	8
Total	26	105	101	37	93	170	41	7	17

Ring data Schiermonnikoog 2000

DATE	2-11	3-11	4-11	5-11	6-11	7-11	8-11	9-11	10-11
SPECIES									
Sparrowhawk			1						
Water Rail					1	5	1		1
Common Moorhen									1
Woodcock							1		1
Meadow Pipit					1				
Winter Wren	1	1	7	2		2	2	2	
Collared Dove						3			
Dunnoek	2	1	1			4	1		1
Robin		1	6	2	6	2	14	12	3
Ring Ouzel									
Blackbird		28	109	62	21	15	111	104	40
Fieldfare						1			1
Song Thrush		17	11	3	1	3	24	6	1
Redwing		32	131	34	37	44	18	35	33
Blackcap		2	4		1		2	1	1
Pallas's Warbler									
Chiffchaff									1
Goldcrest	2	2	4	2	2	1	3	15	9
Firecrest			1	1	1			1	
Long-tailed Tit	8			10				1	
Blue Tit			2		1			2	1
Great Tit		1		1			1	1	
Short-toed Treecreeper									
Starling		2	1				1		
Brambling		1		2					
Chaffinch	1	5	6	3	2	4		1	
Siskin	1	1			2	1			
Lesser Redpoll						1			
Reed Bunting			1		1	2			
Number of Species	6	13	14	10	13	14	12	12	13
Total	15	94	285	122	77	88	179	181	94

Ring data Vlieland 2007

DATE	2-10	3-10	4-10	5-10	6-10	7-10	8-10	9-10	10-10
SPECIES									
Water Rail	2	1		5	4	1			
Common Snipe							1		
Jack Snipe		1							
Meadow Pipit			1						
Rock Pipit						2	1		2
Tree Pipit						1			
Barn Swallow	1								
Winter Wren	3	2	4	1	1	2	7	2	2
Duncock	6	4	2		4	2	1	3	4
Robin	45	56	46	5	26	14	11	9	6
Common Redstart	2	1	1						
European Stonechat					1				
Ring Ouzel	2						2		
Blackbird	45	39	10	4	62	66	43	41	35
Fieldfare				1				1	1
Song Thrush	52	22	14	9	32	8	4	29	10
Redwing	87	21	19	12	44	16	83	130	64
Mistle Thrush	1								
Reed Warbler	4	2	5	1	2	2	1		1
Lesser Whitethroat	1								
Garden Warbler	1	1			1				
Blackcap	20	11	18	12	24	39	23	9	7
Chiffchaff	3	7	3	2	8	4	1	1	
Willow Warbler	1								
Goldcrest	32	14	5		19	12	11	1	4
Firecrest	3	1	1	1			1	2	
Pied Flycatcher	1		1						
Bearded Reedling		6	1	4		2	1	1	
Long-tailed Tit			1						
Blue Tit	2		1		2	1	6	2	4
Great Tit	1	2			1		1	3	
Short-toed Treecreeper		2				1			
Starling				1	8	1	1	3	1
Brambling	2	1	2	3	4	2	1	5	
Greenfinch			1	2	2				2
Chaffinch	2	2	2	9	5	2		7	
Siskin	1				2				
Common Redpoll	1								
Linnet		1							
Reed Bunting	13	1	2	2	7	1	3	7	1
Common Rosefinch		1							
Little Bunting	1								
Rustic Bunting						1			
Number of Species	28	22	21	17	21	21	20	20	14
Total	335	202	140	74	259	180	202	259	142
Hours	14	9	8.30	10.30	14	11.30	13.30	13	13
Number per hour	23.9	22.4	16.5	7.0	18.5	15.7	15.0	19.9	10.9
Penduline Tit								1	

Ring data Schiermonnikoog 2007

DATE	2-10	3-10	4-10	5-10	6-10	7-10	8-10	9-10	10-10
SPECIES									
Sparrowhawk	2								
Water Rail		1	2			1	1	1	6
Common Teal			1						
Common Moorhen	1								
Kingfisher				1					
Great Spotted Woodpecker		1			1				
Winter Wren	2	3	1	5	2	2		2	1
Duncock	1		2	1	1	2	1		
Robin	43	36	25	10	21	13	5	5	6
Common Redstart	1	3	2	1					
Blackbird	12		2	5	13	16	9	25	19
Song Thrush	14	6	3	5	4	3	3	5	3
Redwing	22	27	12	13	35	15	36	60	38
Reed Warbler		1	1						
Blackcap	6	6	1	5	2	11	4	1	3
Yellow-browed Warbler	3	2		2					
Chiffchaff	13	5	4	3	4	4	4	3	
Willow Warbler	2	1			1				
Goldcrest	8	13	12	2	13	5	11	4	11
Firecrest		1	1					1	3
Long-tailed Tit	1			2	1				4
Blue Tit									
Great Tit	4	3	1	1	1	2	3	1	4
Brambling		1	6	2	1	2	1		
Chaffinch	2	4	3	1	7			1	1
Siskin	1			5	1				
Reed Bunting			1		1				
Common Redpoll				1					
Lesser Redpoll			1	1		2	2	2	
Number of Species	19	19	20	20	18	15	13	15	14
Total	139	118	82	69	120	81	83	119	103
Hours	13.30	12.30	12.15	12.30	12.30	12.30	13.30	13.30	13
Number per hour	10.3	9.4	6.7	5.5	9.6	6.5	6.1	8.8	7.9