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Unnamed installations and birds

A desktop study on how to minimize area of conflict

Signe Christensen-Dalsgaard, Nina Dehnhard, Børge Moe, Geir Helge Rødli Systad, Arne Follestad

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Herring gulls in flight (top) © Signe Christensen-Dalsgaard, NINA.
Suggested design of the Peon-installation (bottom left) © Equinor
Kittiwakes breeding on Heidrun (bottom right) © Signe Christensen-Dalsgaard, NINA.

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Abstract

Christensen-Dalsgaard, S., Dehnhard, N., Moe, B., Systad, G.H.R & Follestad, A. 2019. Unmanned installations and birds. A desktop study on how to minimize area of conflict. NINA Report 1731. Norwegian Institute for Nature Research.

Equinor is evaluating several concept developments for the Peon discovery located in the northern part of the North Sea, approximately 100 km west of Måløy. In this report an unmanned topside installation is evaluated. This type of installation is designed to primarily be operated remotely without the presence of personnel, and should require the least amount of maintenance. Birds and bird droppings, in particular, are addressed as a work health and safety aspect for personnel when entering installations related to maintenance operations. Furthermore, seabird faeces can possibly lead to structural deterioration. In this desk top study, the options to minimize the area of conflict between birds and personnel at a proposed unmanned installation has been addressed and evaluated. As the information on birds at unmanned installations is very limited, the report is primarily based on existing knowledge from other types of installations. The information has been collated through a literature review, interviews with people working offshore and information from the Norwegian Species Observation System.

Birds can be attracted to offshore installations since they offer opportunities for foraging and provide resting, roosting and nesting sites. Further, birds can be attracted to installations by the illumination of either position lamps or the flare. The patterns of bird attraction to offshore installations varies across species and seasons. The results from the literature review and the observations carried out on offshore oil installations, showed that gulls are the most likely species group to pose problems related to offshore unmanned installations in the North Sea.

The Peon-discovery is situated in the middle of the Norwegian Trench, which is an area of low biological productivity compared to e.g. the coastal zone and the shelf edge. Based on the analysis of foraging ranges of gulls breeding on the mainland, distribution at sea and information on wintering distribution derived from light-level geolocators, it appears that the area is not highly used by gulls throughout the year. Fishery activities are known to attract gulls. However, the apparent fishing activity in previous years has been low in the Peon-discovery area for most of the year, except for autumn. Gulls that follow fishing vessels may therefore be attracted to the area during autumn.

In the report we focused on mitigation and deterrent methods that are best suitable towards gulls. Nonetheless, the methods may also work on other bird species. Strategies to control the gulls' use of installations can be directed at the gulls' visual, auditory and tactile senses or through physical barriers preventing birds from perching on the structures. There is, however, no single best deterrent method, and the method of choice depends very much on the construction of the installation. In dialogue with Equinor specific areas of potential conflict were identified and specific deterrent methods were suggested. These included **stairways**, **walk-to-work landing platforms**, **balconies used for lay down areas and lifting of goods**, **hand rails**, **horizontal ledges** and **the weather deck.** Deterrent methods included: Fence grating, auditory deterrent, bird "spiders", Bird Free Gel and thin wires. In general, we also recommend a design that minimises the risk of bird faeces and water accumulating e.g. on horizontal ledges, balconies and the weather deck, to reduce corrosion of the installation.

There have been few studies on the effectiveness of bird deterrent methods on offshore installations. We therefore recommend a systematic follow-up study to evaluate the effectiveness of the different methods of deterring birds. Furthermore, there remains a lot of uncertainty about the pH value of seabird faeces and their corrosiveness on various materials. We therefore also recommend a dedicated study looking at effects of bird faeces on materials used on offshore installations.

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Sammendrag

Christensen-Dalsgaard, S., Dehnhard, N., Moe, B., Systad, G.H.R & Follestad, A. 2019. Unmanned installations and birds. A desktop study on how to minimize area of conflict. NINA Rapport 1731. Norsk institutt for naturforskning.

Equinor har planer om å bygge en ubemannet plattform på gassfeltet Peon i den nordlige delen av Nordsjøen, omtrent 100 km vest for Måløy. Denne plattformtypen er designet for fjernkontroll av alle operasjoner, uten fast bemanning ombord og med et minimum av vedlikeholdsarbeid. Fugler og i særlig grad deres avføring, innebærer både et helse- og et sikkerhetsmessig aspekt for personell som skal om bord på plattformen for å utføre vedlikeholdsarbeid. I denne rapporten har vi sett på muligheter for å minimalisere konflikten mellom fugler og personell på en foreslått ubemannete plattformen ved Peon-feltet. Det er tatt utgangspunkt i en av flere utbyggingsløsninger som vurderes for Peon-feltet. Hvis installasjonen blir bygget, kan den derfor se annerledes ut, enn det som er presentert i denne rapporten. Kunnskap om fugler på ubemannede plattformer er svært begrenset og denne rapporten er derfor basert på kunnskap fra andre typer installasjoner. Kunnskap er innhentet gjennom en litteraturstudie, intervjuer med fugleobservatører som arbeider offshore, og observasjoner registrert i Artsobservasjoner.

Fugler kan tiltrekkes offshore installasjoner for næringssøk, for hvile-, raste- og hekkeplasser og på grunn av belysning fra lamper eller gassflammer. Det er både arts- og sesongmessige variasjoner i antall og arter av fugler som tiltrekkes offshore installasjoner. Resultater fra litteraturstudien og tilbakemeldinger fra observatører, viser at måkefugl er de mest aktuelle å vurdere i forhold til de problemene fugler kan medføre på ubemannede offshore-installasjoner i Nordsjøen.

Peonfeltet ligger langs midten av Norskerenna, som er et område med lav biologisk produktivitet sammenlignet med f.eks. kystsonen og eggakanten. Basert på analyser avstanden måker kan fly fra hekkeplassene for å finne næring, kartlegging av i åpent hav og sporing av vandringer i vinterhalvåret med lysloggere, synes det som om området rundt Peonfeltet er relativt lite brukt av måker gjennom året. Fiskeriaktivitet er kjent for å tiltrekke seg måker. Det er imidlertid lite fiske som foregår på Peon-feltet det meste av året, bortsett fra om høsten. Måker som følger fiskefartøyer kan derfor trekkes til området om høsten.

I denne rapporten har vi sett på hvilke forebyggende tiltak og skremmemetoder som kan egne seg best overfor måker. Metodene kan imidlertid også være effektive overfor andre arter. Strategier for begrensning av måkenes bruk av en installasjon, kan baseres på audio-visuelle virkemidler, eller ulike fysiske installasjoner som forhindrer dem i å sette seg på strukturer på installasjonen. Det synes imidlertid ikke å være en metode som skiller seg ut som suveren, og metoden som anbefales avhenger av konstruksjonen av installasjonen. I dialog med Equinor har vi sett på spesielt konfliktfylte deler av installasjonen og foreslått avbøtende tiltak som kan være aktuelle her. Dette inkluderer **utvendige trapper**, **plattformer for ilandstigning av personell**, **balkonger for oppbevaring eller fjerning/tilsetting av materiell**, **rekkverk**, **horisontale avsatser** og **øverste plan av installasjonen**. Forslag til avbøtende tiltak inkluderte bruk av lyd, gitter rundt trappen, wire spent ut over rekkverk, «Bird free gel» og bevegelige installasjoner for å skremme vekk fugler. For å redusere korrosjon av materialer, anbefaler vi også et design som kan minimalisere risikoen for at fugleavføring og vann kan akkumuleres på f.eks. horisontale flater, balkonger og på øverste plan.

Det er få studier som omhandler skremmemetoders effektivitet på offshore-installasjoner. Vi anbefaler derfor et oppfølgende studie der en mer systematisk kan evaluere hvor effektive de ulike metodene er til å skremme eller på annen måte holde fugler vekk fra et område. Det er også usikkerhet rundt pH-verdier i avføringen til måker og hvordan denne kan korrodere ulike materialtyper. Vi anbefaler derfor et eget prosjekt for å studere effekter av fugleavføring på materialer som blir brukt på offshore-installasjoner.

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Contents

Foreword

For this desk top study, the Norwegian Institute for Nature Research was commissioned by Equinor to address and evaluate options to minimize the area of conflict between birds and personnel at the unmanned installation which is proposed to be built at the Peon-discovery in the North Sea. The focus of the work has been on measures to reduce the potential problems connected to birds on unmanned installations and health and safety aspects for maintenance personnel when entering and working on installations. The report is based on one of several possible development solutions for the Peon-discovery, an unmanned topside installation. If constructed, the installation might look different than what is presented in this report. We are aware that offshore installations can also have a negative impact on birds, but this has not been the primary focus of this study.

Our contact person at Equinor has been Ingunn Nilssen. In addition, Bente Johannesen, Liv-Torill Austgulen, Knut Maråk and Jan Ivar Skar, all from Equinor, took part in the discussions on the design of the Peon-installation and the areas of seabird-people conflict. We thank all of them for good co-operation and very useful discussions.

We also thank all ornithologists that reported data from offshore installations in the Norwegian Species Observation Service, and in particularly Finn Hauge, Gunnar Gundersen, Thomm Ove Vedø, Håvar Veding, Dag Brynjelsen, Ronny Johansen and Knut Olsen for answering our questionnaire on birds on offshore installations. We also thank Espen Lie Dahl (SalMar) and Samuel Anderson (Environmental Adviser, NovaSea) for information on birds and conflicts in aquaculture. Further, we thank Jørn Arve Hasselø from the Norwegian Public Roads Administration for information on the measures carried out at Gjemnessundbrua, Møre og Romsdal, Norway to mitigate corrosion problems due to kittiwakes breeding on the bridge.

We would like to thank SEAPOP and SEATRACK for making information available on distribution of seabird breeding colonies, seabirds at sea distribution and seabird movements during the non-breeding season. Finally, we would like to thank Bård Gunnar Stokke for his useful comments and for doing the quality control of the report.

29.11.2019, Signe Christensen-Dalsgaard

1 Introduction

1.1 Background

Unmanned installations are automated offshore oil- and gas installations designed to primarily be operated remotely without the presence of personnel. The number of such unmanned solutions for offshore development is increasing, and with this, the need to address issues related to birds using the unmanned installations for resting, foraging and nesting purposes. Birds and bird droppings, in particular, are addressed as a severe work health and safety aspect for personnel when entering these installations related to maintenance operations.

In general, several measures can be used to minimise the conflict between personnel and birds at unmanned installations ranging from 1) trying to minimise the number of birds being attracted to the installation by e.g. reducing the use of light, 2) designing the installation so that those birds attracted prefer areas outside those used by humans, to 3) investing in technology to keep birds away from the dedicated areas at the installation. In this desk top study, the Norwegian Institute for Nature Research (NINA) has been asked to address and evaluate the options to minimise the area of conflict between birds and personnel at the unmanned installation which is proposed to be built at the Peon-discovery in the North Sea.

So far the information on birds at unmanned installations is very limited. The report is therefore primarily based on existing knowledge from other types of installations. Where relevant, this information is then transferred to unmanned installations.

1.2 Technical solutions and description of area

Peon is a shallow gas discovery, located in the Tampen area in the northern part of the North Sea (61°52' N ,3°20' E; **Figure 1.1**), approximately 100 km west of Måløy and 65 km north-west of the Gjøa oil installation.

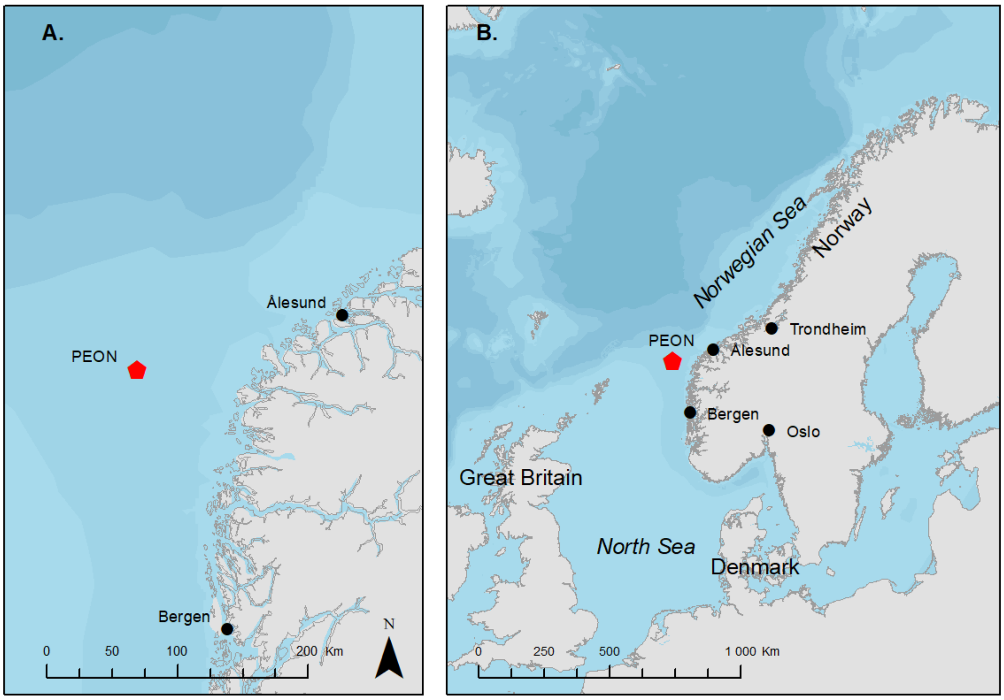

Figure 1.1. *Proposed placement of the unmanned installation at the Peon-discovery.*

The water depth is 365 m to the east of the discovery and is sloping gradually down to 390 m at the west side. Compared to other developments in the area, the Peon-discovery is located relatively close to shore.

The discovery will be developed with six vertical wells. The well stream composition contains more than 99.5 % methane, no H_2S and hardly any CO_2. One of the development designs that are being evaluated is a spar solution. The concept is a floating unit that is designed to be unmanned except from short maintenance campaigns maximum twice a year. The unmanned operation concept includes a Supporting Operating Vessel (SOV) that will act as living quarter during the maintenance campaigns.

The unmanned installation proposed for the Peon-discovery consists of five decks and will raise 47 m from the ocean surface (**Figure 1.2)**. The deck of the installation will be approximately 34 m x 34 m wide and the flare 39 m high. There are two stair towers on the eastern and northern side of the installation, respectively.

***Figure 1.2**. Illustration of the planned design of the Peon-installation. The design of the installation is not finally decided (all figures provided by Equinor).*

The Peon-installation is planned with power from shore and due to the well stream content of pure methane, the topside process is simple without production separators, using a glycol valve for the dehydration system of the gas, hermetically closed compressors and few supporting systems on the installation itself. The only chemical needed is monoethylene glycol for gas handling. The flaring system is not finally decided upon, but the installation will most likely have a system where the flare is ignited on demand. This means that gas can be flared when the process system is being decompressed related to planned maintenance or in case of an unplanned shutdown.

1.3 Seabirds in the North Sea

The most typical seabirds (e.g. northern fulmars (*Fulmarus glacialis),* northern gannets (*Morus bassanus)*, many gulls (Laridae), auks (Alcidae) and some marine ducks (Anatidae)) spend most of their time at sea and depend almost completely on food obtained here. Seabirds are adapted to exploit resources that are widely scattered, highly dynamic and unpredictable in time and space, but during the breeding season they are tied to the breeding colonies on land and thus need to combine the ability to fly between colonies and foraging areas with the ability to obtain food at or below the surface. Many seabird species are colonially breeding. Most of the pelagic foraging species occur in large colonies, while the more coastal species often occur in smaller colonies. The largest colonies in Norway are found in Lofoten and northwards (**Figure 1.3**). The exception from this is Runde, located in Møre og Romsdal north-east of the Peon-discovery, which is the southernmost large bird cliff in Scandinavia.

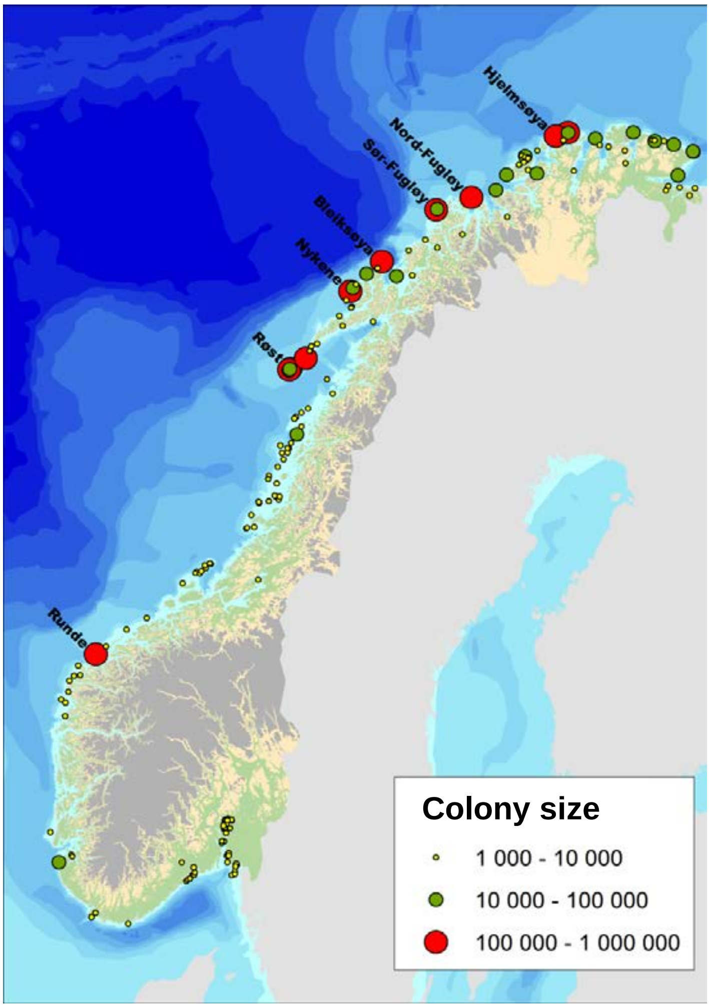

***Figure 1.3**. Distribution of seabird colonies (> 1000 pairs) in Norway. The majority of colonies with more than 10 000 pairs are situated in Lofoten and northwards. Only one of the colonies with more than 100 000 pairs is situated south of the polar circle (data from NINA).*

The planned location of the Peon-installation means that both seabirds from the Norwegian and British parts of the North Sea can be found in the area. The North Sea has several ecological functions for seabirds. Many seabird populations overwinter here, but the distribution of seabirds during the non-breeding season is probably very dynamic and depends on temporary and spatial changes in prey distribution. During spring and autumn, the seabirds present in the area consist both of overwintering birds and birds migrating to and from the nesting areas. During the summer, seabirds found in the North Sea are mainly represented by the breeding populations, as well as immature birds and individuals that are not breeding for various reasons. During the breeding season the birds feed in coastal areas and in the marine areas bordering the colonies.

The presence of seabirds in the area of the proposed Peon-installation, as with other offshore installations, will therefore vary with season and depend on the distribution of seabird prey in the area. At larger spatial scales, prey is often concentrated in association with specific marine features such as shelf breaks (Weimerskirch 2007; Fauchald 2009), and the effect of shelf bottom topography on the Norwegian Coastal Current has proven to be a key determinant of important fish prey for pelagic seabirds along the Norwegian coast (Sandvik et al. 2016). In addition, fishing vessels can form a major food source especially for large gull species (i.e. herring gulls (*Larus argentatus*), great and lesser black-backed gulls (*Larus marinus* and *Larus fuscus*; e.g. Hudson & Furness 1989; Camphuysen 1995), northern gannets and northern fulmars (hereafter fulmar). Fishing activities in a given area might therefore strongly affect the presence of these seabird species in the area and could in the case of unmanned installations affect the numbers of resting seabirds.

1.4 Bird migration in the North Sea

During autumn and spring, birds migrate across and along the North Sea. The migration routes can either cross over open ocean or follow the Norwegian coastline (**Figure 1.4**). For some species, the migration is highly directional, with birds moving between geographically distinct breeding- and wintering areas, while other species move over large areas in less directional migratory movements (e.g., Bakken et al. 2003, 2006). It is unlikely that the migratory movements of birds which follow the Norwegian coast will come into contact with installations located as far from the coast as the Peon-installation.

The migration corridors crossing the North Sea between the Norwegian mainland and the British Isles, might however overlap with the planned position of the Peon-installation. For instance using GPS-transmitters, the Wildfowl and Wetlands Trust has shown that barnacle geese (*Branta leucopsis*) cross the North Sea in the spring (Griffin, unpublished data). For most other species we unfortunately lack such detailed data. There are many passerine birds breeding in Norway and the rest of Scandinavia that overwinter on the British Isles, the European mainland and further south (Bakken et al. 2003, 2006). Whether this spring- and/or autumn migration will pass by the proposed site for the Peon-installation is not well studied, but in August and September some bird flocks may cross the northern section of the North Sea (**Figure 1.4**). Based on existing knowledge on the migratory routes of passerines, the main migratory corridors are probably further south in the North Sea than the Peon-discovery.

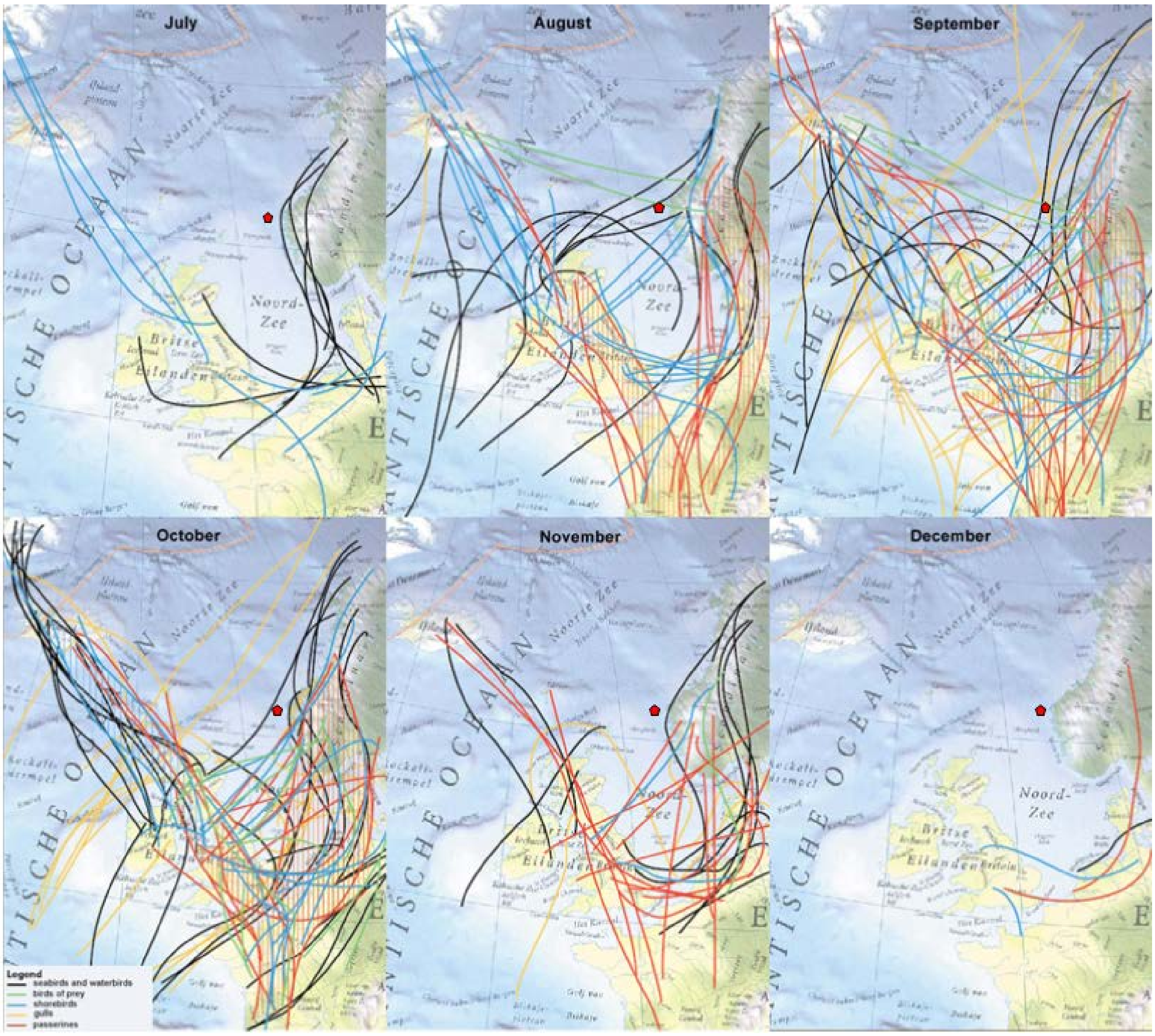

Figure 1.4. *Schematised maps of the migrations of various bird groups through and around the North Sea area. The following groups are distinguished: seabirds and waterbirds (black lines), raptors (green lines), shorebirds (blue lines), gulls and terns (orange lines), and songbirds (red lines). The red pentagon shows the approximated position of the proposed installation at the Peon-discovery. From top left to bottom right, maps are for July, August, September, October, November, and December. Information was not available for the spring migration. (Maps are based on van de Laar (1999) in Poot et al. (2008), reused with permission from the authors).*

1.5 Birds and offshore installations

As the name implies, offshore installations are often situated in the open ocean far from the coastline. The installations therefore create a type of artificial archipelago (Russel 2005), in areas where this type of habitat was not previously present. It has indeed been shown that offshore installations might act as artificial reefs creating habitat conditions attractive to marine fauna, thus enhancing the local marine food supply (Fowler et al. 2018). Birds are attracted to offshore installations both as foraging opportunity (Fowler et al. 2018) and as resting and roosting site (Ronconi et al. 2015). Birds may also get attracted to platforms by the illumination of either position lamps or the flare (Wiese et al. 2001; Burke et al. 2005; van de Laar 2007). Further, light at night (through flares) may attract zooplankton and fish to the surface – gulls have been observed feeding in the shine of flares at night (e.g. Burke et al. 2005). In addition, discharge of food waste from manned installations might attract gulls. The patterns of bird attraction to offshore installations varies across species and seasons (Tasker et al. 1986; Burke et al. 2005).

For migrating birds, such as passerines, the installations may be used as a resting place during spring- and autumn migration, where the birds have an opportunity to rest and recover from fatigue (Russell 2005; Ronconi et al. 2015). This stop-over behaviour can, however, be detrimental to the birds as they expend their reserves while resting on the installation (Hope Jones 1980). The presence of passerines and other birds at the installation further attract birds of prey such as falcons, which use the installations for hunting (Russell 2005).

Gulls are frequent visitors on installations throughout the year, with food availability and possibility for roosting probably being the reason for the attraction (**Figure 1.5**) (Tasker et al. 1986). Tasker et al. (1986) documented herring gulls, lesser black-backed gulls, great black-backed gulls, black-legged kittiwakes (*Rissa tridactyla,* hereafter kittiwakes), and fulmars roosting on offshore installations in the North Sea. In addition, installations may be used as breeding habitat by kittiwakes (Camphuysen & Leopold 2007; Geelhoed et al. 2011; Christensen-Dalsgaard et al. submitted).

The presence of birds on offshore installations opens for the potential of conflicts between seabirds and the personnel on the installations. For the companies operating on the shelf, the main concern is related to human health and safety issues, such as the risk of bird strikes during helicopter operations, transmission of disease and that bird droppings might complicate onboard operations. For birds the interaction with offshore installations might, however, also pose a risk, especially related to collision and incineration.

Figure 1.5. *Gulls frequently use offshore installations for resting and roosting (photo © Signe Christensen-Dalsgaard).*

1.6 Impact of offshore installations on birds

The most evident impact of offshore installations on birds is mortality due to collision with infrastructure or incineration in flares (Ronconi et al. 2015). Collision risk and incineration in flares particularly affect migrating landbirds, but also storm petrels and other procellariforms, which get attracted by the light, are at risk (Sage 1979; Day et al. 2015). The risk of collision and incineration in flares is potentially high, but is likely limited to episodic events, from zero over several weeks (Hope Jones 1980) to hundreds of birds in one night (Sage 1979). As not all carcasses are recovered since they end up in the sea, it is very difficult to make estimates on the extent of mortality due to collision and incineration. A worst case estimate of total annual bird mortality at oil and gas installations in the North Sea is as high as 6 million birds, though numbers are likely much lower (Bruinzeel et al. 2009).

Weather, particularly fog, as well as time of year are important determinants for the extent of collisions, with highest collision risks during the migration period and in poor weather (Wiese et al. 2001; Bruinzeel et al. 2009). In addition, during foggy conditions migrating passerines may circulate for hours around the installations, get exhausted and finally die. The most frequent cause of death for migratory passerines found dead on oil installations in the Gulf of Mexico during spring was starvation, as opposed to collision during autumn migration (Russell 2005). The migrating birds might try to hide on the installations if they are exhausted. Unless they are eaten by gulls or other predators, they may then die and rot on the installations. This could cause minor problems for the crew entering the installations for repair or maintenance work.

1.7 Impact of birds on offshore installations

As the Peon-installation is going to be reached with boat, not helicopter, the risk of bird strikes during helicopter operations is not relevant and contamination of surfaces with faeces and possibly regurgitates, is thus the largest concern regarding birds on this installation.

Faeces and regurgitates on installations is an issue since it can cause slipperiness (especially in rainy conditions), feathers and faeces can cause blockage of drains, the acidity causes corrosion (Spennemann & Watson 2018), and finally there are issues with hygiene and the possibility of disease transfer. A range of different pathogenic bacteria has been found in faeces and cloacal swabs of gulls (*Larus ssp.*), among them Campylobacters (*Campylobacter jejuni*), *Clostridium perfringens, Escherichia coli*, Listerias (*Listeria monocytogenes*), and Salmonellae (*S. enterica* & *S. typhimurium*) (Benskin et al. 2009; Fuirst et al. 2018). Also, some lines of antibiotic-resistant *E. coli* and *S. typhimurium* have been found in gull faeces (Palmgren et al. 2006; Poirel et al. 2012). However, the carriage of at least *Salmonella* by gulls is rather short-lived (few days) and considered to reflect the level of contamination in the environment, with higher prevalence levels in gulls feeding at sewage outfalls than in other environments (Monaghan et al. 1985; Palmgren et al. 2006). The actual risks associated with bird faeces are therefore largely limited to corrosion and causing slippery surfaces.

Generally, seabird faeces are highly corrosive due to the contained uric acid and other chemical compounds, especially chloride, which is contained in faeces of birds feeding in the marine environment (Goldstein 2002). An extensive search of the literature could not produce any data on the pH value of seabird and specifically gull faeces in either fresh form or dried guano. Fresh faeces of pigeons have an almost neutral pH value (6.5 to 6.7; Huang & Lavenburg 2011). However, since diet is known to affect the pH value even within the same bird species (Spennemann & Watson, 2017), seabird faeces likely have different pH values than those of pigeons. The pH value of bat faeces changes from neutral in fresh state (pH of 7.3) to highly acid when dried (pH of 2.7; Wurster et al. 2015). Whether the same is true for (sea-)bird faeces is unknown. Bird faeces are known to cause corrosion of copper and bronze used on buildings and statues (Bernardi et al. 2009), but also construction materials such as steel and concrete (Justnes & Rodum 2003; Huang & Lavenburg 2011). Steel exposed to bird faeces will be affected particularly by the contained chlorides, which increase corrosion (Craig & Anderson 1995).

The effects of seabird faeces on concrete have been examined in detail for the case of Gjemnessundbrua in Møre og Romsdal, Norway, which holds a large breeding populations of kittiwakes. Constructed in 1992, the concrete in the upper 5 mm of the surface underneath bird nests was examined in 2003 and found to be significantly chemically affected by the bird faeces (Justnes & Rodum 2003). Analyses showed considerable chloride contamination, limited sulphate contamination and considerable nitrate contamination in this surface area (Justnes & Rodum 2003). These infiltrated compounds interact with the concrete and lead to the formation of new compounds, including Thaumasite (Ca3Si(OH)6(SO4)(CO3)·12H2O) (Brown & Doerr 2000), which was indeed also found in the surface structures of Gjemnessundbrua in 2003 (Justnes & Rodum 2003). The formation of Thaumasite and similar compounds causes volume changes in the concrete and further decreases its binding properties, causing a degradation and crumbling of the concrete (Haynes et al. 1996).

Steel that is installed within concrete is normally protected from corrosion by the alkali environment in concrete (typically $12.5 < pH < 13.5$), and a stable passive layer which forms around the metal and hinders the penetration of corrosive agents (Yeomans 2004). However, this passive layer is compromised by penetrating ions, particularly chloride, and a decrease in pH, causing corrosion of steel and structural damage (Yeomans 2004). Chloride is one major factor for corrosion of concrete-embedded steel, but sulfate ions can also cause corrosion to a smaller extent (Al-Tayyib & Shamim Khan 1991). To avoid corrosion effects due to chemical compounds contained in bird faeces, the coating or painting of surfaces has been recommended and is now successfully performed at Gjemnessundbrua. The Norwegian Public Roads Administration is for this purpose using Cem Elastic, a two-component seal consisting of cement and a latex membrane, which is suitable for concrete or bitumen-based surfaces (Cem Elastic, MAPEI). Some anti-graffiti coatings may also be effective against effects of bird faeces (e.g. KTX 07, a long-lasting coating produced by Anti-Graffiti System, PhSC Chemicals; https://antigraffiti-system.com/en/product-overview).

2 Materials and methods

2.1 Occurrence of seabirds on installations

Due to the inaccessibility of offshore installations we had to rely on observations from the crew running the installations and operators, to get an impression of the extent and species distribution of the birds present at offshore installations in the North Sea and the Norwegian Sea.

2.1.1 Information from the Norwegian Species Observation System

Many ornithologists in Norway, of which some are working offshore, are active users of the Norwegian Species Observation System (Artsobservasjoner, www.artsobservasjoner.no/). We therefore used information downloaded from the Norwegian Species Observation System to assess which birds had been registered on offshore installations. The Norwegian Species Observation System is a website for observations of plants, animals and fungi in Norway. Private persons as well as professionals and authorities contribute with data and anybody can search the records. An observation in the database includes not only the species identity, location and date but can also include additional information such as activity and cause of death for individuals observed dead. Search functionality enables searching by, for example, region, habitat, or data collection project. As many observers are interested in more rare species, the observer activity – and reporting frequencies of the most common species like gulls – may be higher during migration periods, when the chances to observe rare bird species is higher. Data from the Norwegian Species Observation System may thus be skewed towards more reports on rarer species or occasions with unusually high numbers of birds (of both common and rare species), and with generally fewer reports of the common species seen every day.

To examine the number and type of bird species on offshore installations and how the bird attraction to offshore installations varied across species and seasons, we downloaded all available data from the offshore area in the Norwegian Species Observation System database (search words "Norskekysten hav N" and "Norskekysten hav S"). To filter out which birds were actually present on the installation, we filtered the observations using the keywords "reir med egg eller unger" (nests with eggs or chicks), "reir" (nests), "næringssøkende" (foraging), "stasjonær" (stationary) and "rastende" (resting). As gulls, fulmars, auks, skuas and gannets usually forage in the ocean, we further omitted these species from the dataset when they were labelled as "foraging". Finally, we manually went through the dataset to filter out observations that were not from an offshore installation (i.e. observations from different types of vessels).

2.1.2 Qualitative information from questionnaires

To obtain in-depth information on the behaviour of birds spotted on offshore installations, bird observers that we knew were working offshore or had reported birds on offshore installations in the Norwegian Species Observation System were contacted. In total ten observers were contacted and of these seven responded.

They were asked questions regarding bird activity on offshore installations, including:

- Time of the year and time of the day when gulls and other seabirds are resting on installations
- where the birds prefer to sit (e.g. deck/flat areas or railings, high up or constructions low on the installation)?
- a rough estimate on the maximum number of birds they had observed and how many birds in a more normal situation.
- If they had some knowledge about possible conflicts caused by the birds

- If they had some experience with any mitigating measures

We also contacted bird observers we knew were working in aquaculture (salmon farming) and asked them the same questions, to see if we could learn from their experience with scaring birds away from aquaculture facilities.

2.2 Occurrence of seabirds in the study area

In order to assess the probability of conflict between birds and installations it is important to identify which areas are used by the seabirds and where there might be an overlap between birds and installations. Tasker et al. (1986) and Ronconi et al. (2015) identified gulls as being the primary group of seabirds which are attracted to offshore installations and this was also reported from the offshore observers asked. Concurrently gulls cause most work health and safety aspects for personnel on offshore installations and we have therefore focused on this species group.

2.2.1 Predicted distribution of breeding seabirds around Norwegian colonies

The distribution of birds around the colonies during the breeding period was obtained for herring gull, great black-backed gull and kittiwake which are the gull species most often observed on offshore installations. For this analysis, we used information on colony size and colony location from SEAPOP (www.seapop.no), and we followed the approach by Moe et al. (2018). This method uses the predicted foraging ranges around the colonies to estimate the distribution of seabirds in the marine areas surrounding their colony. We applied a foraging range of 60 km for the coastal feeding gulls (herring- and great black-backed gull) and 99 km for the pelagic feeding kittiwake, as maximum foraging ranges. The density of birds is thought to increase towards to colony, and the standard approach is to use 3 equally sized zones. In zone 1 (closest to the colony), it is assumed that 2/3 of the colony size will be present, while 2/9 and 1/9 of the colony size are present in zone 2 and 3 respectively. This is a standardised and simplified approach (Systad et al. 2018) which is useful for illustrating the distribution of birds around the colonies during the breeding period.

2.2.2 Seabird at sea distribution

Seabirds are counted at sea during ship-based surveys following standardised transect methods (Tasker et al. 1984). Count data from the North Sea are part of the ESAS database (European Seabirds At Sea), while those from the Norwegian Sea are part of the Norwegian seabird database of NINA and Norwegian Polar Institute (www.seapop.no). Modelled density of seabirds at sea have then been derived from models using the count data from surveys during the period 1981-2006 (see Fauchald 2012). The distribution of seabirds changes over the annual cycle, and the density of seabirds has been modelled for three seasons. Summer is defined as the period 1. April - 31. July, autumn as 1. August - 31. October, and winter as 1. November – 31. March. The estimated densities are modelled for 10x10 km grid cells. See the SEAPOP website for further details about these methods (http://www.seapop.no/no/metoder/kartlegging-hav/dataanalyse.html). In this report we use modelled values for the density of herring gull, great black-backed gull and kittiwake, as these are the gull species most often observed on offshore installations.

2.2.3 Seabird movements during the non-breeding season

This report also contains data on seabird movements during the non-breeding season. These data come from SEATRACK (www.seapop.no/en/seatrack), an international seabird tracking program, which includes tracking of eleven seabird species. SEATRACK is tracking seabirds with light-level geolocators (see Moe et al. 2018 for details about this tracking method and the data from SEATRACK). SEATRACK has been tracking both kittiwakes and herring gulls. We have, however, only included data from kittiwakes in this report, as the sample size and the coverage of herring gulls is rather low. In line with Moe et al (2018), we do not present kernel maps for this species in this report, but provide a brief qualitative description of their migration and wintering strategy.

In short, we present maps with kernel contours (50, 75 and 90%) for each of seven kittiwake populations: South Norway, North Norway, Svalbard, Russia, Iceland, Faroe Islands and the United Kingdom. The 50% kernel density contour represents the core areas used, while those of 75 and 90% also include areas with lower densities.

We have defined autumn as the period from August to October and winter from November to March, which is in line with the definitions for the densities at sea modelled from count data. We define spring, however, as April-May, while April-May is part of the summer season for the densities at sea predicted from count data. Geolocators do not provide positions during June-July at high latitudes because of apparent constant daylight. Another limitation is unreliable latitudes around the equinoxes, and positions are discarded for the periods 7. September- 25. October and 21. February- 5. April. Further details about processing of light data, calibration and smoothing of positions are provided in Hanssen et al. (2016). The kernel analyses are performed with Azimuthal equidistant projection and the degree of smoothing was determined using the least-squares cross-validation method.

2.3 Apparent fishing activity

In order to assess the fishing activity in the area, and thereby possible aggregations of seabirds, we downloaded all available fishing data from 2012-2016 collated by the Global Fishing Watch (https://globalfishingwatch.org/) for the area of interest. Briefly, the Global Fishing Watch collates data from the Automatic Identification System (AIS) of fishing vessels collected via satellites and terrestrial receivers. The AIS was originally developed for safety/collision-avoidance and is mandatory for fishing vessels over 15 meters registered in a member state of the European Union. This requirement also applies to Norwegian fishing vessels (https://lovdata.no/dokument/SF/forskrift/2014-09-05-1157). Using a mathematical detection algorithm based on speed and direction, the Global Fishing Watch calculates “apparent fishing activity” by vessels registered as commercial fishing vessels. While the vessel names are not publicly available, the type of fishing (trawling, purse-seine, fixed gear, squid-jigging etc.) is linked to the data. However, due to the minimum length restriction of the AIS registration, fishery activities of smaller vessels, particularly in coastal areas, are underestimated.

For an overview, we calculated the total number of hours of apparent fishing activity in the period from 2012-2016 in the area around the Peon-discovery per spatial 0.25 x 0.25 degree bin. We further provide detailed plots of the apparent fishing activity (in hours for the years 2012-2016, at a spatial resolution of 0.01 x 0.01 degree) separately by season and for the three most common fishery types.

2.4 Mitigation and deterrent methods

Previous literature reviews on the topic by Tasker et al. (1986) and Ronconi et al. (2015), and the observations carried out on offshore installations, showed that gulls are the most likely species group to pose problems on offshore unmanned installations. We have therefore focused the search on mitigation and deterrent methods on those best suitable to be used against gulls. Nonetheless many of the methods also work against other bird species. We did a search on www.scholar.google.com for peer-reviewed literature as well as reports on the topics of mitigation and deterrence measures against gulls. We used the keywords “offshore”, “offshore platform”, “oil rig” as well as “bird”, “gull”, “seabird” and “conflict”, “mitigat*” and “deter*” in double combination (e.g. offshore & bird) or triple combination (e.g. offshore, bird, collision) to search on www.scholar.google.com. We also searched in some of the discovered literature for references to other reports and “grey” literature. We further searched on www.google.com for commercial solutions offering deterrence methods against gulls. Finally, contacts and experience from previous projects were taken into account.

Deterrence methods, their advantages, disadvantages and usefulness have been reviewed multiple times for various purposes, especially in the context of airports and use of agricultural fields (e.g. see Bomford & O’Brian 1990; Koski et al. 1993; Harris & Davis 1998; Bishop et al. 2003). Of all the available methods, we therefore in this report only present those that appear relevant in the framework of this study and are suitable to long-term deterring of gulls.

3 Results

3.1 Occurrence of seabirds on offshore installations

3.1.1 Information from Norwegian Species Observation System

Information from 4 268 unique observation events totalling 62 220 birds were included from the Norwegian Species Observation System. Of these 10 observations prior to year 2000 were excluded.

During the period 2000-2019, 159 different bird species were observed on offshore installations in Norwegian waters, with great black-backed gull being the most common species observed (in total 35 003 individuals). Similarly, when assembling the species observed in species groups, gulls were the most common group observed, comprising 79.9% of the observations (**Table 3.1**).

Table 3.1. *Distribution of species groups observed on offshore installations in the period 2010-2019. Species groups with less than 50 individuals have been omitted from the table.*

Species group	*Individuals observed*
Gulls	*49 411*
Fulmars	*8 214*
Passerines	*2 530*
Corvids	*524*
Falcons	*272*
Cormorants	*196*
Doves	*168*
Ducks	*120*
Hawks	*114*
Swallows	*101*
Herons	*84*
Owls	*80*
Geese	*65*
Plovers	*56*

To assess the temporal variation in birds on offshore installations, we looked at both total number of birds observed and the total number of independent observation events. This was to see, 1) how consistently the species were reported throughout the year e.g. how common the observations were and, 2) the total number of birds observed. When the observations from all installations were grouped together, there was a clear temporal pattern of observations of the different species groups both with regard to number of birds and number of observations (**Figure 3.1**). For both gulls and passerines there was an increase in number of unique observations and total number of birds counted during spring and autumn (**Figure 3.1**). The tendency was most pronounced for the passerines for which of the observations occurred in April-May and August-October. As fulmars are very rarely reported to land on offshore oil installations, they were not included in the figure.

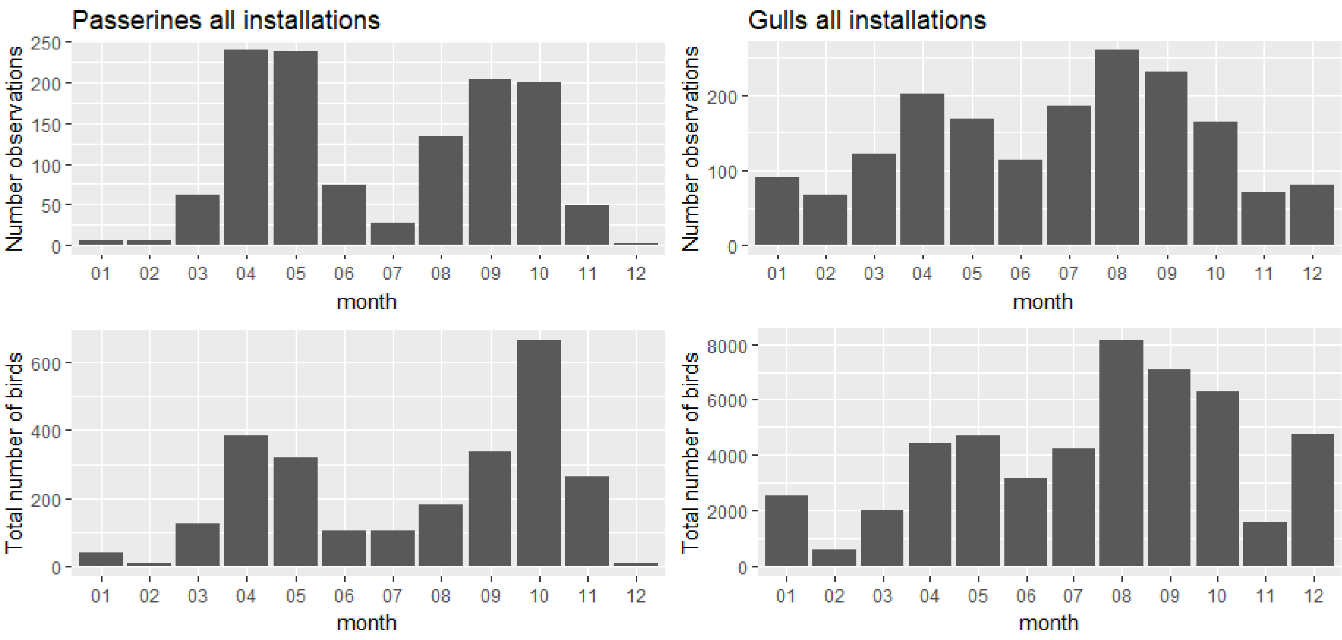

Figure 3.1*. Total number of observations and total number of birds, here shown for passerines (left) and gulls (right), on offshore oil installations in Norwegian waters.*

In order to investigate the prevalence of birds in the area where the Peon-installation is proposed to be build, we limited the search to observations done on installations situated within ca. 80 km of the Peon-discovery (in total twelve installations). For this study we separated between the two most common gull species observed, great black-backed gull and herring gull. For great black-backed gull the patterns of total number of birds observed and total number of observations of birds followed the same pattern with most birds/observations during the last part of summer and during the winter months (**Figure 3.2**). For herring gulls the total number of birds observed during the year was dominated by a large number of birds being observed in December, whereas the number of observations showed that the species is actually observed throughout the year, but most often in August-October and December-January (**Figure 3.2**). For the passerines, the number of observations showed a peak during spring- and autumn migration, but the total number of birds observed peaked in April, July and October (**Figure 3.2**). However, overall a very limited number of passerines was observed on these installations, which supports the perception that the area of the Peon-discovery is not an important flyway for migrating passerines. Alternatively, the limited number of registrations, could be caused by lack of bird observers on the installations in this area.

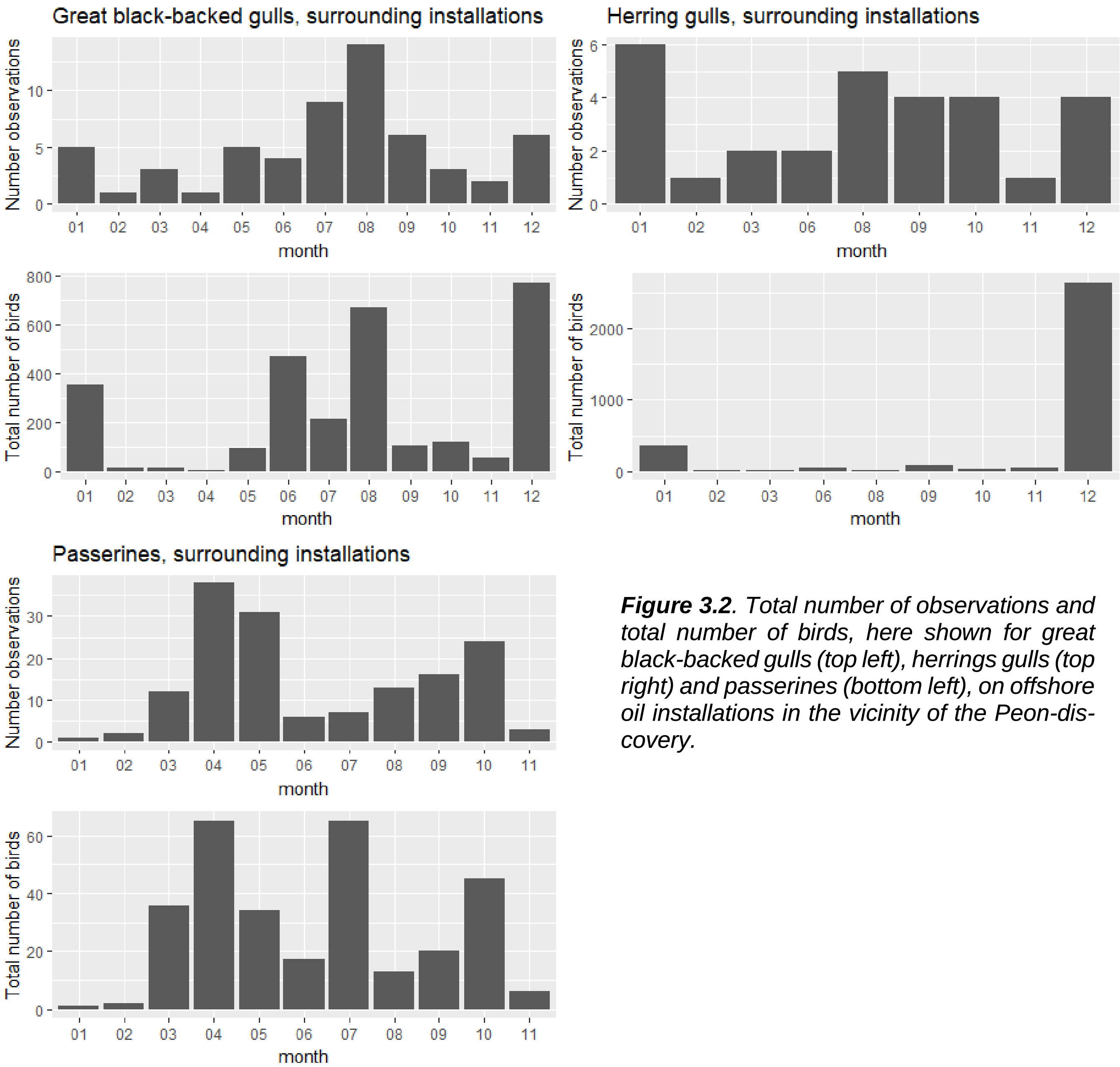

***Figure 3.2**. Total number of observations and total number of birds, here shown for great black-backed gulls (top left), herrings gulls (top right) and passerines (bottom left), on offshore oil installations in the vicinity of the Peon-discovery.*

3.1.2 Qualitative information from questionnaires

The seven bird observers that responded to our request have worked on installations in many parts of the North Sea and the Norwegian Sea, some for as long as 40 years. The observers have had different functions on the installations. One of the observers is responsible for the quality check of observations south of the Polar Circle entered into the Norwegian Species Observation System. It is therefore assumed that the observers represent a set of persons with good knowledge of the bird occurrence on offshore installations.

All observers reported the great black-backed gull to be the most regular visitor on offshore installations. Their numbers were, however, reported to normally be low or typically 20-50 individuals around the installations. Most of the great black-backed gulls observed are adults, except for the breeding season, when most of the adults probably are staying in their breeding colonies. Some observers mentioned that the numbers may vary with distance to fishing grounds and land (but with no proof for this). On installations near fishing grounds there can be thousands of gulls in the air, but the observers do not know if all these birds rest on the installations. Great black-backed gulls have been observed feeding on migrating birds roosting on the installation.

The gulls observed on installations seem to prefer to sit on installations that are not in service, like some of the installations in the Ekofisk-complex where activity and noise is low, and where they have a good view of the surroundings. In particular “Tanken” on Ekofisk, which is made of concrete, is a popular resting place, possibly because it looks like a cliff. Otherwise the feedback from the observers was that the gulls sit “everywhere” with a good view of the surroundings, e.g. on the helideck, decks, railings, on top of pipelines and other structures, roofs and jackets. Wind direction and speed is important, with the gulls showing a preference of sitting with their heads towards the wind. Some of the observers concluded that it would be nearly impossible to keep the gulls away from an offshore installation, as there are thousands of places where they can sit. Herring gulls and other gulls are in general less commonly observed on installations, with the highest numbers present during migrating periods.

None of the observers reporting to us had observed fulmars sitting on installations, though they may be numerous in the vicinity of the installation. Fulmars are often observed resting at sea, and also feeding on waste and – probably – small fish and other organisms around the installations. One observer suggested that fulmars may decide to land on an installation to examine if there is an opportunity to breed there, as they might do on natural breeding sites on islands and along the coast.

Kittiwakes have been observed resting on installations, also during summertime. The kittiwakes reported from Ekofisk were mainly juvenile/immature birds moulting into adult plumage, and numbers can be high, sometimes hundreds of birds. On Ekofisk they prefer to sit on “Tanken”, or on the concrete wall which is still left there. Some kittiwakes have been observed bringing in nest material. Some observers thus believe they may take the opportunity to breed on unmanned installations, as they have done on other installations. It has been observed that western jackdaws (*Corvus monedula*) have tried to breed on Ekofisk, but so far not successfully.

From 2010 to 2016, there were few seabirds searching for food on the Ekofisk field, except of those feeding on food waste, like fulmars and gulls, and on mussels on the jackets. Similarly, on Heidrun a decrease in the numbers of seabirds at the installation was reported, before the kittiwakes started to breed. On Heidrun a flock of eiders (*Somateria mollissima*) was observed over a long time feeding on mussels on the main structure of the installation, more or less the whole year around.

3.1.3 Kittiwakes breeding on offshore installations

Through the SEAPOP-financed project “Oil installations as breeding refuge for Norwegian black-legged kittiwakes”, which was carried out in 2018 and 2019, the prevalence and breeding success of kittiwakes breeding on offshore oil installations on the Norwegian shelf was documented (Christensen-Dalsgaard et al. submitted). The results from this project showed that at least six (10%) of the 63 installations addressed in the study were reported to have breeding kittiwakes, four of which had a total of 1145 breeding pairs in 2019. The nesting habitats appears to be highly variable, with kittiwakes inhabiting a variety of surfaces on the oil installations. On the floating production storage and offloading units (FPSOs) included in that study, kittiwakes were mainly breeding on suitable ledges on the sides of the installations, whereas on fixed concrete installations the birds were primarily breeding on the main construction and the top of the shafts (**Figure 3.3**).

Figure 3.3. *Approximately 300 pairs of kittiwakes breed on Heidrun. The birds use different types of ledges to build their nests on (photo: © Signe Christensen-Dalsgaard).*

3.1.4 Experience of bird-human conflict from comparable structures

Information from environmental advisers in two nationwide companies which run salmon farms along most of the Norwegian coastline, indicated that problems with seabirds are now in general less than they were in the first decades of commercial salmon farming. The salmon farming industry now uses nets installed above all cages, thus preventing birds from wounding or feeding on fish beneath them. However, when many gulls sit on the net, they can still get access to the food from the dispersers. Several deterrent methods have been used. Lasers were found not to be successful and were efficient only for a short while (1-3 days), but we have no information on how lasers were used, especially to avoid habituation effects. Also, lasers were used separately, and thus not in combination with other methods like sound (**see 3.4.2**).

Gulls and common eiders, which are the most common bird species connected to salmon farms, seem to be less problematic than birds like great cormorants (*Phalacrocorax carbo*) and grey herons (*Ardea cinerea*) attacking the fish. There are rarely problems with gulls sitting somewhere on the fish farms, as they seem to prefer to rest on nearby islets or islands, where they are less disturbed and may find shelter from the wind.

One problem with nets above the cages is that birds get entangled in them. One company solved most of this problem when they changed mesh size from 20 x 20 cm to 10 x 10 cm. Problems with great cormorants were, however, profound in a period after this change, as the birds seemed to be used to getting through the meshes to catch small fish. This mesh size can, however, not be used on sites with strong winds or where there is a risk of icing.

Through ASC (Aquaculture Stewardship Council), developed by WWF (see www.asc-aqua.org), salmon farms cannot use deterrent methods involving sounds, like gas canons. This ban of acoustic deterrents is to avoid strong noises that can scare breeding birds nearby or disturb whales, that can be strongly affected by acoustic pollution.

3.2 Occurrence of seabirds in the study area

3.2.1 Predicted distribution of breeding seabirds around Norwegian colonies

During the breeding period, seabirds are tied to the colony by activities like mate guarding, nest defence, egg-laying, incubation and chick rearing. Foraging occurs within a certain radius around their breeding colonies (central place foraging). The different ecological groups of seabirds have different foraging ranges. We assume a maximum foraging range of 60 km for herring gulls and great black-backed gulls (Moe et al. 2018). The Peon-discovery is located approximately 80 km from the Norwegian coast, and thus does not overlap with this maximum foraging range. We therefore expect no breeding herring gulls or great black-backed gulls from Norwegian colonies around Peon (**Figure 3.4 A, B**). We assume a maximum foraging range of 99 km for kittiwakes (Moe et al. 2018). Under certain circumstances, kittiwakes can use areas up to 400 km from the colony during breeding. The Peon-discovery is located within this range for some colonies at the Norwegian coast, and we expect that some kittiwakes breeding on the coast may use areas around the Peon-discovery (**Figure 3.4 C**).

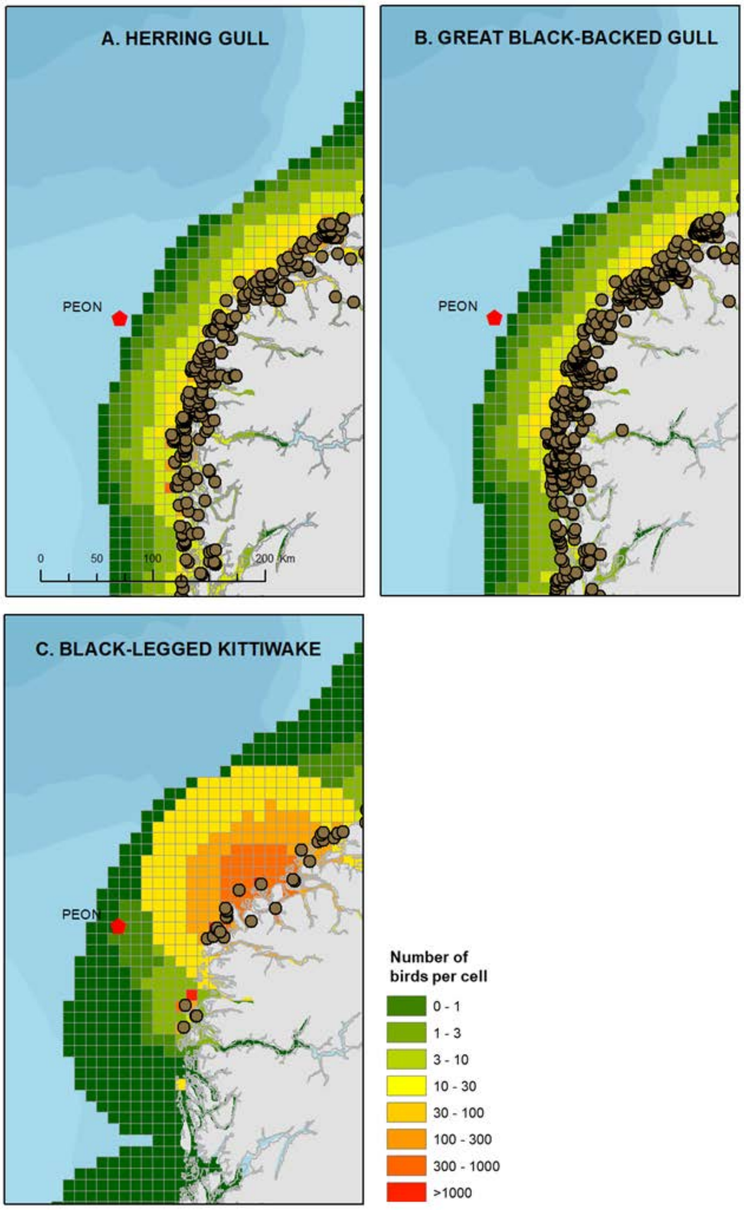

Figure 3.4. *Estimated densities of (A) herring gulls, (B) great black-backed gulls and (C) kittiwakes around colonies in South Norway during the breeding period. Colonies are indicated with brown circles. The legend colours provide the density of birds in grid cells of 10 x 10 km.*

3.2.2 Seabird at sea distribution

During the non-breeding season, seabirds are no longer central place foragers, and they can move away from the colonies to follow the temporal and spatial distribution of their prey. The seabird distribution is therefore dynamic throughout the year. The distribution (or abundance) of seabirds at sea is estimated from seabird counts during surveys in summer, autumn and winter. Herring gulls and great black-backed gulls have very low abundances during summer and autumn around the Peon-discovery (**Figure 3.5 A, B, Figure 3.6 A, B)**. In winter, the abundance is somewhat larger, with up to 10 and 30 birds per 10 x 10 km at the Peon-discovery (**Figure 3.5 C, Figure 3.6 C**). The estimated abundance of kittiwakes in the area is highest during winter, with 100 birds per 10 x 10 km, lower during summer and lowest during autumn (**Figure 3.7**).

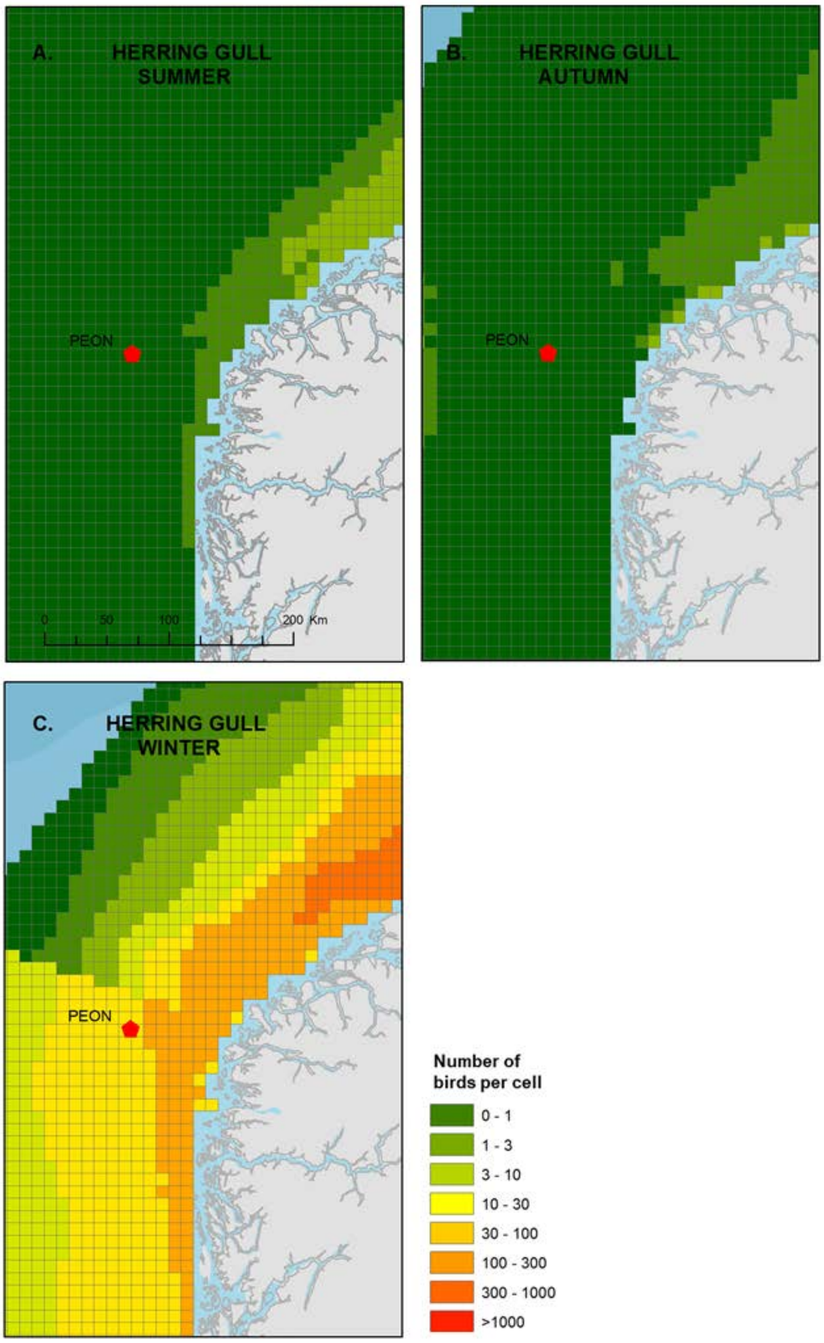

Figure 3.5. *Distribution of herring gulls in off-shore areas around Peon in (A) summer, (B) autumn and (C) winter. Peon (red pentagon) is located in the north-eastern part of the North Sea, close to the border of the Norwegian Sea. The legend colours provide the density of birds in grid cells of 10 x 10 km.*

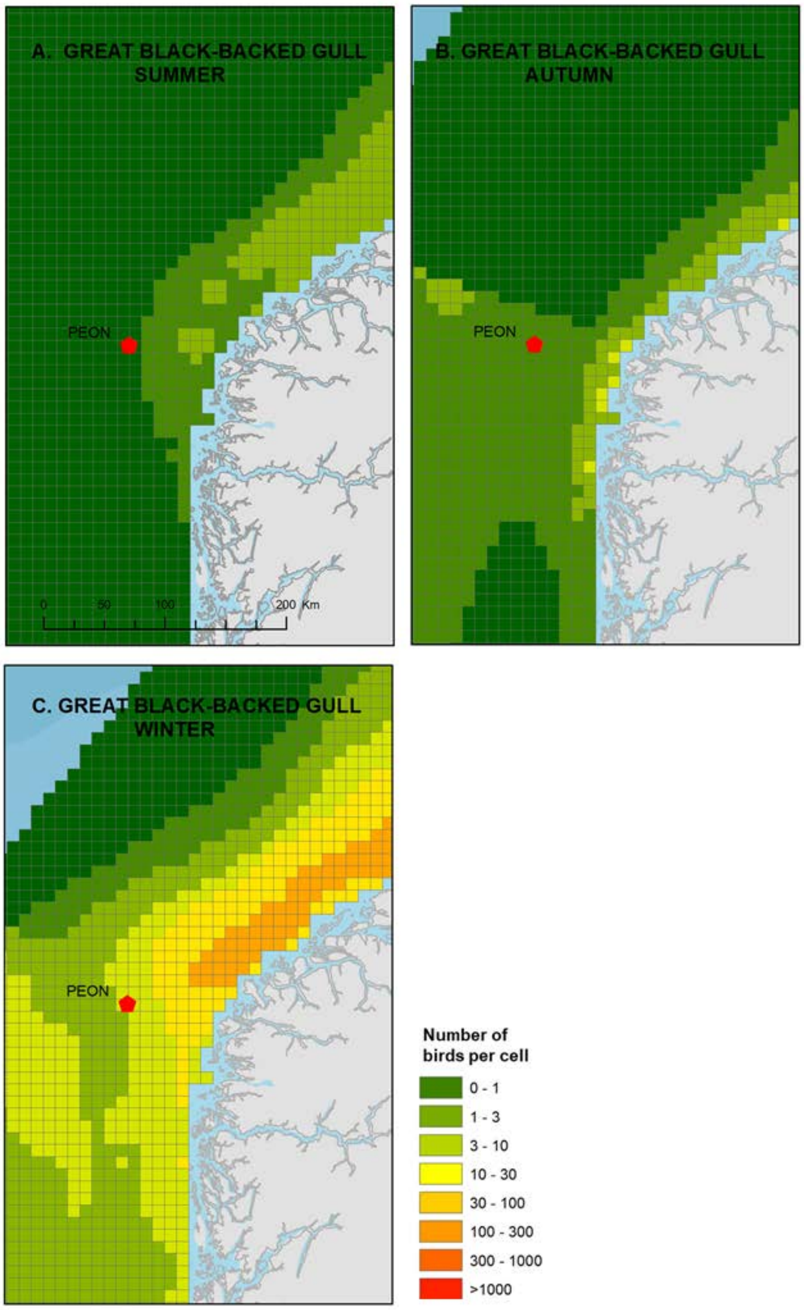

Figure 3.6. *Distribution of great black-backed gulls in offshore areas around Peon in (A) summer, (B) autumn and (C) winter. Peon (red pentagon) is located in the north-eastern part of the North Sea, close to the border of the Norwegian Sea. The legend colours provide the density of birds in grid cells of 10 x 10 km.*

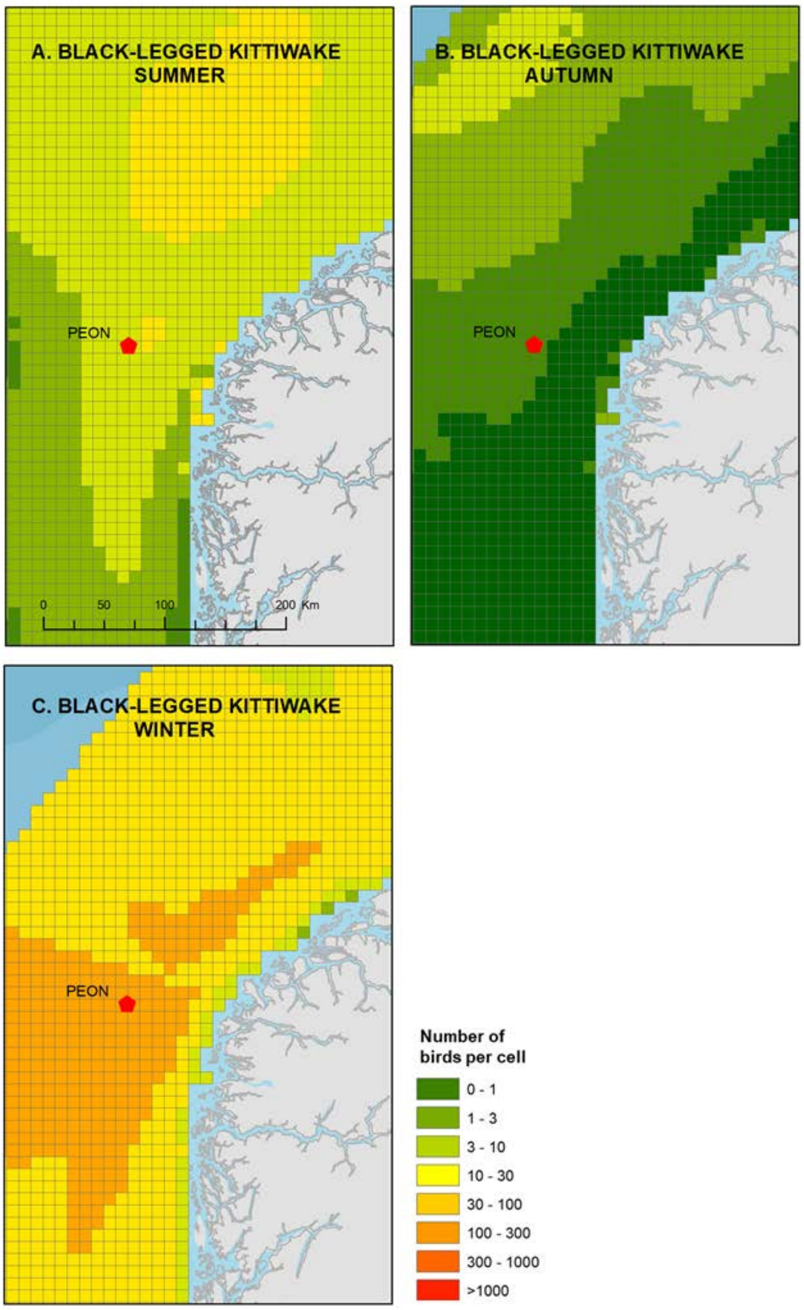

Figure 3.7. *Distribution of kittiwakes in offshore areas around Peon in (A) summer, (B) autumn and (C) winter. Peon (red pentagon) is located in the north-eastern part of the North Sea, close to the border of the Norwegian Sea. The legend colours provide the density of birds in grid cells of 10 x 10 km.*

3.2.3 Seabird movements during the non-breeding season

The kernel-maps show that kittiwakes from South Norway are in the area of the Peon-discovery during all three seasons (**Figure 3.8**). In addition, kittiwakes from northern Norway and Svalbard are distributed around the Peon-discovery during winter (**Figure 3.8**). Also, the kernels indicate that kittiwakes from Russia are distributed around the Peon-discovery in spring (**Figure 3.8 C**). Those birds are most likely on passage during spring migration. The kernel maps are based on SEATRACK tracking data from 15 kittiwake colonies (**Figure 3.8 D**).

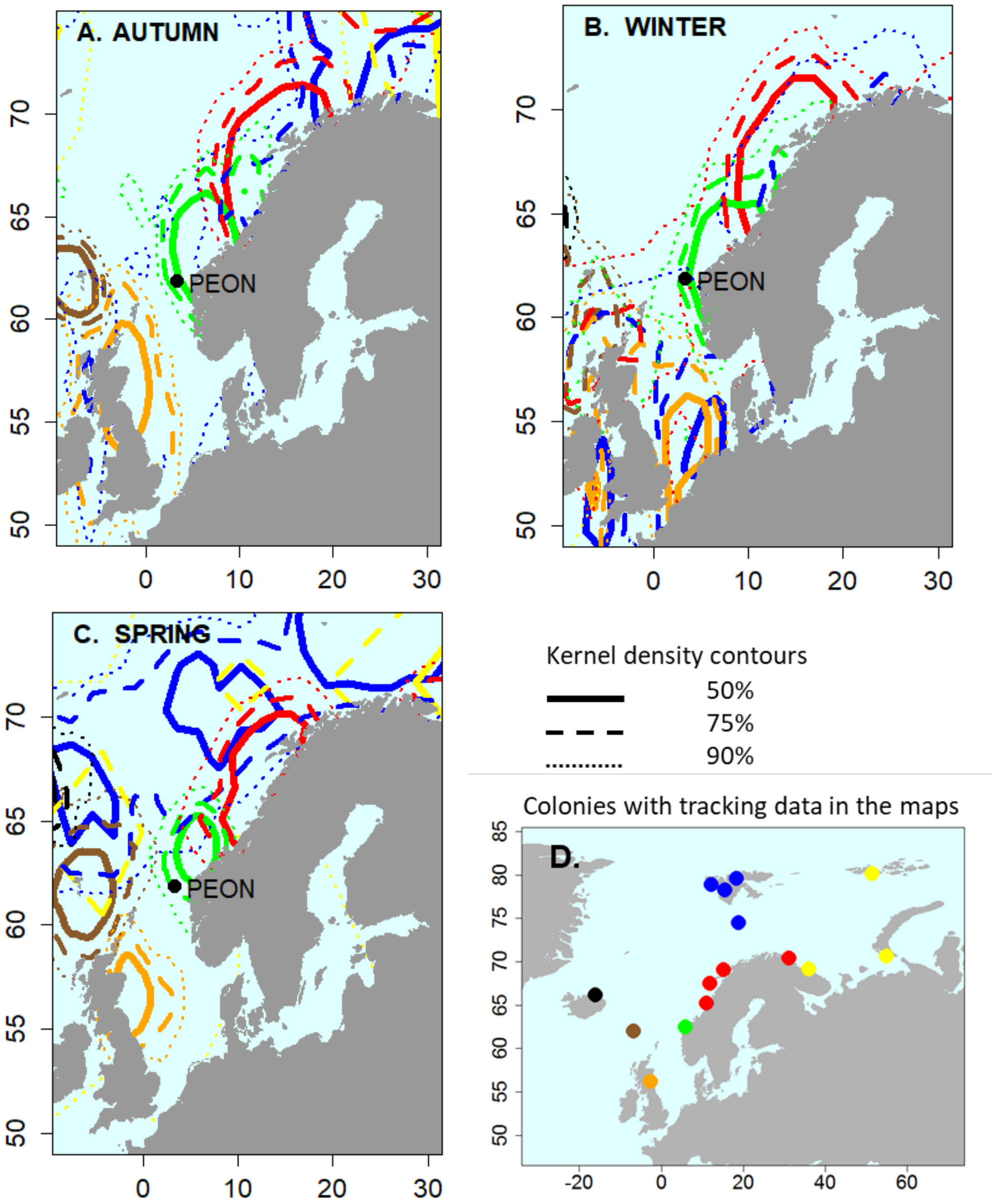

Figure 3.8. *Kernel contours (50, 75 and 90%) for kittiwakes during autumn (A), winter (B) and spring (C). Kittiwakes have been tracked with geolocators in the SEATRACK project from colonies (D) in South Norway (green), North Norway (red), Svalbard (blue), Russia (yellow), Iceland (black), Faroe Islands (brown) and the United Kingdom (orange).*

Based on this, we conclude that most of the kittiwakes using waters close to the Peon-discovery are from colonies in South Norway. During winter or spring some of the kittiwakes in the area most likely also stem from colonies in northern Norway, Svalbard and Russia. Unfortunately, no tracking has been done in Shetland. Shetland colonies are located quite close to the Peon-discovery (approximately 300 km). We therefore assume that some of the kittiwakes around the Peon-discovery can potentially belong to colonies in Shetland, as well. SEATRACK has only tracked breeding birds. Non-breeding adult birds and juveniles may have different distributions.

Some of the herring gulls from northern Norway migrate south to wintering areas in the North Sea, and we expect this to be the main reason for the higher densities of herring gulls estimated in this period around the Peon-discovery (**Figure 3.5 C)**.

3.3 Apparent fishing activity

Fishing activities are known to attract gulls, which feed on bycatch or leftovers of fish that are gutted at sea. According to the data from Global Fishing Watch, the fishing effort in the waters surrounding the proposed site for Peon is overall comparatively low (**Figure 3.9**). This may imply that Peon will be used by less gulls for resting purposes compared to installations located in areas with a higher fishing effort, e.g. further south in the North Sea or closer to the coast.

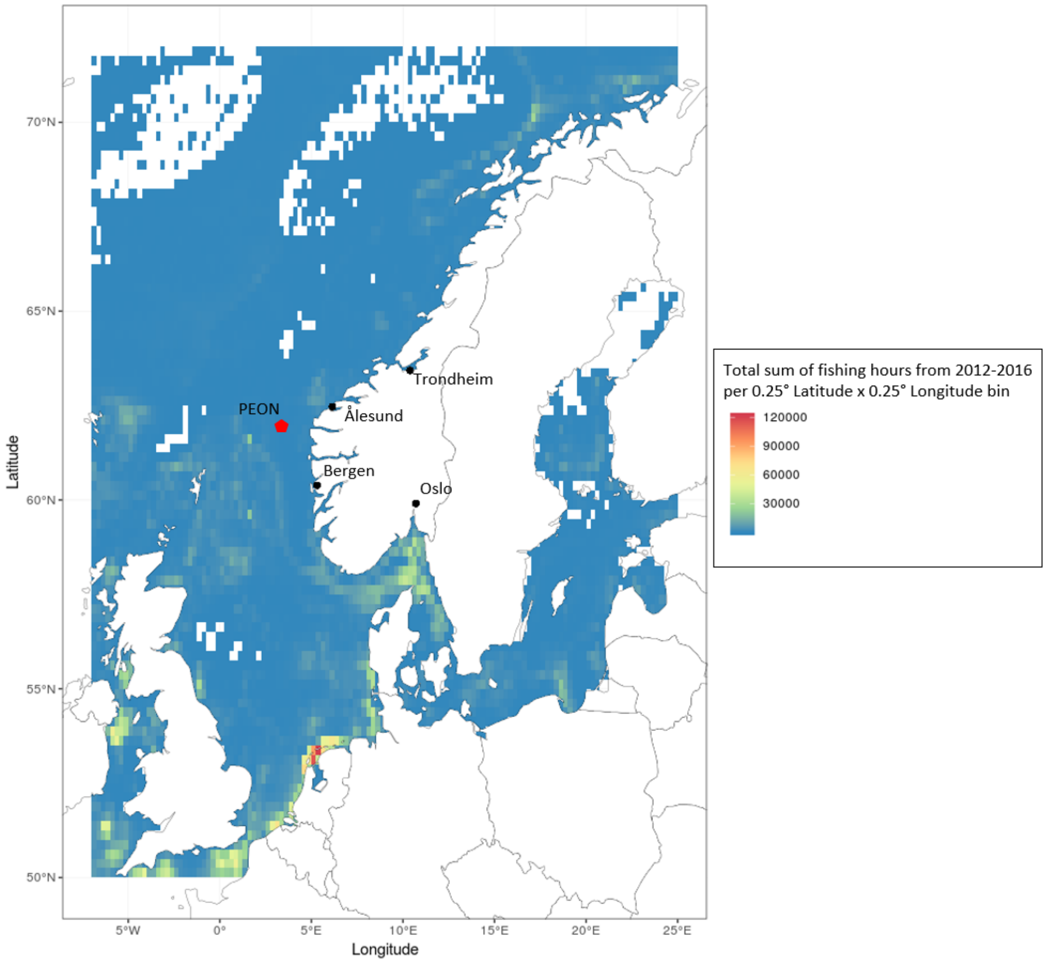

Figure 3.9*. Apparent fishing activity in the North Sea and Norwegian Sea based on information from the Global Fishing Watch. The apparent fishing activity in the Peon-discovery area is low compared to other areas in the North Sea. White areas indicate areas with no recorded fishing activities.*

Split by season, the highest fishing activity near Peon occurred in autumn, i.e. between September and November (**Figure 3.10**), and this is mainly by trawling (**Figure 3.11**). We may therefore expect the highest numbers of resting gulls on Peon in autumn.

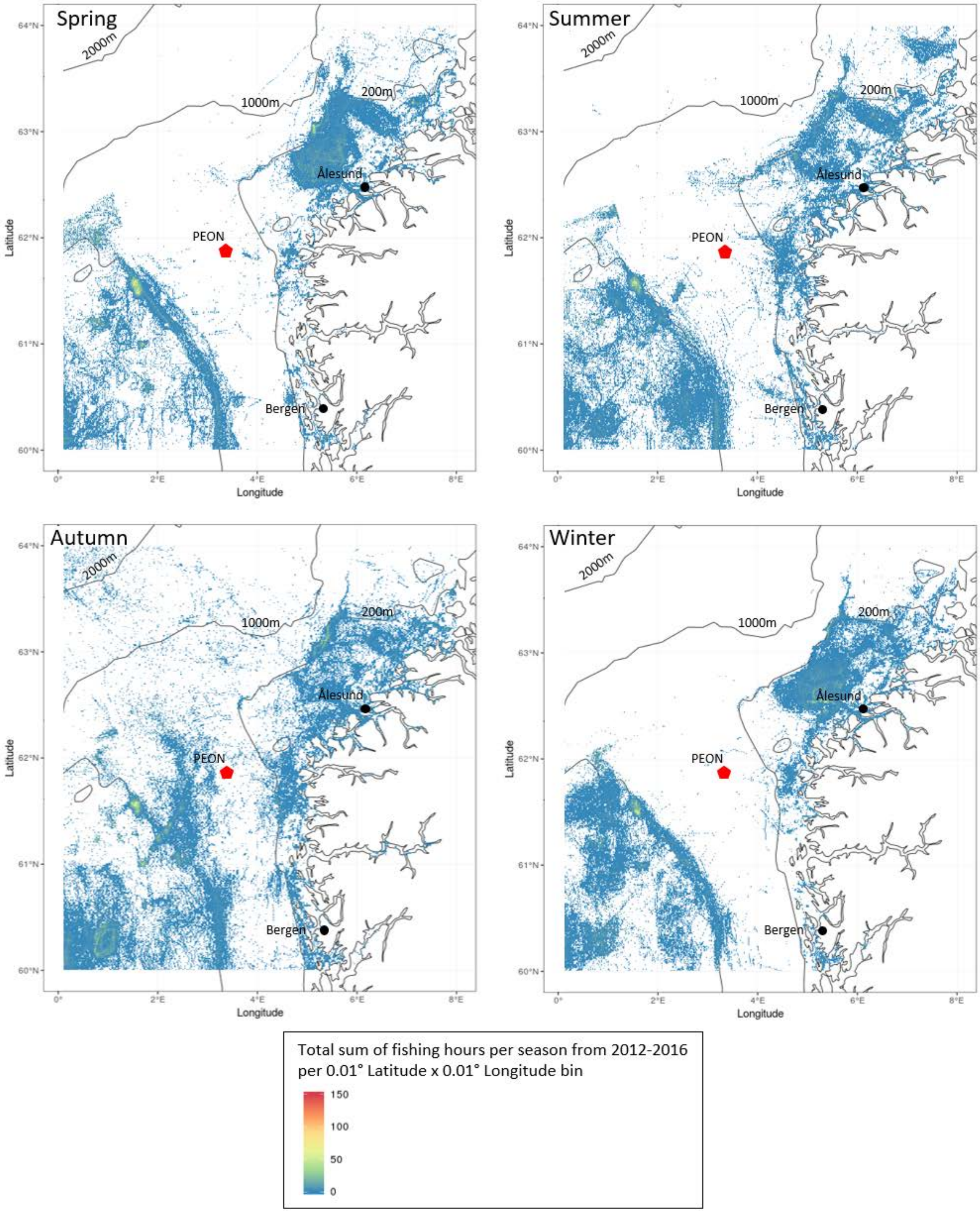

***Figure 3.10**. Apparent fishing activity split by season in the waters surrounding the proposed placement of Peon based on information from the Global Fishing Watch. The apparent fishing activity concentrates on the continental shelf. Increased fishing activity near Peon has been present in past years only during autumn. White areas indicate areas with no recorded fishing activities.*

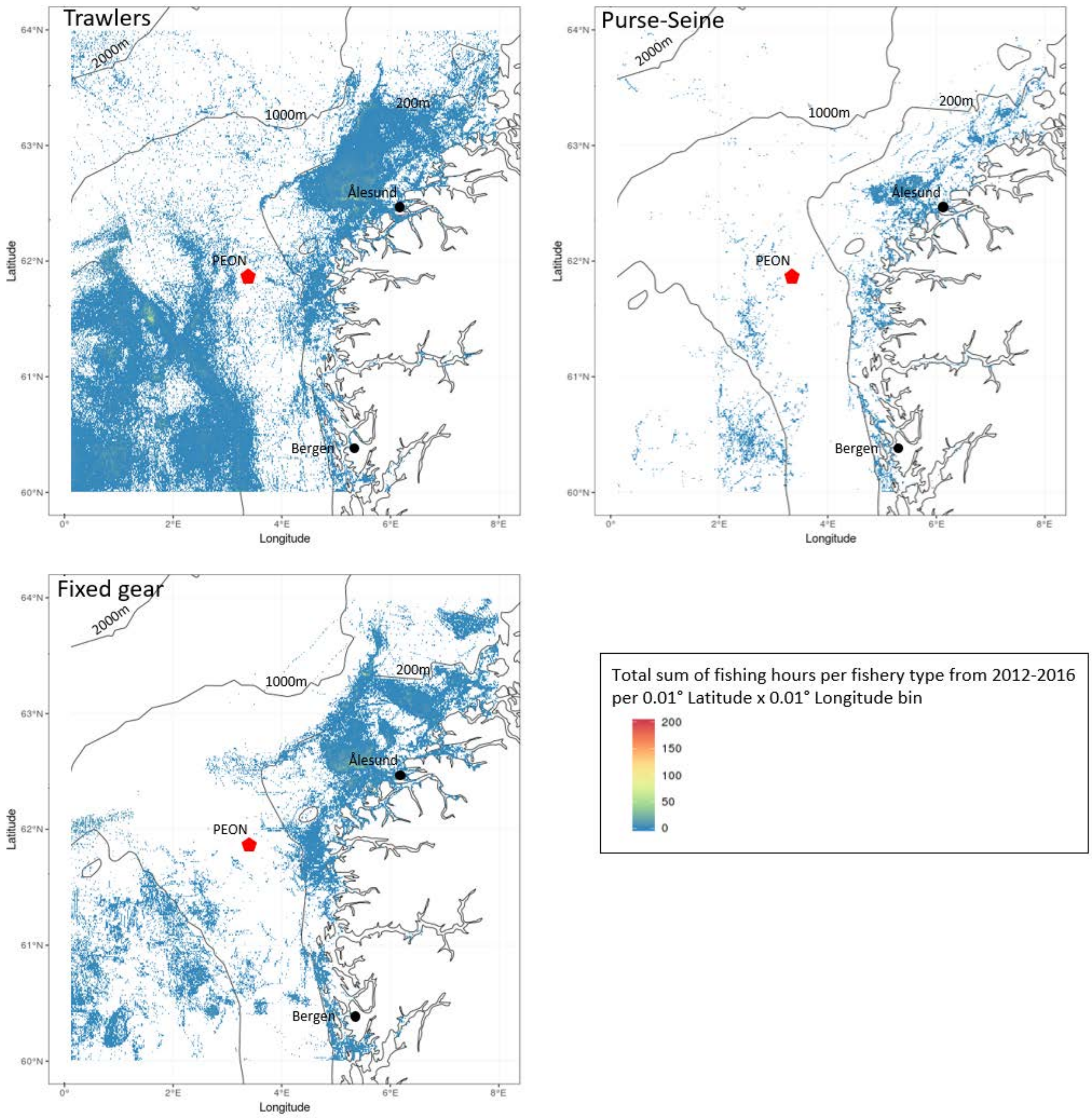

Figure 3.11*. Apparent fishing activity by the three main fishing types in the waters surrounding the proposed placement of Peon based on information from the Global Fishing Watch. Fishing by trawling is the dominating fishing type in the area. White areas indicate areas with no recorded fishing activities.*

3.4 Mitigation and deterrent methods

The results from the literature-review and the observations from offshore oil installations, showed that gulls are the most likely species group to pose problems on offshore unmanned installations that are placed at a distance from the coast, such as the Peon-discovery. The description of mitigation and deterrent methods is therefore focused on those best suitable to be used on gulls. Many of the methods, however, also work on other bird species.

3.4.1 Consideration of factors attracting gulls

A first step in mitigating the effects of gulls and reducing numbers of roosting gulls is to reduce – where possible – factors that attract gulls to installations. Light at night (through flares and lights on the installation) may attract zooplankton and fish to the surface and gulls have been observed feeding near oil installations in the shine of flares at night (e.g. Burke et al. 2005). Lights on installations should therefore be minimised as far as safety aspects (position lamps) permit. Discarding food offal or waste from recreational fishing activities has been observed to attract gulls to manned oil installations. For the case of Peon, being an unmanned installations, the distance to neighbouring installations and fishing activities, may therefore impact on the number of gulls present.

3.4.2 Acoustic-based deterrence

Distress calls of gulls, predator calls or a combination of both in varying succession have previously been used successfully to deter gulls from offshore installations, e.g. the BP Skarv field in the Norwegian Sea. The system provided by SEMCO Maritime combines a loudspeaker unit with a detection module, so that sound is only played if birds are in fact present (https://www.semcomaritime.com/en-en/bird-deterrent-system-product-information). While sound-based deterrence systems could be annoying for staff on manned installations, they appear to be highly suited for unmanned installations and the loudspeakers could further be deactivated during maintenance visits. This system can further be combined with an automated laser system (see below). SEMCO Maritime, however, suggested that to deter gulls, the sound-based system alone (without laser) is in most cases sufficient and the more economical solution. Additionally, for potential similar installations that are to be installed closer to the shore, SEMCO Maritime highlighted that great cormorants cannot be deterred by their sound-based systems, in which case they do recommend the use of laser systems.

3.4.3 Vision-based deterrence

Automated laser systems
Automated laser systems have been successfully applied on offshore and coastal installations to deter gulls from large open areas like helicopter landing platforms (e.g. by Mærsk Oil and Shell; see https://www.birdcontrolgroup.com/oil-gas/?utm_source=Markets%20homepage&utm_medium=Home-oilandgas). The laser system projects an object, point or line onto the ground, and is designed in a way that birds and humans cannot be blinded. According to one provider of laser systems, the Bird Control Group (www.birdcontrolgroup.com), some of the laser systems have been used for several years, and the company claims it is a long-term solution to which gulls do not habituate. However, in the Dutch harbour of Vlissingen, an automatic laser system did not succeed in deterring breeding lesser black-backed gulls (Prof. Wendt Müller, University of Antwerp, personal comm). Furthermore, the laser system is most effective at low light conditions during night or when it is overcast (SEMCO Maritime 2019; Prof. Wendt Müller personal comm.), which might be a problem during summer. SEMCO Maritime suggests the use of the laser system only in combination with acoustic deterrence, and only to deter both gulls

and great cormorants. To deter gulls only, the recommendation was the sound system on its own, since this is much more cost-efficient.

Bird Free Gel
Also referred to as "Bird Fire Gel", this is a sticky gel that emits UV light in a way that birds perceive it as a burning surface (https://www.insight-security.com/bird-free-fire-gel-where-to-use-it, **Figure 3.12)**. It further emits a deterring smell and taste. Active ingredients are peppermint oil and citronellal – the exact composition is confidential, but the product is classified as free of hazards under EC regulation 1272/2008, and registered under EU-number 0018311-0000. Bird Free Gel is sold in dishes that are easy to install and the gel is long-lasting (2 year guarantee; it has been effective more than 5 years after installation even in harsh outdoor conditions). Bird Free Gel is currently successfully in use on an offshore oil installation in the North Sea and has also been used successfully at other places to deter breeding kittiwakes and other gulls as well as roosting pigeons (see www.bird-free.com/case-studies). To be efficient against gulls, the manufacturer suggests a maximum distance of 40 cm between dishes with bird free gel (www.bird-free.com/installation-manual). This product may be a good solution for particularly sensitive, small-scale areas on an installation or handrails.

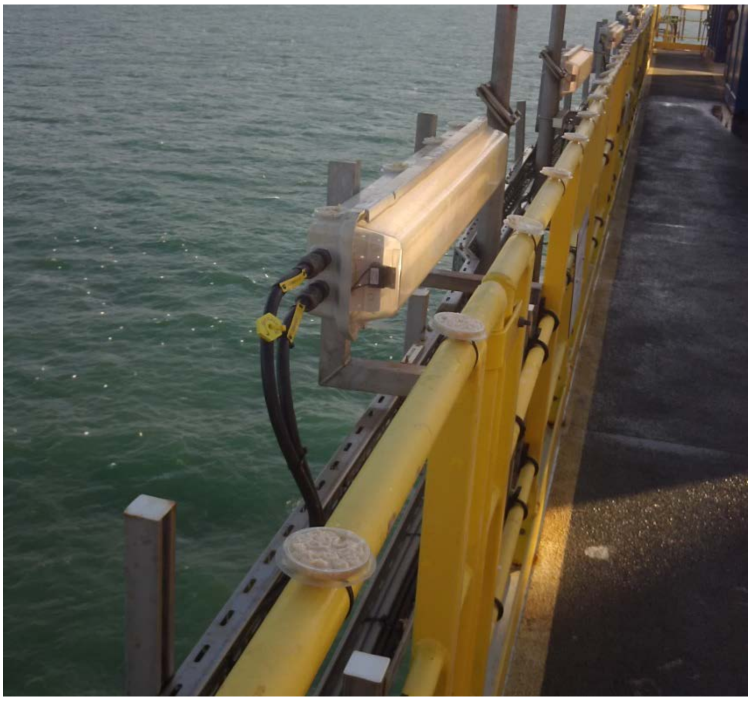

***Figure 3.12**. Example of "Bird Free Gel" installed on rail to keep birds from resting here (photo: © Bird Free)*

3.4.4 Physical deterrents

Nets or fence grating
Nets or fence grating that prevent access from certain areas of installations (e.g. staircases) are obvious mitigation measures for sensitive parts of the installation. Construction has to occur in such a way that birds may not get trapped in the fenced off areas or in netting. Nets and fence grating have to be maintained accordingly. Nets in aquaculture are, however, not used on sites with strong winds or where icing might be a problem. Fence grating might thus be a better alternative on offshore installations.

Spikes on surfaces
Vertical wire spikes (https://bird-x.com/bird-products/spikes/) limit perching options for birds and may be a deterrent option for specific sensitive areas of an installation (**Figure 3.13)**. However,

such wire installations pose risks for bird injuries and may furthermore hinder human access and pose a safety hazard also for maintenance staff. In addition, they may not hinder gulls from using the area, since kittiwakes have been found to build their nests on top of spikes (Newcastle City Council 2019).

***Figure 3.13**. Spikes installed on Heidrun to keep gulls from resting on rails. (photo: © Signe Christensen-Dalsgaard)*

Horizontally installed wires
Installations of overhead wires have been proven efficient to deter gulls feeding at landfills (McLaren et al. 1984) as well as roof-nesting gulls (Belant & Ickes 1996). Wires are installed on upright poles (2.5 – 10 m high), either in a parallel or a crossed design, with maximum spacing between wires of 16 m. This allows gulls to still enter and leave an area, but they appear to avoid areas with overhead wires. There is a risk of collision with wires and resulting injuries with fixed wires for gulls. This method can be suitable for large open areas.

Moving wire constructions
Similar to the horizontally installed wires there are commercial solutions for smaller areas available, in which wires are in addition moving with the wind, e.g. the "Bird Control Spider" (https://www.ornitec.de/produkte/bird-control-spider/kran-und-hebeanlagen/, **Figure 3.14**) or the "Bird Boggle" (https://www.boggle.at/?overview&lang=gb). The advantage of these options compared to horizontally installed wires is a lower risk of injury for gulls and easier installation in narrower spaces. Birds will not sit in the reach of the moving wire arms and the system therefore physically excludes gulls in the long-term from sitting in delicate areas. Bird Control Spiders are currently constructed only in plastic and can be easily mounted and removed. A stainless-steal version that would be suitable for use in the marine and offshore environment is under design.

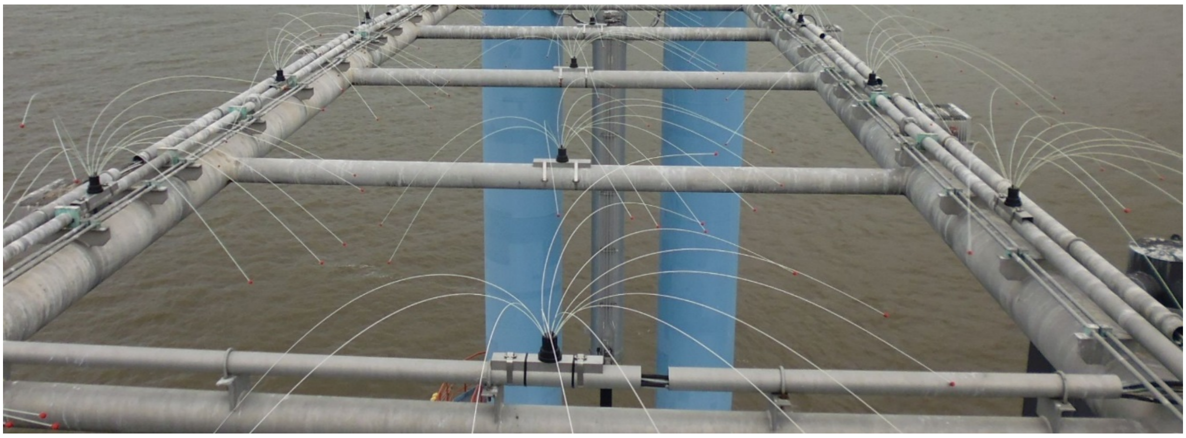

***Figure 3.14**. Bird Control Spiders mounted on a lifting unit at Airbus-Finkenwerder (Hamburg, Germany). (photo: © ORNITEC)*

Deterrence with electrical impulses

Electrical impulses are also effective successful deterrents without risking injury to the birds or habituation effects. The use of electrical systems can be used for the edge of an installations or a given area. Possibly, several rows of electrical system can be installed along the edge. A suitable system for offshore use is the OTES ceramic electro-system from the company Ornitec, which consists of sea-water resistant stainless steel as conductor and Cerdierit, a ceramics-product, which is long-lived also in coastal/offshore areas. Electric pulses of 3000 Volt / 0.6 Joule are created every 1.2 seconds. Since this is a high-voltage system, safety regulations need to be considered both for staff and regarding explosion risks.

4 Discussion and recommendations for deterrent methods

Bird utilisation of human structures is a well-known issue, causing considerable bird-human conflicts (Harris et al. 2016; Rock 2005). Offshore oil installations are no exception to this. It has been shown that birds use offshore installations as resting/roosting/breeding site (Ronconi et al. 2015; Christensen-Dalsgaard et al. submitted) and as a foraging opportunity (Fowler et al. 2018). Birds can further get attracted to installations by the illumination of either position lamps or the flare (Burke et al. 2005; Wiese et al. 2001). From a human perspective, the main conflicts are centred around the contamination of surfaces with bird faeces resulting in exposure to droppings and debris accumulation which in turn lead to health and safety concerns and possibly structural deterioration.

The Peon-discovery is located in the northern part of the North Sea, approximately 80 km from the Norwegian mainland. Situated in the middle of the Norwegian Trench, it is an area of low biological productivity compared to e.g. the coastal zone and the shelf edge. Based on the results from the analysis of foraging ranges of birds breeding on the mainland, seabird distribution at sea and the tracking data derived from light-level geolocators, it appears that the area is not commonly used by gulls throughout the year. The Peon-discovery is situated so far from land that it is not likely that breeding gulls will be present in the area during the breeding season. The exception from this is the pelagic feeding kittiwake, which can travel long distances from the colony during the breeding season (Christensen-Dalsgaard et al. 2018). The modelled distribution of seabirds based on boat surveys identified the highest densities of herring gulls, great black-backed gulls and kittiwakes in the Peon-discovery area during the winter months. Apparent fishing activity in previous years has been low in the Peon-discovery area for most of the year, except for autumn. Gulls that follow fishing vessels to feed opportunistically on offal may therefore get attracted to the area during autumn and might potentially stay into winter.

Our review of existing knowledge on birds on offshore installations showed that it is mainly gulls and passerines that are found resting/roosting on offshore installations in considerable quantities. As reported in the literature for other localities (e.g. Burke et al. 2005; Tasker et al. 1986) the patterns of bird attraction to offshore installations clearly varied across species and seasons. For passerines, the number of birds on installations showed a bimodal-distribution, with most birds present during the spring- and autumn migration. The information on passerines available, however, primarily originates from installations located further south in the North Sea. Based on the location of the Peon-discovery and known migration pathways (Poot et al. 2008), we expect that there will be less passerines migrating across this area. The gulls also showed a tendency of being more numerous during spring and autumn. In addition the observers reported variation in age composition of the birds present on the installations throughout the year, with less adults being present during the breeding season.

When considering the negative effects of birds on the working environment on oil installations on the Norwegian shelf overall, gulls stood out as the species group most commonly observed on and around the installation, and of which most conflicts were reported. This corresponds with results from other studies, showing large numbers of gulls around offshore installations. Based on these results, it therefore appears to be most important to consider methods of deterring gulls from the installations. Based on the feedback from the observers, the gulls will generally sit in areas with a horizontal surface where there is a good view of the surroundings, e.g. on the helideck, decks, railings, on top of pipelines and other structures, roofs and jackets. In addition, the wind direction and speed is important, with gulls generally preferring to sit with their heads against the wind. This is important when considering the different methods of deterring gulls from an unmanned installation.

Offshore oil installations can also function as a breeding habitat for kittiwakes. Christensen-Dalsgaard et al. (submitted) documented six installations on the Norwegian shelf where kittiwakes are breeding successfully. The results show that within just a few years of the construction of an offshore installation kittiwakes can start to establish a colony, as was observed on the Goliat installation in Finnmark. Kittiwakes have so far not colonised installations in the Norwegian sector of the North Sea, though the phenomenon has been documented on offshore oil installations in the Dutch sector of the North Sea (Camphuysen & Leopold 2007; Geelhoed et al. 2011). Consequently, the possibility of kittiwakes colonising Peon, or similar installations in the North Sea, cannot be disregarded. Considering the lack of kittiwakes breeding on the installations in the vicinity of the proposed locality of the Peon-installation, we do however not consider the risk of breeding activity on the installation as imminent. When considering possible mitigating methods to avoid conflicts connected to birds on offshore installations in general, it is however important to consider the possibility of kittiwakes establishing breeding colonies. The experience from offshore installations where kittiwakes have establish breeding colonies, is that kittiwakes can build nests on most types of horizontal ledges, both on the sides of the installation and in the area between the topside installation and the shaft.

4.1 Deterring gulls from specific areas of conflict

In dialogue with Equinor, specific areas of potential conflict were identified. These included 1) stairways, 2) Walk-to-work landing platforms, 3) balconies used for lifting of goods, 4) hand rails, 5) horizontal ledges and 6) the weather deck (**Figure 4.1**). Strategies to control the gulls utilising the installations can be directed at the gulls' visual, auditory and tactile senses. A reduction of potential problems can also be achieved through habitat modification where the placement of physical barriers prevents birds from perching on the structures. There appears to be no single best deterrent method, and the method of choice depends very much on the construction of the installation. For example, staircases could be fenced in to physically restrict access for gulls. For sensitive areas on the rails, Bird Free Gel or Bird Control Spiders could be suitable options. For larger open spaces such as the weather deck (or on manned installations the helicopter deck), a sound system, possibly in combination with a laser might be the most suitable option. Sound systems – in combination with a detection system to trigger the start of the loudspeakers – were rated as highly effective to deter gulls. A specialised company selling both sound and laser systems recommended the use of laser systems only for the case of expected problems with cormorants in addition to gulls, also since laser systems have only limited effectiveness in daylight conditions and are substantially more expensive. Habituation is a potential issue with most of the proposed deterrent methods, and it is difficult to foresee if gulls may over several years habituate to the installed deterrent systems. To reduce the risk that birds get used to one deterrence method, it appears useful to combine two methods and to trigger systems with sensors (e.g. radar or visual), so that sound only is activated once birds land on the surface. Finally, it may be useful to design a follow-up study that investigates the long-term effectiveness (> 5 or 10 years) of applied deterrent methods.

The problem with habituation of gulls to deterrent methods will depend on the exchange rate of gulls sitting on the installations. Observers have seen gulls flying far away from the installation, further than they can follow them with binoculars. When gulls later (same day or at a later date) rest on the installation, it is not possible to tell if it is the same gulls returning to the installation, or new ones. It the exchange rate is high, there might be less problems with habituation.

4.1.1 Stairways

The most suitable method for stairways is to physically restrict access for birds by installing fence grating around the entire stairways, with doors at the bottom and the different decks. The size of the grating should be sufficiently small to limit access for gulls but also passerines. Alternatively, if a larger grating is used, where it might be possible for passerines to get through, escape routes for the passerines should be established.

4.1.2 Walk-to-work landing platforms

The three walk-to-work landing platforms at the walk-to-work deck of the installation to facilitate entering by ship for maintenance visits are likely attractive roosting places for gulls. Due to their size, the loudspeaker option appears to be the most suitable deterrent option for this part of the installation.

4.1.3 Balconies used for lay down areas and lifting of goods

Similarly to the walk-to-work landing platforms, the balconies on each of the levels used for lifting goods on and off (landing area) could be attractive roosting places. Once more, deterrence with a loudspeaker system is an option (possibly coupled with a detection system for all different levels). Bird Control Spiders installed on the hand rails on the outside of the balconies could be a more economically feasible alternative, and these could be easily dismounted or neutralised during maintenance visits.

4.1.4 Hand rails

There are several possible deterrent methods for the hand rails on the outside of each of the decks and balconies. Independently of the chosen deterrent method, hand rails should ideally be painted with a smooth paint that facilitates the washing off of bird faeces with sea spray and rain which reduces the risks of corrosion. Dishes of bird free gel spaced out at 40 cm intervals on the top bar of the hand rails are one option to deter gulls. Alternatively, a thin wire installed few centimetres above the top bar will prevent birds from landing. By placing extra bars or wires between the deck and top bar of the hand rails, the design of hand rails can furthermore be adapted so that gulls cannot sit comfortably on lower bars. A final option could be to design handrails not with round bars, but in triangular shape, with the sharp edge pointing towards the top. This may, however, also make the use of handrails more difficult for humans and thus pose a concern for work health and safety.

4.1.5 Horizontal ledges

Horizontal ledges resemble the natural nesting habitat of cliff-breeding kittiwakes. By avoiding horizontal ledges in the construction process of an installation, future risk of colonisation by kittiwakes can therefore be minimised. Infilling of spaces in the structure to make the outside of an installation smooth or consist only of vertical ledges could be one option to minimise potential breeding habitat for kittiwakes. Remaining horizontal ledges should be treated with anti-corrosive paint or cement (material-dependent) since these are high-risk areas for corrosion – both from bird faeces and accumulating sea salt.

4.1.6 Weather deck

For the wide open space on the weather deck of the installation, the sound-based deterrent method appears to be the best suited method to deter gulls.

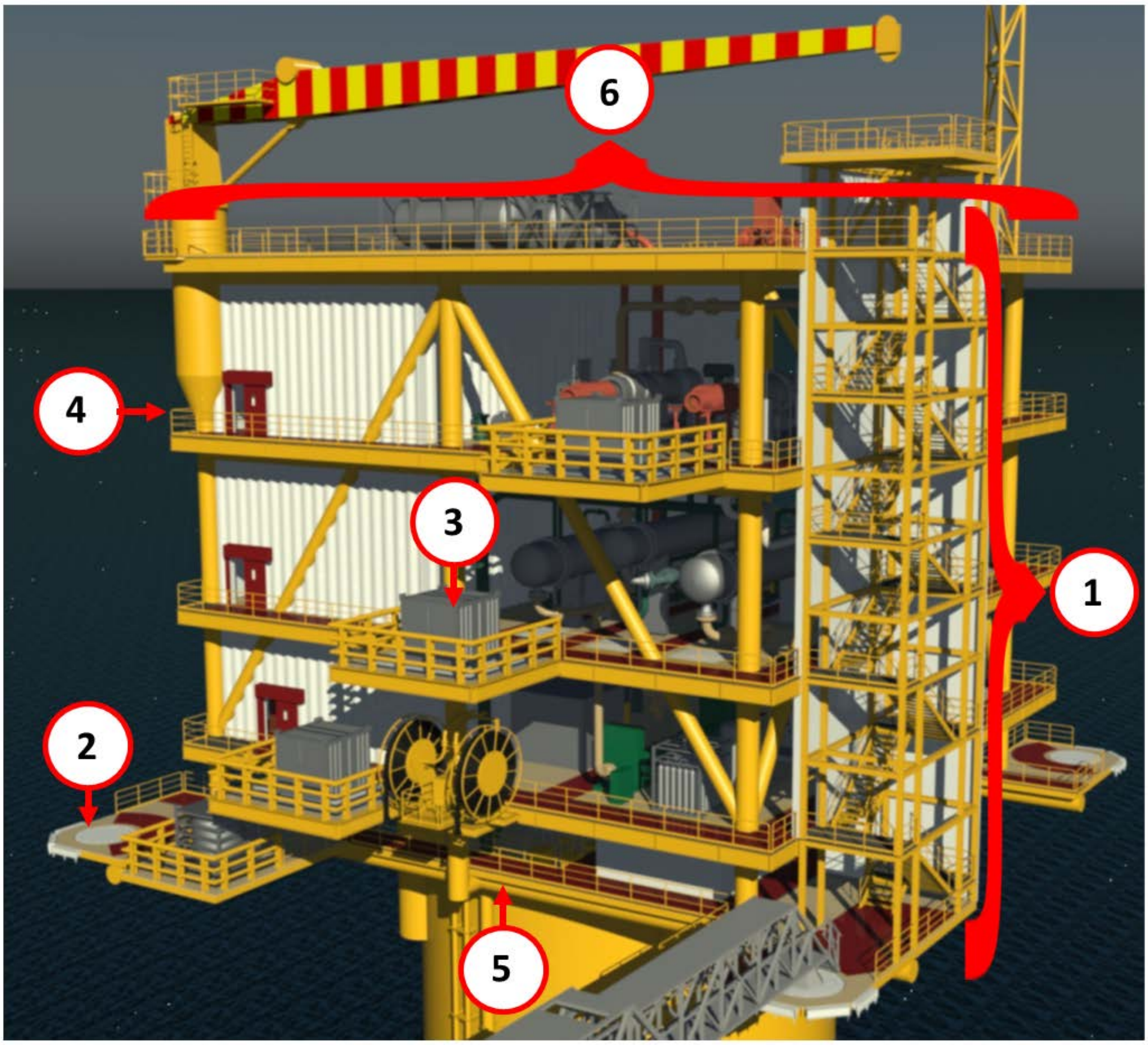

***Figure 4.1**. Constructional sketch of Peon. The design is subject to change based on ongoing planning. Numbers refer to potential conflict areas with resting gulls: 1) stairways, 2) walk-to-work landing platforms, 3) balconies used for lifting of goods, 4) hand rails, 5) horizontal ledges and 6) weather deck. (illustration: © Equinor)*

4.2 Other considerations

Since the design of Peon has not been finalised, the above suggested deterrent methods are based on the preliminary constructional sketches and the identified areas of conflict. Based on the planning, the construction design and thus conflict zones, might inevitably still change, in which case deterrent methods would have to be re-considered. Generally, a design that minimises the risk of bird faeces but also water to accumulate (e.g. on horizontal ledges, balconies and the weather deck) reduces corrosion of the installation and would therefore be beneficial.

Gulls, being the most likely group of bird causing conflicts on offshore oil installations, are intelligent and opportunistic animals and are known to habituate to various disturbance methods, which is why long-term deterrence can be challenging. Deterrent actions against gulls in other places, e.g. roof-nesting gulls in cities near the coast, have frequently simply caused the gulls to move to other available, less disturbed places. Deterrent actions in one place may therefore increase problems in another place, without solving the overall problem of gulls in a given area, if this is e.g. a highly profitable foraging area for gulls. Even though the areas of the Peon-discovery appears to be less attractive for gulls than the locations of other offshore installations, it is questionable whether a 100% bird-free oil installation is realistically achievable. Given this consideration, it might be worthwhile in the construction of the Peon-installation to consider having a designated bird area, where birds can roost undisturbed (preferably areas that will not have to be accessed for maintenance) and do not cause conflicts (e.g. structurally reinforced to avoid corrosion of material). Such an area might be best suited under the lowest deck of Peon. Having a designated bird area would very likely reduce the pressure on other, more sensitive parts of the installation, so that deterrent methods will work more effectively there.

Finally, to reduce the already relatively low risk of attracting birds to Peon through light at night, and the even lower risk of incinerating overflying birds by flaring, we recommend to flare gasses only in daylight conditions, if technically feasible.

4.3 Transfer of knowledge to future installations

The focus of this project report was on the Peon-installation, a possible future unmanned offshore installation in the northern North Sea, located 80 km away from land and 30 km away from the nearest manned oil installation. While much of the knowledge in this report can be transferred to other installations, the specific location and situation of the proposed Peon-installation being unmanned and far away from other manned installations does present a special situation.

Firstly, installations situated closer to shore will likely experience more activity of birds and possibly different species. For example, great cormorants are likely visitors that can sit and rest on installations, and also feed on fish attracted by the hard substrate of the installation. Observers on installations closer to shore have in fact reported great cormorants and specifically many immature birds.

We furthermore expect the number of birds in general, specifically gulls, to be higher in areas where food is more available, e.g. on the shelf in the southern part of the North Sea. Similarly, the overlap with the primary migratory routes of passerines, is likely larger in other areas, which can affect the amount of passerines being present at installations.

Further, as already outlined above, manned installations can be attractive for gulls due to increased food availability (e.g. waste treatment, fishing activities by staff). If future unmanned installations are placed close to manned installations, it is therefore possible that gulls will prefer the less disturbed unmanned installations as resting places – a phenomenon seen in the aquaculture industry.

5 Further evaluation and testing

It is important to emphasise that the conclusions in this report are based on existing knowledge. As there have not been any dedicated studies of seabird distribution in the area of the Peon-discovery, we had to rely on information from other studies, primarily from further south in the North Sea. In addition, the information on occurrence and species composition of birds on offshore installations is based on opportunistically collected data from a range of different installations. It is therefore possible that there are local conditions that we have not been able to account for.

Additionally, the information on the functionality of deterrent methods summarised in the report partly derives from the producers, and consequently cannot be considered as objective. Objective testing of the effectiveness of the here proposed deterrent methods and potential habituation effects would therefore be desirable. This could be achieved by monitoring the presence of birds in different areas of the installation using video/camera monitoring. For example, for the hand rails, Bird Free Gel and wire could be installed at different places to see which deterrent method is most effective. Similarly, the success of the sound system could be monitored. It would be desirable to conduct such follow-up studies for multiple years to assess potential habituation effects.

Furthermore, there is at present a lot of uncertainty about the pH value of seabird faeces and their corrosiveness on various materials (e.g. aluminium alloys) due to either pH or contained chloride. When testing corrosion effects, it is important to use faeces of the relevant seabird species from their natural environment, since diet has been shown to affect the chemical properties of bird faeces (Spennemann & Watson, 2017). Furthermore, tests should be conducted with both fresh and dried faeces, again due to changes in the chemical properties of faeces (Wurster et al. 2015). Besides studies in a controlled lab environment (i.e. same temperature, same amount of faeces of the same chemical properties), it is also worth considering the effect of bird faeces on materials under more realistic conditions (changes in temperatures, exposure to rain water, sea spray and solar radiation). This could be possible by fixing plates of potential construction materials in conflict areas with gulls on existing offshore installations, e.g. on Heidrun. Since corrosion is acting over time, we recommend to fix multiple small plates (e.g. 20 x 20 cm) of the same construction material in an area colonised by birds and expose plates for a different duration of time to bird faeces (e.g. 6 months, 1 year, 2 years etc.). In the same manner, the effectiveness of anti-corrosion paint could be tested. Additionally, the amount of corrosion can already now be measured in areas that have been exposed to bird faeces during the lasts years.

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