Breeding Behaviour and Health & Safety Implications of Kittiwakes Nesting on Offshore Substations Surrounding Walney Two Windfarm.

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Contents

Glossary of Abbreviations

AON	Apparently occupied nest
CTV	Crew Transfer Vessel
CWT	Cumbria Wildlife Trust
IOV	Inter-observer Variation
NE	Natural England
OFTO	Offshore Transmission Owner
OSS	Offshore Substation
OWF	Offshore Wind Farm
RSPB	Royal Society for the Protection of Birds
WODS OSS	West Of Duddon Sands Substation
WOW01 OSS	Walney One Offshore Substation
WOW02 OSS	Walney Two Offshore Substation

1. Introduction

Climate change presents an intensifying threat to society and biodiversity across the globe (IPBES, 2018; IPCC; 2023 UNFCC, 2023). Biodiversity loss is an equally significant threat and exacerbates climate change by deteriorating the ecosystem services that support life on Earth, e.g., biological carbon sequestration (WWF, 2020; Burns *et al.,* 2023). To mitigate climate change and provide an alternative to pollutive, finite, fossil fuels, renewable energy development has become increasingly prevalent (IRENA, 2023; UN, 2023). The United Kingdom (UK) Government aims to install 50 GW of offshore wind energy by 2030 (DESNZ & DBT, 2023), in the context of its commitments to international climate agreements, including the 2015 Paris Agreement of limiting global warming to 1.5°C and achieving net zero by 2050 (HM Government, 2021). However, the development of renewable energy can result in adverse environmental impacts, which are identified and assessed through Environmental Impact Assessments (Gasparatos *et al.,* 2017; Gibson *et al.,* 2017; Nazir *et al.,* 2020). Nonetheless, there is a growing evidence base showing that renewable energy infrastructure can also provide habitats for species and opportunities for biodiversity enhancement (Glarou *et al.,* 2020; Cale and Churn, 2021; Lemasson *et al.,* 2024). Understanding the interactions between biodiversity and renewable energy is crucial to enabling a renewable energy transition that mitigates climate change whilst supporting biodiversity's recovery. In particular, the emergence of ecological compensatory measures within development consents (Ørsted, 2021) and early policy developments for Marine Net Gain (DEFRA, 2023) present the need for further research into impacts of renewable energy within the marine context.

Black-legged kittiwakes (*Rissa tridactyla*, henceforth referred to as kittiwakes) were first surveyed on an offshore substation of Walney 2 Offshore Wind Farm (OWF) in 2023 (Peyton-Jones and Rounce, 2023). Kittiwakes are now listed as vulnerable on the International Union of Conservation Nature Red List and the Birds of Conservation Concern Red List, due to global and UK population declines associated with widespread breeding failure (Mousley and Kershaw, 2023). This species is considered to be especially vulnerable to the impacts of wind farms (Mousley and Kershaw, 2023) due to their typical flight heights overlapping with blade swept zones of OWF turbines (Furness *et al.,* 2013). The colony on this substation presents a unique opportunity to monitor kittiwake nesting behaviour on offshore artificial nesting sites within OWF arrays. Researching this colony could provide vital insights into kittiwake ecology and kittiwake interactions with OWF infrastructure. Such findings could help inform the effective implementation of artificial nesting structures (ANSs) as ecological compensation for renewable energy developments. This is especially relevant given Ørsted's recent development of the first ANSs for ecological compensation (Ørsted, 2022).

In 2023, the colony on the offshore substation of Walney 2 OWF (hereafter referred to as WOW02 OSS) was studied for the first time, with a scientific report subsequently published: *Kittiwake Nesting Behaviour on Walney Two Offshore Substation: Data and Recommendations* (Peyton-Jones and Rounce, 2023). In 2024, a second investigation was requested by Ørsted and Natural England to build on the report from 2023, following its recommendations and developing a longer-term monitoring campaign that can provide further insights into the colonies' breeding behaviour and its wider implications; the results of which are the subject of this report.

The 2023 report should be referred to for an introduction to kittiwake ecology, pressures on kittiwakes, offshore wind compensation opportunities and Walney Two Offshore Wind Farm and Substation. Peyton-Jones and Rounce (2023) identified the nearest land-based kittiwake colony as the St Bees colony, approximately 60km from WOW02 OSS (Figure 1).

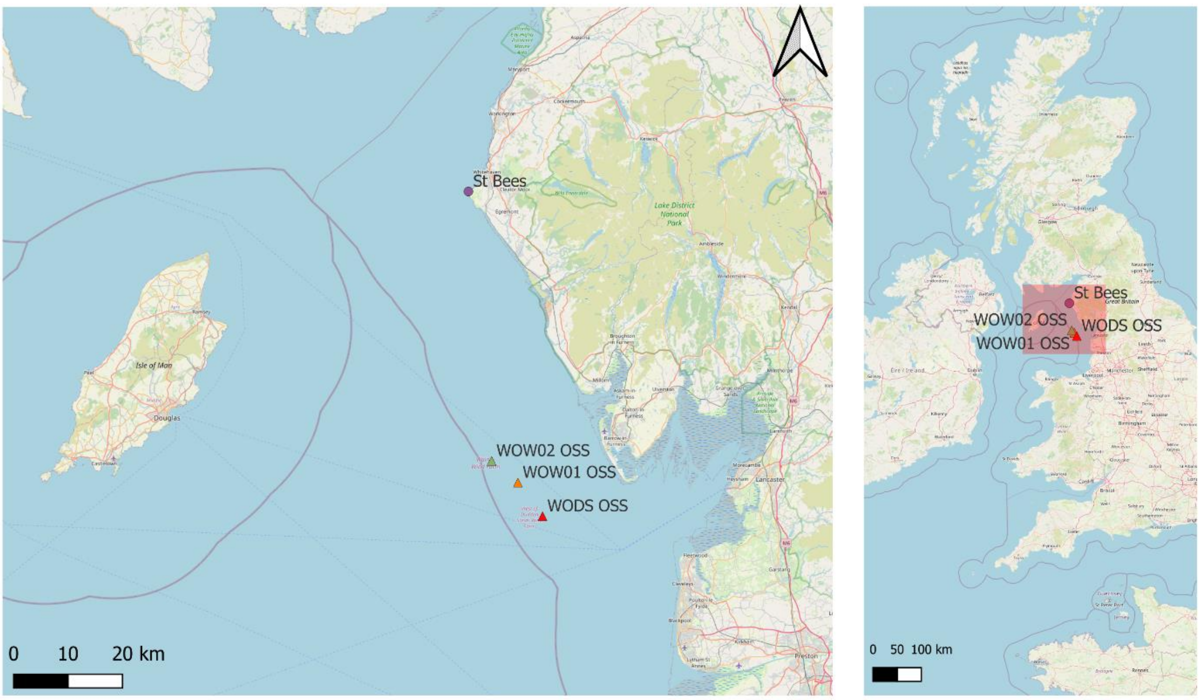

Figure 1. Locations of the offshore substations considered in this study, i.e., West of Duddon Sands offshore substation (WODS OSS), Walney Two offshore substation (WOW02 OSS) and Walney One offshore substation (WOW01 OSS), and St Bees: St Bees being the nearest land-based kittiwake colony, approximately 60 km distant from WOW02 OSS.

2. Aims and Objectives

2.1 Development of Project Aims

The aims of this project were informed by the recommendations set out in the preceding report. In addition, new areas of enquiry were identified throughout the project, which were incorporated into the aims:

- Health and safety implications of the kittiwake colony being present on the substation was highlighted as a necessary area for investigation. Although biodiversity enhancement is a priority for future renewable energy development, renewable energy infrastructure must remain a safe working environment. Understanding the health and safety implications of the kittiwake colonies on the substation could provide vital insights to ensure a safe working environment of Offshore Transmission Owner (OFTO) technicians and, in turn, the sustainable operation of the OWF assets.
- The offshore substation of Walney 2 OWF (WOW02) was the main focus of the 2023 report. The preliminary survey in 2024 also found kittiwake colonies on the substation of Walney 1 and West of Duddon Sands (hereafter referred to as WOW01 and WODS OSS, respectively). On recommendation from Natural England, these two colonies were also counted on subsequent surveys when possible, in addition to the colony on WOW02. This provided the opportunity for comparisons of colonies between different substations.
- Early investigations revealed limitations and challenges within the survey methods, which prompted the need to evaluate the approach to inform more reliable data collection from longer-term monitoring of the kittiwake colonies.

2.2 Aims

This project aims to:

1. Investigate the breeding behaviour of kittiwakes nesting on the offshore substations: WOW01 OSS, WOW02 OSS and WODS OSS.
2. Evaluate the survey method used to conduct counts of these kittiwake colonies to develop a robust approach for longer-term monitoring of these kittiwake colonies.
3. Investigate the health and safety implications of these kittiwake colonies.
4. Utilise the findings to provide recommendations for future management and research.

2.3 Objectives

To achieve these aims, the following objectives were set out:

1. Estimate the number of adults, fledglings and nests present within each colony to assess productivity.
2. Analyse and compare the productivity and distribution of the three colonies.
3. Collate and analyse qualitative evidence of the health and safety implications.
4. Provide a list of recommendations from the findings to inform management and research, including a standardised method for future surveys.

3. Methods

3.1 Data Collection

The method used to collect data on the kittiwake population was based on the method described in the 2023 report (Peyton and Jones, 2023), to allow for reliable inter-annual comparisons.

Surveys were conducted at Walney Two Substation (WOW02 OSS) on the 29th May, 8th July and 30th July 2024. Additional data from Walney One Substation (WOW01 OSS) and West of Duddon Sands Substation (WODS OSS) was collected on the first and third survey dates. These surveys were carried out from the deck of a crew transfer vessel (CTV) motoring around the substations at a slow speed, maintaining a distance of approximately 100 m from the platform to minimise disturbance. At each side of the substation, photographs were taken using a DSLR camera with 70-300 mm stabilised lens. Photographs were taken with the aim of capturing a full aspect image for each side, as well as further zoomed in images breaking down the different layers so that these images could be used at a later date to conduct accurate counts. Backup counts were conducted in person on the vessel using binoculars: the numbers of adults, fledglings and nests on each side were recorded. Sea state, weather conditions, and direction of travel were also recorded.

The substation aspects were categorised as northside, eastside, southside, westside and underside and separated further by horizontal layers: top, middle and bottom. Identifying features such as the tank on the southside were used to orientate which aspect observers were viewing (Figure 2). The underside was analysed as a side opposed to a level to allow for consistency with the approach used in 2023. Dividing the underside counts by aspect (i.e., if the underside is analysed as a layer) proved challenging as the orientation of images of the underside was not always easily interpretable.

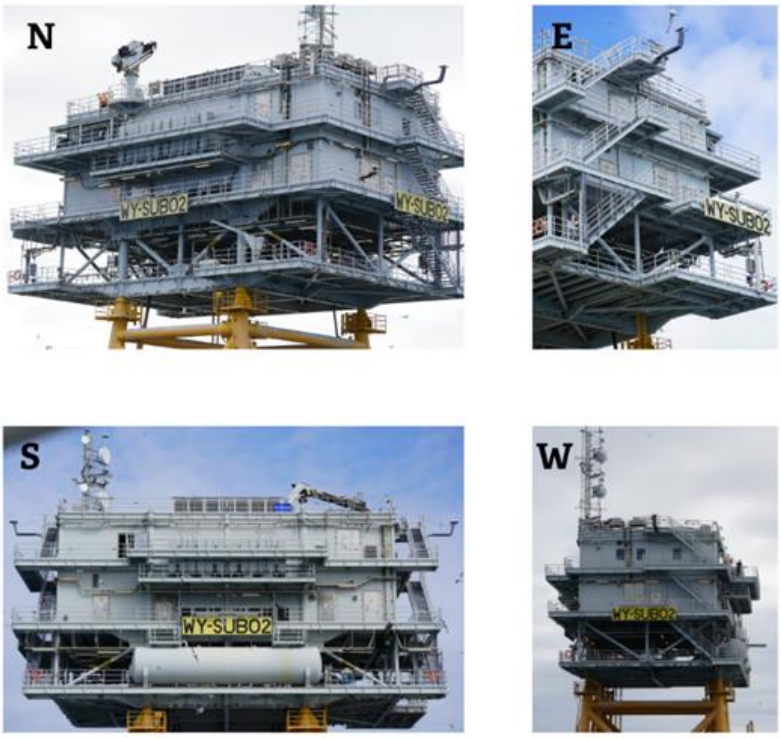

Figure 2a. WOW02 OSS sides with their identifiable features. Northside (N): identifiable as one of the larger sides with a crane at the top and no tank. Eastside (E): mooring ladders on yellow structural supports and stairs going up the left side. Southside (S): large side with a storage tank at the bottom. Westside (W): with satellite tower on top and stairs up the right side.

Figure 2b. Image of WOW02 OSS exemplifying how the substation was divided into sides according to aspect and the underside: southside (yellow), eastside (red) and underside (blue).

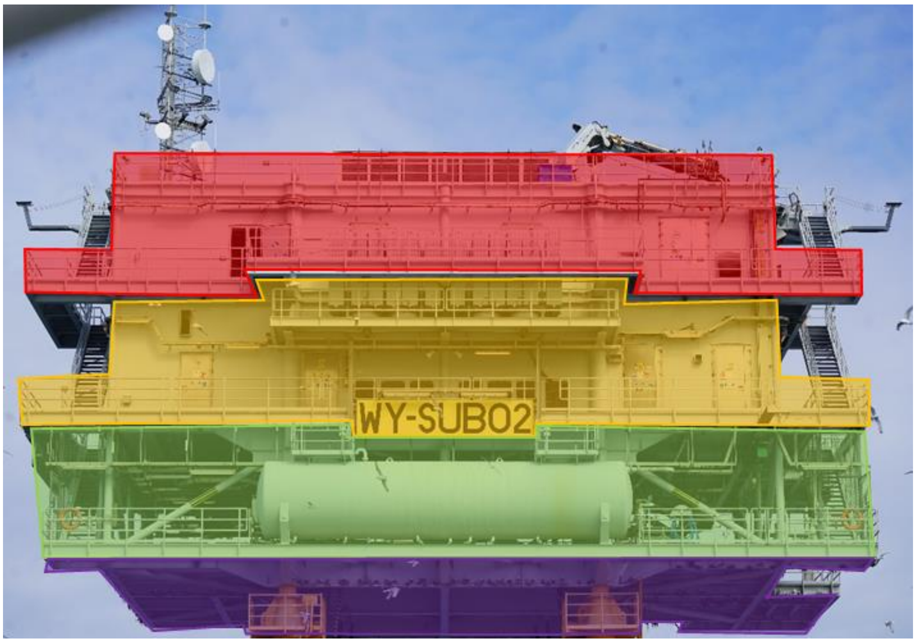

Figure 2c. Image of WOW02 OSS southside exemplifying how the substation was divided into layers: top (red), middle (yellow) and bottom (green) layers. The underside (purple) was categorised as a side.

Figure 2d. Image of WOW02 OSS northside exemplifying how the substation was divided into layers: top (red), middle (yellow) and bottom (green) layers. The underside (purple) was categorised as a side.

The southside and northside have been split in slightly different ways, due to the presence of the storage tank on the southside. The tank provides a degree of shelter for the lowest ledge, which is otherwise exposed on the northside. Because of this difference, and the hypothesis that the underside may be preferred for nesting thanks to the shelter provided, the lower ledge on the north side was classed as part of the bottom layer, whilst the area under the tank on the southside was classed as part of the underside. This difference can be seen in Figures 2c and 2d.

3.2 Survey Date Details

3.2.1 Preliminary Survey 29th May 2024

On the 29th May 2024, a preliminary survey was carried out to establish the optimum timeline for the monitoring surveys. The date of this survey was selected based on the 2023 survey findings. Observations on the day indicated the colony was not as advanced in the breeding season as expected, as most pairs were seen guarding and building nests rather than incubating. On this survey date counts were conducted at WOW02 OSS (the original focus of the 2023 study) and observations were made of WOW01 OSS while passing. The observer from Natural England suggested that future surveys should attempt to count at more substations, where kittiwakes have been noticed. Following the preliminary survey, it was recommended that the second monitoring date ideally be conducted between the 19th and 26th of June, to allow for pairs to be incubating full clutches. The third monitoring date to confirm productivity was recommended to then take place 35 days later, coinciding with the week before fledging of most chicks.

3.2.2 Survey on 8th July 2024

Due to poor weather and vessel availability, the second survey was delayed to July 8th. Counts were only conducted at WOW02 OSS on this date. A few fledglings were observed, but most of the breeding pairs were seen to be incubating, while a few were still observed copulating.

3.2.3 Survey on 30th July 2024

WOW02 OSS was the main priority for this survey, so counts of adults, fledglings and nests were conducted and photographs taken of all sides and layers of this substation. At this substation it was observed that fledglings were present, though none were seen flying or leaving the ledges. WOW01 0SS was surveyed in a similar manner, though in person counts were not conducted as time pressure meant the main focus was getting photographs for later analysis. This technique was reciprocated at WODS OSS, where there were notably fewer birds present but photographs were still taken.

3.3 Counts Method

Counts were conducted from the photographs taken on survey days, using the software DotDotGoose (version 1.7). Images for counts were selected to ensure all angles and ledges of the substation were covered. While selecting images for use, a drawing of the underside (Figure 3) of the substation was used to ensure all angles and ledges were suitably represented.

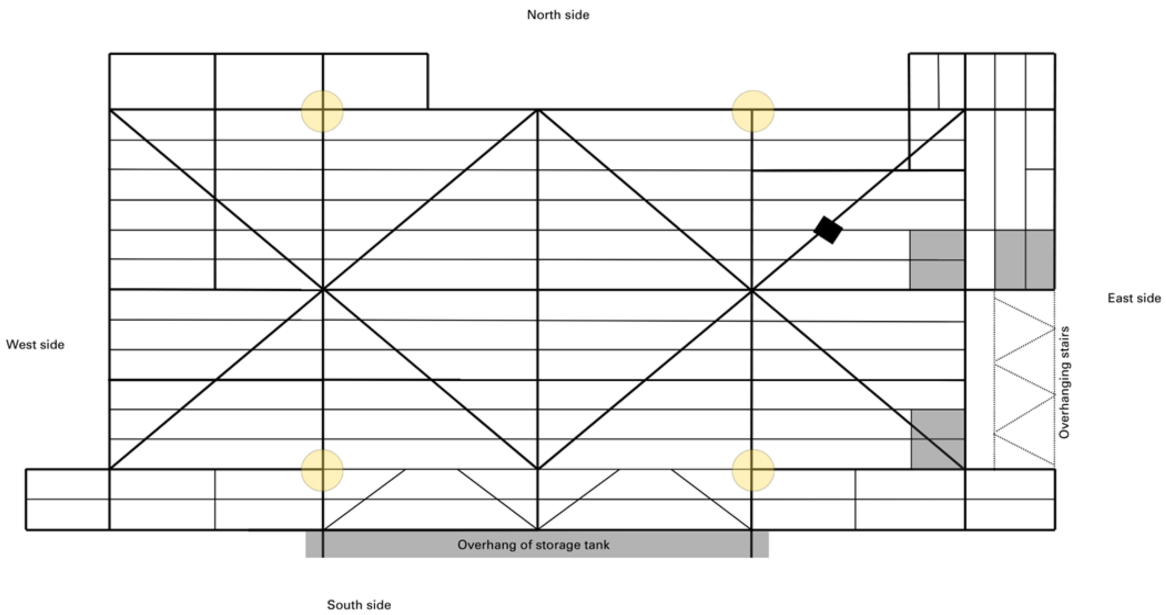

Figure 3. Map of the underside that was used for keeping track of photographs of different ledges.

When analysing the images, counts were split based on the side of the substation and layer of each side.

3.4 Calculating Productivity

Productivity was calculated as a recommended indicator to assess population changes and breeding behaviour (Walsh *et al.,* 1995). The calculation was based on the method used last year (Peyton-Jones and Rounce, 2023), to allow for inter-annual comparisons (Equation 1). The counts from the survey when most fledglings were observed was used to calculate productivity, since this would be most representative of the number of fledglings produced that year.

$$Productivity = \frac{Number\ of\ fledglings\ observed}{Number\ of\ nests\ observed}$$

Equation 1. Calculation of productivity.

3.5 Inter-Observer Variation Test

When conducting the counts, it became apparent that there was variation between different observers' counts from the same survey. This inter-observer variation (IOV) could affect the reliability of comparing counts from surveys undertaken by different observers, e.g., inter-annual comparisons.

To capture this IOV for more reliable analysis, an IOV Test was conducted. Four volunteers counted the number of adults, fledglings and nests from the same four images from the surveys. The volunteers used DotDotGoose to conduct the counts, with no conferring between the participants. They were given minimal instructions (Appendix 1) to allow individual interpretation of include in the counts for adults, nests and fledglings in each image.

The results from these counts (Appendix 2) were used to calculate a standard deviation for each variable (i.e., nests, adults and fledglings). This standard deviation was used as the indicator of IOV.

4. Results

4.1 2024 Surveys

Surveys undertaken in 2024 on the 19th May, 8th July and 30th July 2024 are referred to as Survey 1, Survey 2 and Survey 3, respectively. For full results from surveys undertaken in 2024 see Appendix 3.

4.1.1 Total Counts by Survey and Substation

Figure 4 summarises the total number of nests, adults and fledglings counted during each survey of each substation this year. The error bars on each bar show the results from the IOV Test ($\pm$3.4 for adults, $\pm$9.6 for nests and $\pm$1.2 for fledglings when fledglings were present).

For WOW02 OSS, the number of adults surveyed was relatively consistent across all three survey dates: 258, 267 and 203 consecutively. Fewer nests were observed during Survey 1 (40 nests), compared to the relatively consistent and high number of nests observed during Survey 2 (241 nests), and Survey 3 (221 nests). Most fledglings were observed during Survey 3 (221 fledglings). Therefore, results from Survey 3 were considered the most representative counts to assess breeding success and behaviour and, thus, were used for further analysis.

For WOW01 OSS, the results from Survey 1 exclude the underside of the substation as there was limited time to photograph the underside on this survey. WOW01 OSS was only surveyed again during Survey 3. WODS OSS was only surveyed during Survey 3. Thus, results from Survey 3 were used for further analysis for WOW01 OSS and WODS OSS. For WODS OSS, Survey 3 was accepted as having captured the majority of fledglings produced, based on the results from WOW02 OSS.

Using the counts from Survey 3, markedly more kittiwakes and nests were observed on WOW02 OSS (221 nests, 203 adults, and 196 fledglings) than WOW01 OSS (48 nests, 70 adults and 43 fledglings) and WODS OSS (23 nests, 34 adults and 10 fledglings). More than three times as many nests, adults and fledglings were observed on WOW02 OSS than WOW01 OSS, which has more than double the number of nests, adults and fledglings observed on WODS OSS (based on Survey 3).

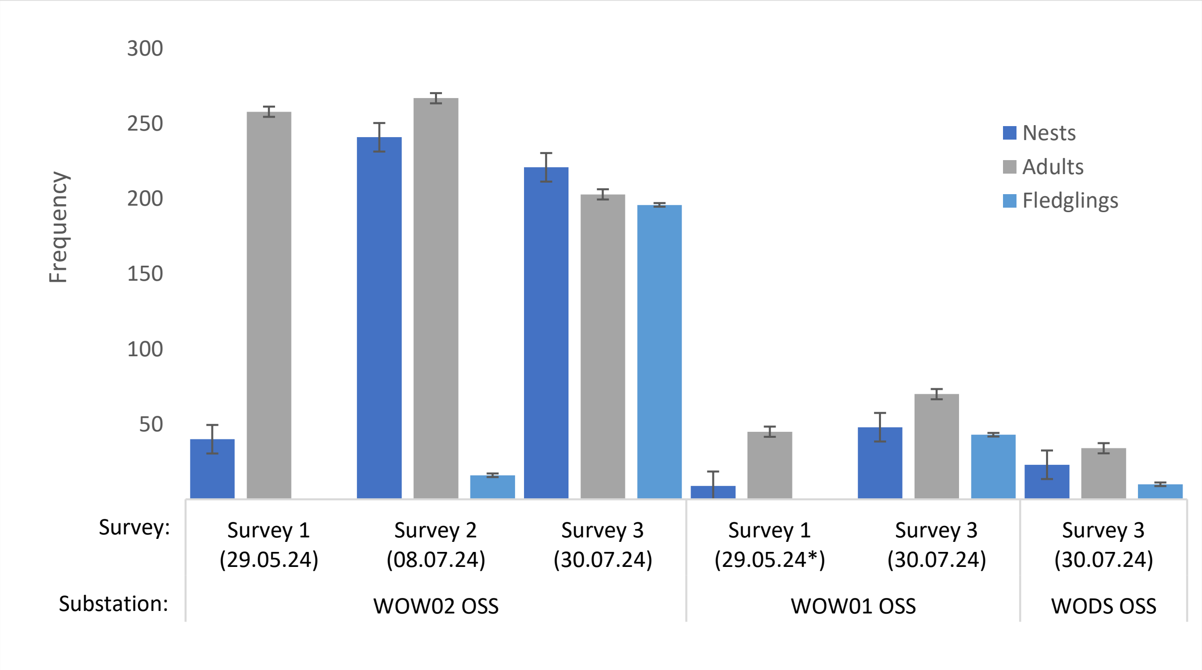

*Figure 4. The total number of nests, adults and fledglings observed by survey and substation with error bars showing IOV. *Counts from 29.05.24 exclude the underside.*

4.1.2 Productivity by Substation

For WOW01 OSS only Survey 1 and 3 were undertaken and for WODS OSS only Survey 3 was undertaken (Figure 4). Therefore, the productivity of WOW01 OSS and WODS OSS was calculated using the counts from Survey 3, based on the results from WOW02 OSS indicating that this was when most fledglings were present.

The productivity was similar for WOW02 OSS (0.886 fledglings/nest) and WOW01 OSS (0.896 fledglings/nest), being two times greater than the productivity calculated for WODS OSS (0.435 fledglings/nest).

4.1.3 Counts by Side of Substation

Figure 5 shows the distribution of nests, adults and fledglings on each substation, categorised by sides: the underside, northside, eastside, southside and westside. The results show no consistent pattern in terms of which side is the most and least populated across the three substations. For WOW02 OSS, most nests, adults and fledglings were observed on the underside. For WOW01 OSS, the most nests, adults and fledglings were observed on the underside and eastside, with these sides hosting a similar proportion of in each case. For WODS OSS, most nests, adults and fledglings were observed on the northside. A greater proportion of nests, adults and fledglings were observed on the underside for WOW02 OSS than that of WOW01 OSS and WODS OSS. The least populated side was the southside and westside for WOW02 and WOW01, respectively, whilst for WODS OSS no kittiwakes or nests were observed on the eastside and westside.

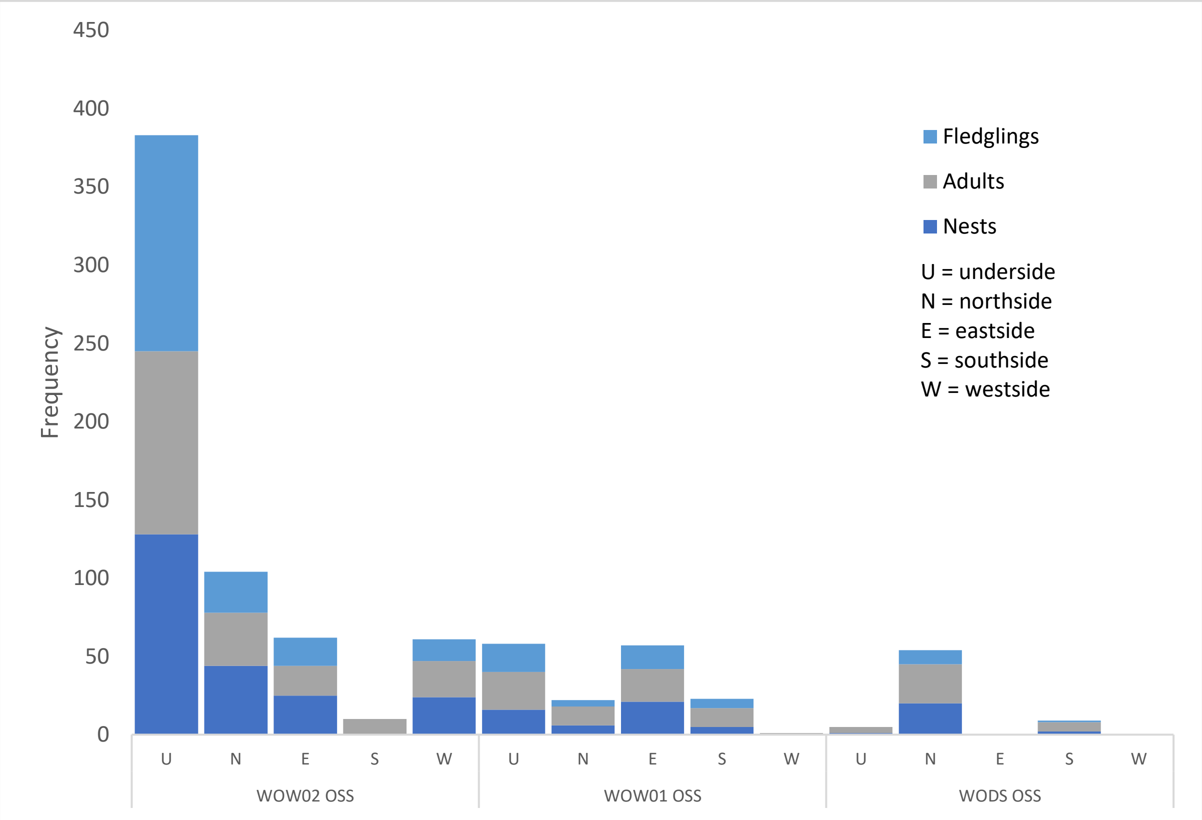

Figure 5. The number of nests, adults and fledglings observed on each side of the substation for WOW02 OSS, WOW01 OSS and WODS OSS.

4.1.4 Counts by Layer of Substation

Figure 6 shows the pattern of distribution of nests, adults and fledglings, categorised by layer for each substation: top, middle and bottom.

For all substations, most nests, adults and fledglings were observed on the bottom layer, with the proportion of adults, nests and fledglings on the bottom greater than 70% in each case (where the total number excludes the underside). For all substations, the layer second-most populated with nests, adults and fledglings was the middle, and the top layer was least populated.

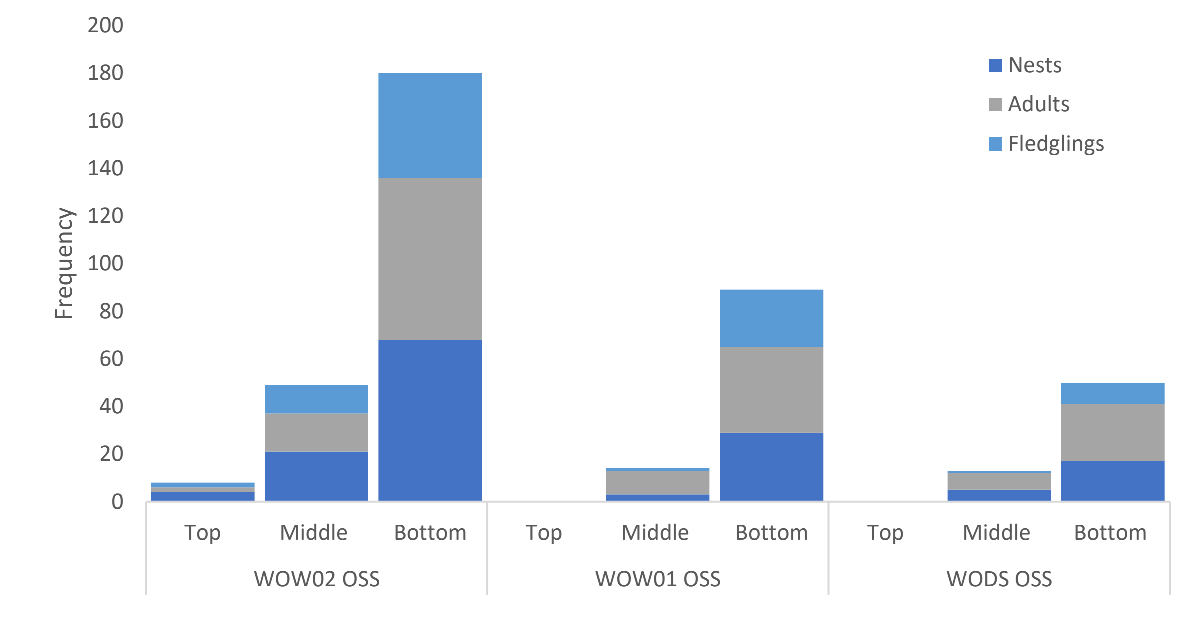

Figure 6. The number of nests, adults and fledglings observed on each layer of the substation for WOW02 OSS, WOW01 OSS and WODS OSS. Note this graph excludes the underside.

4.2 2024 and 2023 Survey Comparisons

For 2024, surveys taken on 29th May, 8th July and 30th July are referred to as Survey 1.24, Survey 2.24 and Survey 3.24, respectively. For 2023, surveys taken on the 19th April, 28th July and 18th August are referred to as Survey 1.23, Survey 2.23 and Survey 3.23, respectively. Inter-annual comparisons could only be undertaken for WOW02 OSS as this substation was the only one surveyed in 2023.

4.2.1 Total Counts

The number of nests, adults and fledglings counted for each survey of WOW02 OSS undertaken in 2023 and 2024 is shown in Figure 7. The error bars represent the results of the IOV Test.

Results from surveys with the most fledglings were used for inter-annual comparisons: Survey 3.24 for 2024 and Survey 2.23 for 2023 (as selected in last year's report). Also, these surveys were taken at the same time of year (28th July 2023 and 30th July 2024, respectively). Comparing the surveys from each year with most fledglings, 29 more nests and 42 more fledglings were observed in 2024 (with 221 nests and 196 fledglings) than in 2023 (with 192 nests and 154 fledglings) though 52 fewer adults were observed in 2024 (with 203 adults) than in 2023 (with 255 adults). However, the maximum number of adults observed in 2024 (267 adults during Survey 2) is slightly higher (12 more adults) than the maximum number of adults observed in 2023 (255 adults during Survey 2). These differences are greater than the error bar for IOV (±3.4 for adults, ±9.6 for nests and ±1.2 for fledglings when fledglings were present).

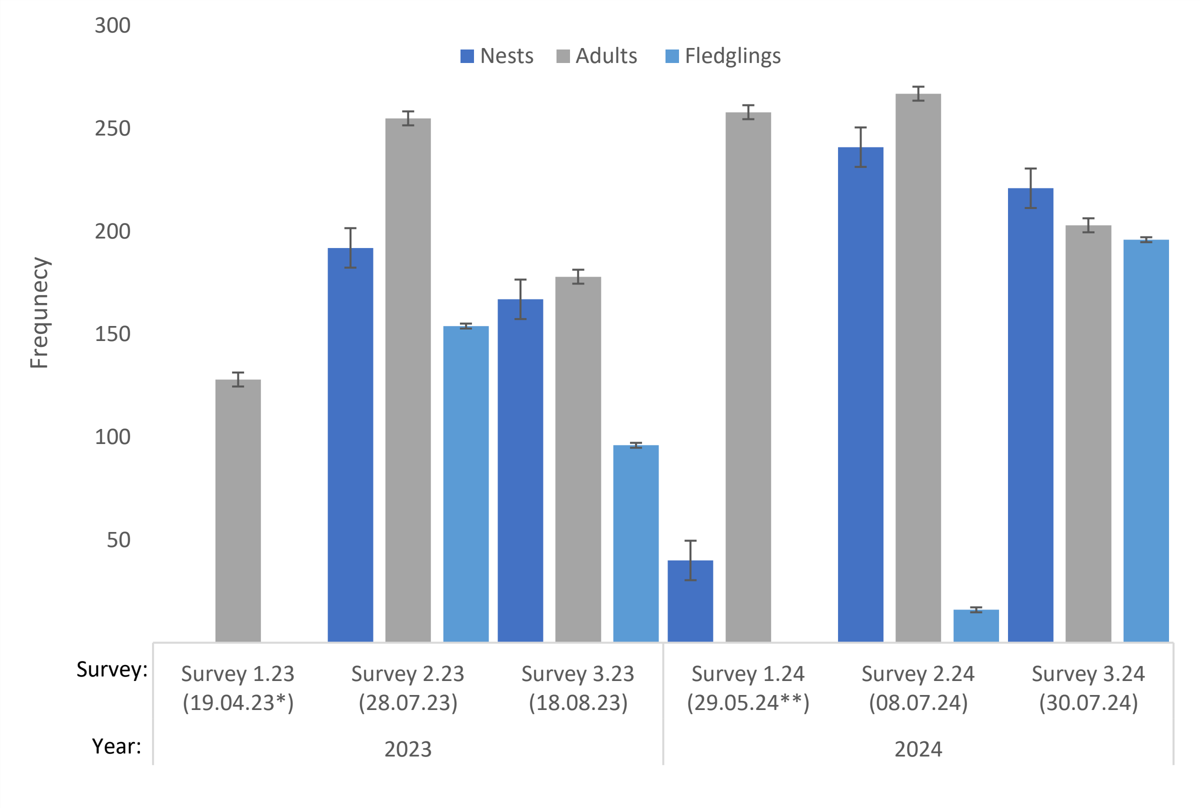

*Figure 7. The number of nests, adults and fledglings observed on OSS02 during surveys undertaken in 2023 and 2024 with error bars showing IOV. *Only adults were counted on 19.04.23. **Counts from 29.05.24 exclude the underside.*

4.2.2 Productivity

The productivity calculated for 2024 (0.886) and 2023 (0.802) are similar, with a small increase of approximately 10% from 2023 to 2024.

4.2.3 Counts by Side of Substation

Figure 8 shows a similar pattern of distribution of nests, adults and fledglings between the sides of WOW02 OSS for 2023 and 2024. A similar proportion (approximately half) of all nests and adults were observed on the underside in 2023 and 2024. A higher proportion of fledglings were observed on the underside in 2024 (70% of fledglings) than in 2023 (49% of fledglings). The side second-most populated with nests, adults and fledglings was the northside in 2023 and 2024. In 2024 the least populated side was the southside, whereas that in 2023 was the eastside. However, in both years the southside, eastside and westside were markedly less populated than the northside and underside.

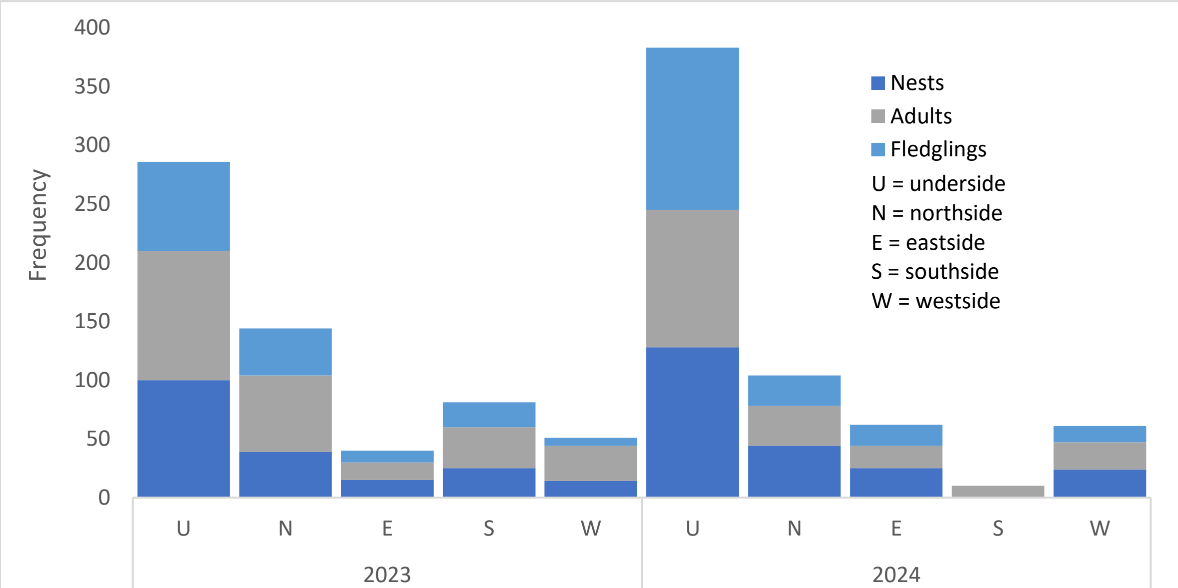

Figure 8. The number of nests, adults and fledglings observed on each side of OSS02 in 2023 and 2024, based on results from the survey dates where most fledglings were observed for each year (28.07.23 and 30.07.24, respectively).

4.2.4 Counts by Layer of Substation

Figure 9 shows a similar pattern of distribution of nests, adults and fledglings between layers of WOW02 OSS for 2023 and 2024. The large majority of nests, adults and fledglings were observed on the bottom layer for both years. A similar proportion (70-85%) of all adults, nests and fledglings were observed on the bottom in 2023 and in 2024 (excluding the underside). For both years, the second and third-most populated with nests, adults and fledglings was the middle and top layer, respectively.

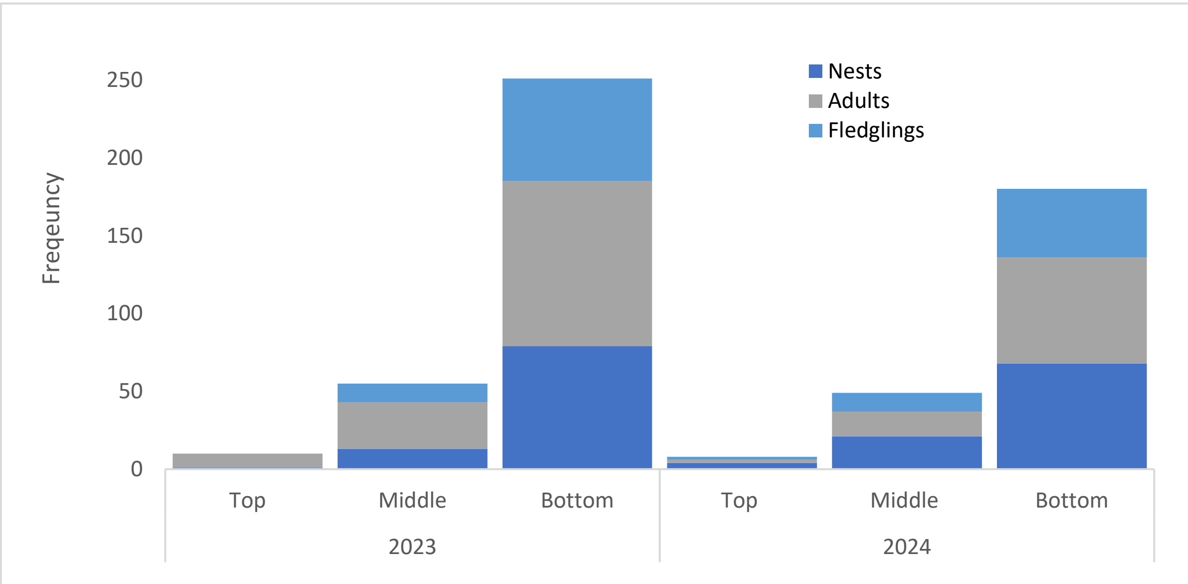

Figure 9. The number of nests, adults and fledglings observed on each layer of OSS02 in 2023 and 2024, based on results from the survey dates where most fledglings were observed for each year (28.07.23 and 30.07.24, respectively).

4.3 Additional Bird Species Present

One Western jackdaw (*Coloeus monedula*) was observed on WOW02 OSS during Survey 1.24 and one European herring gull (*Larus argentatus*) was observed on WODS OSS during Survey 3.24.

5. Discussion

5.1 Inter-Observer Variation

The IOV Test found an IOV of $\pm$3.4 for adults, $\pm$9.6 for nests and $\pm$1.2 for fledglings when fledglings were present. Including the IOV Test results where fledglings were not present significantly reduced result for the inter-observer variation, so these results were excluded.

Overall, the results of IOV were lower than expected, which may be due to only four observers participating in the test. All four participants had previous experience using the DotDotGoose software. The two observers who had previously conducted kittiwake counts from the images using DotDotGoose reported lower numbers of nests in each image than the observers who had not previously done this (as much as 88% fewer nests in one instance) (Appendix 2). This could be due to the experienced observers not counting nests that were difficult to see at the angle of the given photograph, as they anticipated another image from a different angle would be used to count nests in that area of the substation (which the other observers may not have assumed without knowing the survey method).

The IOV for nests was markedly higher than that of fledglings and adults, which likely reflects the subjectivity of determining what to count as a single nest. For instance, given the relatively poor quality of the nests, it is difficult to determine if some unoccupied small accumulations of material are utilised as nests (Figure 10). Longer periods of surveillance would help determine what material deposits are used as nests, i.e., if observers could observe kittiwakes' movements to and from nests overtime rather than relying on instantaneous counts and photographs. Also, giving a reference 'nest' on which to base their counts on may create more consistency between surveyors.

Figure 10. Images to exemplify the small unoccupied accumulations of material (circled in red) that may be sources of subjectivity in determining to the number of nests.

Overall, the test determined values for IOV that were lower than expected, though greatest for nest counts. Further analysis with more participants and unexperienced observers would allow for a more reliable estimate of IOV, whilst longer term surveillance of nests could help minimise the subjectivity affecting the counts.

5.2 Surveys in 2024

5.2.1 Comparisons by Survey

The surveys in 2024 found the most fledglings were observed during Survey 3.24 (on 30th July) for all the substations. This suggests this survey date most accurately captures the number of fledglings produced by the colony, i.e., capturing when most have hatched but the chicks have not yet fledged. Hence, results from Survey 3.24 were used for further analysis of breeding success and behaviour. This closely aligns with the date when most fledglings were observed in 2023: during Survey 2.23 on 28th July. These results imply that future monitoring should include scheduled surveys leading up to and including late July to best capture the productivity of this colony.

The survey dates were selected based on the typically lengths of phases in kittiwakes' lifecycle: approximately 27 days of incubation with fledging occurring at least 36 days after (Coulson and White, 1958; Vulcano, 2021). The timing of kittiwake colonies' lifecycle phases varies geographically and can fluctuate between years for the same colony (Coulson, 2011). The survey results indicate most fledglings are present in late July, which coincides when most chicks are typically observed at the nearest land-based kittiwake colony at St Bees, i.e., between late July to early August (Shackleton, RSPB, personal communication, 2024). Variations in length of the incubation period and how long chicks stay with the nest typically relate to weather conditions and food supply (Vincenzi and Mangel, 2013; Christensen-Dalsgaard *et al.,* 2018). Thus, similar timings of breeding phases could imply the St Bees and substation colonies rely on shared food resources. Further investigation, e.g., dietary analysis and tagging, could provide better insights into this potential association.

However, only three surveys were conducted with no surveys subsequent to Survey 3.24 or Survey 3.23 during the respective years. Therefore, it cannot be reliably determined if these surveys accurately captures when most fledglings were present. Furthermore, some photographs from Survey 3.24 included fledglings whose downy plumage had been replaced with adult feathering (Figure 11), potentially indicating they were in late stage of the fledgling period and some may have fledged and returned to the nest (Shackleton, RSPB, personal communication, 2024). This suggests Survey 3.24 may have been too late to capture all fledglings or fledglings may have been absent from nests at the time of photographing. Kittiwakes may not leave their nest following their first flight; during a 'post-fledgling dependence' period, kittiwakes have been observed to return for approximately 14 days to the natal nest to be fed by their parents (Mulard and Danchin, 2008). Consequently, determining the exact timing of maximum fledglings within the colony would require many days of uninterrupted observations (Coulson and White, 1958). Moreover, only one complete survey was conducted for WOW01 OSS and WODS OSS (Survey 1 for WOW01 OSS excludes the underside), so fledgling progress on these substations was less effectively tracked. However, disturbance from technicians on the substation was observed to cause adults to fly during Survey 3.24, but no fledglings were observed flying around the substation. This implies that most fledglings were not in the 'post-fledgling dependence' stage. Nonetheless, more continual observations would allow for more accurate estimations of the colonies' productivity.

Figure 11. Photographs taken from Survey 3 that exemplify some late-stage fledglings observed.

Ultimately, the survey results indicate most fledglings were present on the substations in late July, implying that future monitoring should schedule surveys leading up to and including this period. However, with incomplete triplet survey campaigns for two substations and no surveys beyond the third survey of each year, more regular monitoring would enable more reliable estimates of productivity.

5.2.2 Comparisons by Substation

Markedly more kittiwakes and nests were observed on WOW02 OSS than WOW01 OSS and WODS OSS. This is most likely attributable to the colony on WOW02 OSS being older and, therefore, more established. Kittiwakes on WOW01 OSS and WODS OSS were first counted during the preliminary survey of this year. Anecdotal evidence suggests kittiwakes could have been present on these substations in 2023, if not before. Usually, new kittiwake colonies are formed by 3-20 young individuals, the colony rapidly grows for the first two to four years, and then slows to a population growth rate of 10-20% per year (Coulson, 2011; Kildaw *et al.,* 2005). The survey results suggest the colony on WOW02 OSS has not experienced this rapid growth from 2023 to 2024. This may indicate the WOW02 colony is past the initial rapid growth phase (typically observed from year two to four), given reports of this colony's presence were made prior to 2023 (Browning, L., Natural England, personal communications, 2024). Also, individuals previously nesting on WOW02 OSS may have migrated to WOW01 OSS and WODS OSS, due to limited space being available in preferable areas for nesting. Given the substations are less than 14 km distant from each other (Figure 12), the kittiwakes nesting on each could represent an interconnected colony. Coulson and de Mévergnies (1992) analysed the British Trust of Ornithology's dataset of kittiwakes ringed from 1923 to 1987, which included 145 ringing recoveries predominately from North-East England. They found that 43% of young breed in another colony within 100 km of the colony of birth. As such, tagging individuals could reveal interconnectivity between the substation colonies.

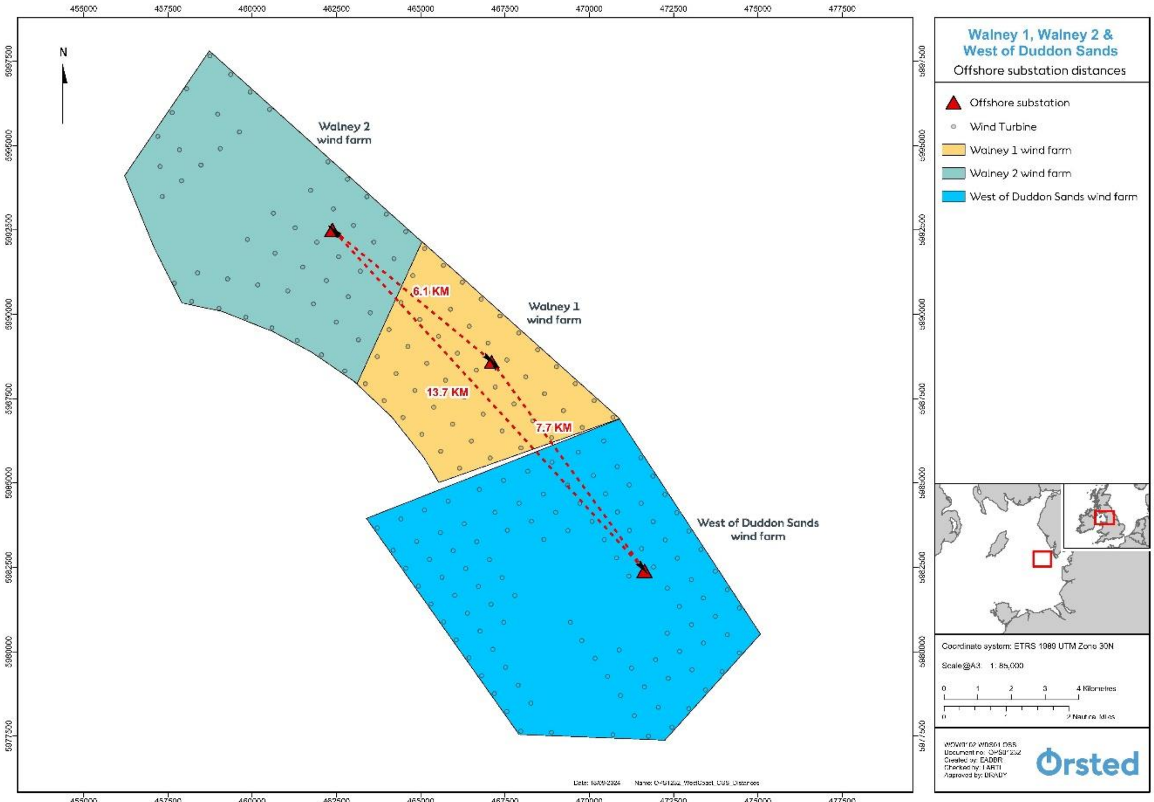

Figure 12. Diagram showing the distance between the WOW02 OSS, WOW01 OSS and WODS OSS.

The results give a similar productivity of 0.886 fledglings/nest and 0.896 fledglings/nest for WOW02 OSS and WOW01 OSS, respectively. 'Natural' land-based nesting sites appear to report lower productivity; however, this is often not directly comparable due to methodological differences (e.g., calculating fledglings per pair or developing estimates based on regular monitoring to determine apparently occupied nests (AONs)) (Gill and Hatch, 2002; Wheatley and Saunders, 2010; JNCC, 2021). Therefore, productivity of the St Bees colony cannot be reliably compared to that of the substations (see 5.4 Discussion with RSPB). Based on field observations from River Tyne area, Coulson (2017) estimated a mean productivity of at least 0.8 fledglings/pair is required to maintain breeding numbers in Britain. Dividing the number of adults into pairs, gives a productivity of 1.78 fledglings/pair for WOW02 OSS, 1.79 fledglings/pair for WOW01 OSS and 0.59 fledglings/pair for WODS OSS. Based on Coulson's (2017) threshold this suggests a markedly high productivity for WOW02 OSS and WOW01 OSS (beyond what is required for a growing population), and a productivity that would not enable population growth for WODS OSS. However, these figures are likely to overestimate productivity, since Coulson (2017) calculated productivity using figures for AONs. Future studies with more detailed observations of AONs would facilitate more reliably comparisons with 'natural' nesting sites and existing survey results from elsewhere.

Nonetheless, kittiwake colonies breeding on offshore installations typically exhibit high to moderate productivity. A review of colonies on 63 offshore oil rigs on the Norwegian shelf found productivity ranged from 0.61-1.07 chicks per nest (Christensen-Dalsgaard *et al.,* 2020). Greater food availability and reduced exposure to terrestrial predators are generally hypothesised as factors contributing to higher productivity of kittiwake colonies on offshore installations (Christensen-Dalsgaard *et al.,* 2020). High productivity of the substation colonies is expected, since new colonies have been observed to exhibit higher productivity than older colonies. Kildaw *et al.* (2005) found this was true for colonies on Kodiak Island, Alaska, which they attributed to new colonies attracting prospecting kittiwakes including first-time breeders and established breeders relocating from old to new colonies. Habitat quality was thought to be a more significant factor than population density in determining the formation of new colonies (Kildaw *et al.,* 2005). Although this study only surveyed 'natural' nesting sites, this may support the hypothesis that substations (i.e., artificial nesting sites) are attracting first-time and older breeders due to the improved habitat suitability compared to 'natural' land-based nesting site, since there is less predation and closer food resources.

The productivity for the colony on WODS OSS was found to be approximately half that of the productivity of the colony on WOW02 OSS and WOW01 OSS. The observations suggest WODS OSS hosted half the number of adults that WOW01 OSS hosted and less than one sixth of adults hosted on WOW02 OSS. Although these results appear to indicate a relationship, productivity is generally unrelated to the size of the colony (Kildaw *et al.,* 2005). Differences in productivity between colonies can be associated with travel distance from food resources to the colony as this determines the energy expenditure of foraging (Chivers *et al.,* 2012). The closest of the substations to land is WODS OSS, followed by WOWO1 OSS and the furthest from land is WOW02 OSS (being 15.8 km, 16.8 km and 20.3 km distant from Walney Island, respectively). As such, WODS OSS is the southmost and eastmost of the substations. It is plausible that kittiwakes from the substation colonies are travelling to feeding grounds further out into the Irish Sea, i.e., northwards or westwards. In such case, individuals nesting on WOW02 OSS would have the least distance to travel (resulting in lower energy expenditure), whilst those nesting on WODS OSS would have the greatest distance to travel for foraging. Kittiwakes forage within 54.7 km of their breeding colony on average, but they have been found to travel up to 156.1 km for foraging (Woodward *et al.,* 2019). Yet, shorter foraging distances have been linked to higher breeding success in the North Sea (Daunt *et al.,* 2002). As such, there is a sequential pattern of productivity by distance from land: WODS OSS as the most landward substation with lowest productivity, WOW01 OSS with higher productivity and WOW02 as the most offshore substation with the highest productivity. This hypothesis could also partly explain why WOW02 OSS was first colonised as the most proximal to the feeding resources. However, substantiating this association would require longer-term monitoring and tagging to track the foraging behaviour of the substation colonies.

Lastly, WODS OSS and WOW01 OSS were not surveyed three times, which reduces the reliability of determining if the counts used to estimate productivity effectively captured when most fledglings were present. This may contribute to WODS OSS and WOW01 OSS having contrasting values for productivity. In all cases, more regular monitoring (i.e., more surveys per year) or remote sensing (e.g., onsite cameras) would enable better tracking of fledgling development, resulting in more accurate estimates of productivity.

Overall, the colony on WOW02 OSS was found to be much larger than the colonies on WOW01 OSS and WODS OSS. WOW02 OSS and WOW01 OSS appear to be highly productive, with productivity double that of WODS OSS. However, methodological differences inhibit reliable comparisons with land-based nesting sites. It is hypothesised high productivity may reflect greater food availability and reduced predator exposure on the substations, and the differences between the productivity of the substation colonies could relate to the relative distance to feeding grounds. Further investigation involving tagging, dietary analysis and more regular monitoring to more effectively track the fledglings' progress would give more detailed insights and more reliable productivity estimates.

5.2.3 Comparisons by Side and Layer of Substation

For WOW02 OSS most kittiwakes were observed on the underside of the substation. Most kittiwakes and nests were observed on the underside and eastside for WOW01 OSS and on the northside for WODS OSS. Across all three substations, the side least populated with kittiwakes and nests is either the southside or westside. This may suggest a preference for more sheltered locations, given the predominant wind direction is south-westerly. As such, Peyton-Jones and Rounce (2023) attributed the preferential selection of the underside of WOW02 to it being most sheltered from weather, sunlight and potential risk of avian predators. This reflects evidence from previous studies that kittiwakes preferentially nest on more sheltered areas of oil and gas platforms (Christensen-Dalsgaard *et al.,* 2018; Ørsted, 2021). The substation that shows no preference to nesting on the underside (WODS OSS) was found to have markedly lower productivity. This implies preferential selection of the underside for nesting may contribute to improved breeding success, as would be expected with reduced exposure to weather and avian predators. Yet, only with surveys of more substation colonies could such conclusions be drawn. Site-specific factors are known to influence aspect preferences on a case-by-case basis (Coulson, 2011; Ørsted, 2021). Hence, wider analysis of site-specific conditions may reveal such factors influencing the difference in the distribution of the colonies across the three substations.

It should be noted the influence of aspect on colony distributions will be affected by the fact each substation is not orientated to the same bearing, i.e., the northside is facing slightly different degrees from true north for each substation. Although this was not deemed significant enough to classify the sides differently, this may affect how significantly the shelter effect determines the selection of nesting positions on each substation.

The survey results indicate a similar pattern of distribution of kittiwakes and nests by layers of the substation. For all three substations most kittiwakes and nests were found on the bottom layer, followed by the middle and then top layer. This likely due to the bottom layer being most sheltered.

Considering both layer and side, the results indicate the underside is preferentially selected for WOW02 OSS and is one of the most populated sides for WOW01 OSS, whilst the bottom layer appears to be the preferentially selected for all substations. Such a pattern may suggest being closer to the sea surface or being at lower altitude is a significant influence on nesting site selection across all three substations. This potentially relates to the shelter effect but may also reflect the avoidance response of kittiwakes to nearby turbines, resulting in individuals approaching the substation from lower altitude (i.e., nearer the sea surface). There are significant research gaps in understanding wind farm avoidance responses of kittiwakes (Black *et al.,* 2019). However, Pollock *et al.*'s (2024) study used data from tracking 20 adult breeding kittiwakes at Whinnyfold in the North Sea and found significant avoidance of the area around 60-80m from the turbine swept zone. Similar studies found comparable responses at meso-scale for kittiwakes (Tjørnløv *et al.,* 2023) and lesser black-backed gulls (Johnston *et al.*, 2022). Pollock *et al.*'s (2024) results appear to indicate that in most instances kittiwakes fly below or within the outer limit of the rotor height range between the sea surface and approximately 30 m altitude. The nearest turbines are approximately 300-500 m distant from the surveyed substations and with a minimum blade height of 30.3 m above MHWS for WODS and 22 m above MHWS for WOWO1 and WOW02. The substations are approximately 70 me high (Ørsted, n.d.). Hence, if the kittiwakes are avoiding turbines by flying at lower altitudes below the blade swept area this could result in them arriving at lower layers and underside of the substation. This could result in the preferential selection of lower altitude areas for resting and nesting. Yet, it should be noted Pollock *et al.* (2024) highlighted their analysis struggled to capture the complexity of kittiwake response at the meso-scale, with potential nuances due to site-specific conditions. Thus, tracking kittiwakes that are nesting on these substations would be necessary to understand avoidance responses and any implications of this on breeding behaviour. If the underside was analysed as a 'layer' instead of a 'side' this would make the preference for lower altitude positions more apparent. Nesting ledges on the underside are distributed among all aspects so classifying the underside as a layer may also provide additional information that is relevant to aspect preference.

Overall, the observed distribution of all three colonies by side and layer indicate a preferential selection for more sheltered locations. Also, the results suggest a potential preference for lower altitude areas of the substation. This is hypothesised to reflect turbine avoidance responses of kittiwakes. However, classifying the underside as a 'side' rather than 'layer' may have confounded the apparent distribution pattern and slight differences in the orientations of the substations may affect the extent of the shelter effect of the same sides of different substations. Further investigation into site-specific conditions alongside GPS tracking to understand kittiwake avoidance of turbines could provide better insights into the factors contributing to the observed distribution pattern.

5.3 Inter-annual Comparisons: 2023 and 2024 Survey Results

Survey 2.23 (on 28th July 2023) and Survey 3.24 (on 30th July 2024) were used as inter-annual comparison surveys, as they are the dates with the highest number of fledglings present for each respective year. They were therefore assumed to be the most representative dates for assessing the success of the colony.

The number of nests counted in 2024 (221 nests) was higher than in 2023 (192 nests), possibly indicating a growing population. However, as all nests were counted, not just AONs, this increase may not accurately represent the number of birds in the colony. Number of fledglings was also higher in 2024. Both of these increases were outside of the value identified for IOV.

However, the number of adults decreased from 255 to 203 from 2023 to 2024. On the 30th July 2024 survey date, the presence of a CTV at WOW02 OSS caused notable disturbance to the kittiwakes, with adults seen flying around the substation and leaving the ledges in response to the technicians working and the vessel moored. This disturbance could be a possible explanation for the apparent decrease in adults between the two survey years, especially considering that both nests and fledglings had increased in the same period. The second survey date of 2024 (on 8th July), however, recorded higher numbers of adults, with 267 individuals counted so may be a more accurate figure for number of adults in the colony.

Productivity increased from 0.802 fledglings/nest in 2023 to 0.886 fledglings/nest in 2024. Coulson (2017) suggested that in order for a kittiwake population to maintain breeding numbers, productivity should be at least 0.8. Both the 2023 and 2024 productivity numbers calculated at WOW02 OSS meet this value, suggesting a stable, if not growing, population. However, it should be noted that Coulson's (2017) used a different method of calculating productivity so may not be directly comparable to results.

One potential explanation for the apparent success of this population could be the lack of fishing activity in the area, and therefore increased prey availability for the kittiwakes. The substations are within the West of Walney Marine Conservation Zone (Figure 13), which has been designated since January 2016, covering 388 km^2 off the coast of Cumbria. The protected features within this designated zone include subtidal sand, subtidal mud, and sea-pen and burrowing megafauna. As part of this designation there is a Bottom Towed Fishing Gear Byelaw (in place since 2018).

The enforcement of this byelaw may have led to an increase in sand eel numbers in the area, as the sand habitat has been identified as an area where sand eels are present and camouflage themselves on the sediment. This could be related to the success of the kittiwakes at the substations, believed to consume sand eels as their primary food source in the UK (Furness *et al.,* 2013). Furthermore, Carroll *et al.* (2017) showed higher kittiwake breeding success in the North Sea was associated with higher sand eel spawning stock biomass. However, discussions with Natural England suggested that the impact of this byelaw may not have been significant enough to boost sand eel stocks. Furthermore, breeding diet studies suggest kittiwakes' reliance on sand eels is weaker in the Irish Sea and west coast of the UK, being replaced by clupeids and gadoids (Ruffino *et al.,* 2023). Further exploration into this is needed to draw a conclusion about the reason behind the kittiwakes' apparently high productivity, for instance through diet analysis using the kittiwake guano (see 5.6.3 Recommendations for Future Investigations).

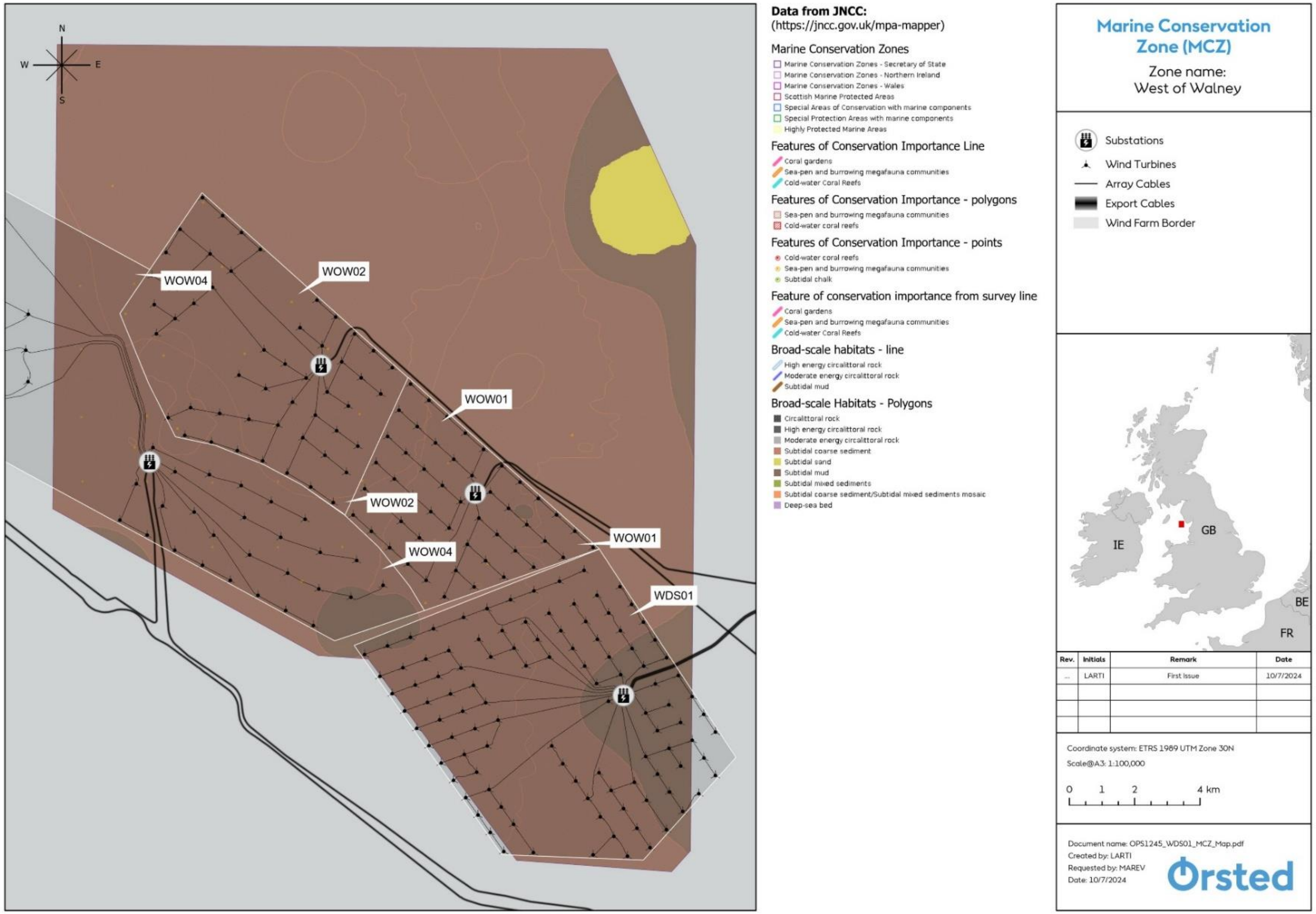

Figure 13: West of Walney Marine Conservation Zone boundaries, showing the locations of the three wind farms within the MCZ. Substation locations represented as triangles.

5.4 Discussion with RSPB

Following discussions with the RSPB ornithologists at St Bees, the decision was made not to compare the WOW02 OSS productivity count for 2024 with the St Bees productivity count due to:

- Differences in method of calculating productivity.
- Differences in method of monitoring the population. St Bees conduct counts for a subsection of the colony (around 10-15%) which may not be representative as it only uses a small area of the cliffs that is visible, whereas most of the colony are in a more sheltered, inaccessible location.
- Exclusion of trace nests (unoccupied nests) in counts at St Bees.
- Discussion around whether it is appropriate to compare productivity at such different sites, considering multiple variables and differing contexts.

RSPB ornithologists recommended that the survey method for the substation productivity counts could be adapted to follow more widely used methods such as monitoring AONs and mapping nests throughout the season. Survey methods found in the *JNCC Seabird Monitoring Handbook* were suggested as templates that could be used. *Productivity-monitoring method 1* for kittiwakes in this handbook suggests mapping nests requires following the same nests and calculating productivity as number of chicks fledged divided by the number of completed nests. Following AONs in this way would require more survey dates throughout the season and developing a system of mapping nests so they can be accurately followed. Co-ordinating an increased number of survey dates each year may have its logistical challenges, but would help to provide a more accurate view of the productivity of the substation colonies.

5.5 Health and Safety Implications

When considering the health and safety implications of kittiwake presence on the substation, it became apparent that the technicians who carry out work there may have valuable insights to give. To capture these views, a technician interview questionnaire was developed and sent out to substation technicians. The questions included in this questionnaire are given in Appendix 4. As of the end of October 2024, only two responses have been gathered from this technician interview. Given the questionnaire was made easily available to technicians and was voluntary questionnaire, the low response rate itself may indicate low levels of concern amongst the technicians. Despite this small sample size, there are some notable comments that can be considered:

- One participant selected the response that kittiwakes have an overall negative impact on them while conducting their work, though the scope of this was rated as 'little impact.'
- The other participant responded to this same question by stating there is 'no impact.'
- Both participants said they normally come within 3 m of the kittiwakes when working on the substation.
- One participant stated feeling concerned for their physical health and/or safety as a result of the kittiwakes, experiencing the kittiwakes flying close to them and having guano land on them.
- Both participants expressed that they felt concerned by the presence of guano on the structures, and one felt it affected their ability to carry out jobs.
- One participant commented that their biggest concern is the amount of guano present, and how that will affect themselves in the long term.
- Neither of the participants have ever reported or logged an incident of near miss with the kittiwakes.

- One participant left a comment that they are unaware of any technicians being attacked by a kittiwake, or that the birds have been a nuisance towards anyone.

These results indicate that the presence of kittiwakes, and their guano, on the substation is causing some level of concern amongst the technicians, though this does appear to be a low level of concern. Further surveys and interviews with technicians would be necessary in order to determine the extent of this impact and cover all perspectives that were not represented here due to the small sample size of only two participants.

5.6 Recommendations

5.6.1 Further Inter-Observer Variation Analysis

In order to continue improving the validity of this multi-annual study, the IOV Test should be repeated with more participants to generate a more accurate estimate. Eventually, with a large enough data set from multiple years of surveys, it should be possible to conduct statistical analysis that can determine the significance of annual variation. Until then, the IOV can be developed and used to determine the validity of inter-annual comparisons.

5.6.2 Standardised Method

Standardising the method used for this study will also help in securing the robustness of inter-annual comparisons. This needs to be considered within the context of the study, maintaining consistency in the way the data is collected and analysed each year and between observers. For guidance on how to replicate the 2024 study, and further information on a standardised method refer to Annex 1.

However, standardising the method should also be investigated outside the context of this study, considering the methods used by ornithologists around the UK when monitoring kittiwakes and calculating productivity. As discussed, the decision in this study was made not to compare to the RSPB productivity counts for St Bees, due to variation in the methods used. In order to understand the substation colonies of kittiwakes within the context of the rest of the nation, the method may need to be adapted. Again, referring to the *JNCC Seabird Monitoring Handbook* and other best-practice guidance will help in making future decisions about the survey methods used here.

The current method classifies the underside as a side of the substation. Alternatively, the underside could be classified as a layer, rather than a side. This would also allow observers to consider that nests on the underside in relation to their positioning associated with the four vertical sides (i.e., northside, eastside, southside, westside), which could more effectively evidence the factors contributing to nesting site preferences, e.g., shelter and altitude. Further study could be conducted using the 2024 data, analysing the underside nests and assigning them each a vertical aspect. Ideally, future monitoring would analyse colony distribution classifying the underside as both a 'layer' divided by the different aspects and a standalone 'side' which would best reveal if such manipulation of data reveals different patterns in colony distribution. Also, analysis of the available ledge space of each side and layer of each substation may provide further insights into factors contributing to nesting positions and colony distribution.

5.6.3 Recommendations for Future Investigations

The following recommendations echo those given by Peyton-Jones and Rounce (2023) and further detail on the subjects can be found by reading their recommendations section.

5.6.3.1 Guano Sampling

Diet analysis through guano sampling would provide insights into the feeding behaviour of the kittiwakes and help in understanding their success within the wind farms. Suggestions for proposed methods for guano sampling are given in Annex 2. Conversations with the OFTO about the practicalities of such study methods have already begun and could continue ahead of the next year of annual monitoring so that samples can be taken early in the breeding season. Alternative methods of diet analysis could be explored, such as regurgitate sampling. However, this approach requires handling the birds and, therefore, may be more technically challenging to implement.

Seabird guano has the potential to cause structural damage to metal surfaces due to its uric acid content (Ørsted, 2021). Sampling at the substation could open up exploration of kittiwake guano composition analysis to address health and safety concerns relating to these possible corrosive effects. The results of such sampling should be assessed alongside further technician interviews, to build a holistic view of the impacts of guano on the substation, and the technicians' ability to complete maintenance tasks.

5.6.3.2 Tagging

GPS tracking of kittiwake movements by deploying tags could be considered to understand the movement of the birds throughout the wind farm, allowing a more robust estimate of collision risk, and therefore informing compensation requirements for industry. See Pollock *et al.,* (2024) for a GPS tagging method to analyse kittiwake interactions with offshore wind farms, at macro and meso-scales. Being able to track birds' movements in and out of the OWFs would also help in developing an understanding of their foraging behaviours and determining why the colonies are situated within the wind farms.

Ringing or using other visual tagging methods would support a greater understanding of the connectivity of the kittiwake colonies on substations within the three OWFs, and further afield. Natural England and RSPB ornithologists have expressed interest in this area of study and in exploring whether the birds at the substations should be classed as a homogenous group or 3 individual colonies. It was also suggested that tagging fledglings could help in determining whether the population is made up of returning individuals.

Barriers to conducting such research include the availability of qualified ornithologists to conduct a tagging study, with the additional complication of access to the substations due to health and safety requirements of appropriate training in order to alight to the substation. Accessing the structures themselves requires clearance and permissions through the OFTO. Possible methods of catching and tagging birds from the vessel itself may be explored and discussion of the feasibility of these has already started with Natural England. Barriers also exist for conducting tagging at a site such as St. Bees, where access to the birds would require abseiling and other technical considerations such as vessel availability.

5.6.3.3 Cameras

The presence of cameras on the substation could be used to provide information on the feeding patterns of kittiwakes. Observing the timings of feeding trips and using those timings to establish a foraging range could help in answering questions around where the birds are finding prey. However, kittiwakes feed their young through regurgitating partially digested prey, so it may be difficult to identify the contents through cameras alone. Cameras focused on the nest sites would allow for observation across the season, not limited to the vessel-based survey dates. This would give observers a view of the entire season from the start of nest building, through hatching, to eventual departure of fledglings. Such insights could help the survey dates to be more accurately determined to coincide with the period where most fledglings are present and visible.

This method of study would not necessarily require a qualified ornithologist to implement, as technicians who already have access to the substation could attach a camera system in a suitable location. Therefore, cameras could be considered an alternative, less invasive method of obtaining dietary and movement information, in comparison to tagging and guano or regurgitate sampling. Monitoring using cameras and one-way glass is currently underway on the Ørsted ANS project, where insights about battery life and outputs could be used to inform camera installation on the substations. The issue of camera battery life on the substations may not be a significant barrier to implementing this monitoring, as the substation has an existing, constant power supply that could be used for camera operation. Retrospectively fitting external equipment to wind farms has proven challenging on projects, this could prevent this method from being utilised. Livestreaming cameras are currently installed on the substation for security purposes. Although these cameras may have limited coverage of areas of interest on the substation (e.g., the underside), this method for remote observing should be further investigated.

Drones could be used as an alternative to photography from the vessel, allowing for images to be captured from underneath the substation as the drone flies below it. However, the use of drones in surveys of kittiwakes has been found to cause some disturbance, at a drone distance of at least 30m from the cliff edge, (Bishop et al., 2022) causing the birds to take flight. This would result in lower counts of adults on ledges if implemented at the substation. In addition, drones may require unique upwards facing cameras or other means to sufficiently photograph the underside of the substations, which would require further investigation.

5.6.3.4 Comparisons with Land-Based Colonies

In future, aligning survey methods with the RSPB ornithologists would be beneficial to allow for valid comparisons of the substation colonies with the nearest land-based colony at St Bees. Applying the method used by the RSPB ornithologists to the substation surveys is unlikely to be feasible, e.g., the inaccessibility of the substations inhibits mapping of AONs each season. Alternatively, the method used in this study for the monitoring of the substation colonies may be adaptable to survey the St Bees' colony to allow more reliable comparisons of productivity. For instance, photographs of the section of the St Bees colony surveyed by the RSPB could be used to count nests, fledglings and adults and the counts used to indicate productivity as fledglings per nest. Hence, further collaboration with the RSPB at St Bees is recommended as this could provide a unique opportunity to investigate how substation colonies compare to land-based colonies.

5.6.3.5 Surveying Other Substation and Structures

This study surveyed kittiwakes on the WOW01 OSS and WODS OSS for the first time and built on the initial survey of WOW02 from 2023. Further investigations should consider all potential nesting structures in the vicinity of the WOW02 OSS to identify if kittiwakes are nesting on other structures. Analysing subsequent results could provide insights into why particular substations are colonised over others. This report therefore recommends that an annual survey of all the platforms is undertaken.

5.6.3.6 Improvements to Survey Efficiency

To overcome the communication of survey expectations, as seen in the 2023 and 2024 surveys, this report recommends producing a paper briefing note that can be shared with the CTV captains ahead of the survey season. This should include:

- Purpose and background to survey;
- OSS to be surveyed, in order of priority; and
- Proximity, speed and number of transits around each OSS.

In conjunction to this, this report recommends that investigation into whether training of personnel on the CTVs would be either possible or of interest in order to aid data collection throughout the survey season. This data would be analysed along with the data collected on the organised survey dates.

Due to interest from technicians and CTV personnel, this report recommends that a presentation is held following the conclusion of the survey season to update on the colonies progress and answer any queries they may have.

6. Conclusion

This report has built on the 2023 study by investigating the breeding behaviour of the kittiwakes nesting on WOW02 OSS for a second year, researching the colonies on WOW01 OSS and WODS OSSWODS OSS for the first time and providing insights into the health and safety implications of these kittiwake colonies.

Key findings from this study include:

- Markedly more kittiwakes and nests being observed on WOW02 OSS than WOW01 OSS and WODS OSSWODS OSS, which is hypothesised to relate to the former being a potentially older and, therefore, more established colony.
- WOW02 OSS and WOW01 OSS colonies were found to have apparently high productivity, being double that of the WODS OSSWODS OSS colony. It is hypothesised high productivity may reflect greater food availability and reduced predator exposure on the substations, and the differences between the productivity rates of the three substation colonies could relate to the relative distance to feeding grounds.
- For the substation colony with most data available, WOW02, the results indicate a preferential selection for the underside. Most kittiwakes and nests were observed on the bottom layer, compared to the top and middle layer (consistent with the 2023 results). Comparing the three substations found the distribution of kittiwakes and nests suggests a preferential selection of more sheltered locations and potentially lower altitude locations that may reflect avoidance responses to turbines. However, further evidence is necessary to determine factors that contribute to the colony distribution, especially given that considering the underside as a 'side' (opposed to a 'layer') somewhat confounds the results.
- An increase in number of nests and fledglings in 2024, compared to 2023 were observed. However, a decrease in adults present was noted, which is possibly due to disturbance at WOW02 OSS on the study date chosen for inter-annual comparison. Overall, the productivity appears to be slightly higher in 2024 (10% higher), indicating a stable population.
- Technicians responded with some concerns around the presence of guano on the substation, and how this may impact their work and wellbeing. However, only two participants responded to the questionnaire and they gave mixed responses in relation to their level of concern about potential health and safety implications of the colony. Further investigation is needed to understand the scale of the impact of these concerns.

Several methodological limitations affect the reliability of these conclusions. These concerns informed the creation of standardised method that is recommended for a robust approach for longer-term monitoring. Recommendations for further study include dietary analysis, GPS tracking and remote sensing (e.g., cameras) to provide better insights into kittiwake behaviours and influences on breeding success, alongside further qualitative research and guano sampling for a greater understanding of the health and safety implications and other potential operational impacts of the kittiwake colonies.

7. Acknowledgements

The authors of this report would like to thank all the people involved in this project. Credit for contribution is given in Appendix 5.

Collaboration between Ørsted, Natural England, the North West Wildlife Trusts and The Crown Estate has been fundamental to the success of this project, as the partner organisations of the North West Marine Futures Internship. Maintaining these relationships will be valuable for future study and realising the potential of this area of research for industry and conservation. Participation from RSPB ornithologists, in discussion around kittiwake productivity and monitoring methods, was greatly appreciated.

We would like to thank the North West Wildlife Trusts, Natural England, Ørsted and the Crown Estate for providing this opportunity of the Marine Futures Internship, for the skills, experience and knowledge we have gained and to all our colleagues within these organisations who have made this experience so valuable.

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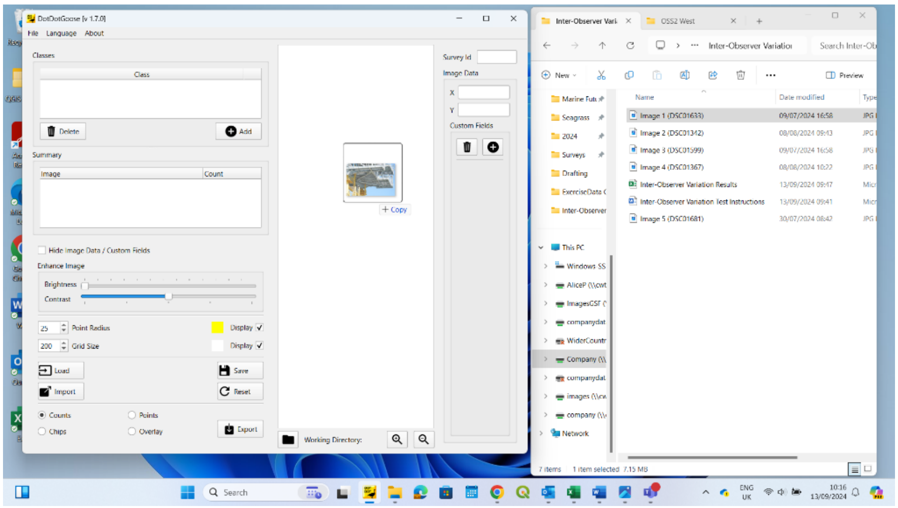
Appendix

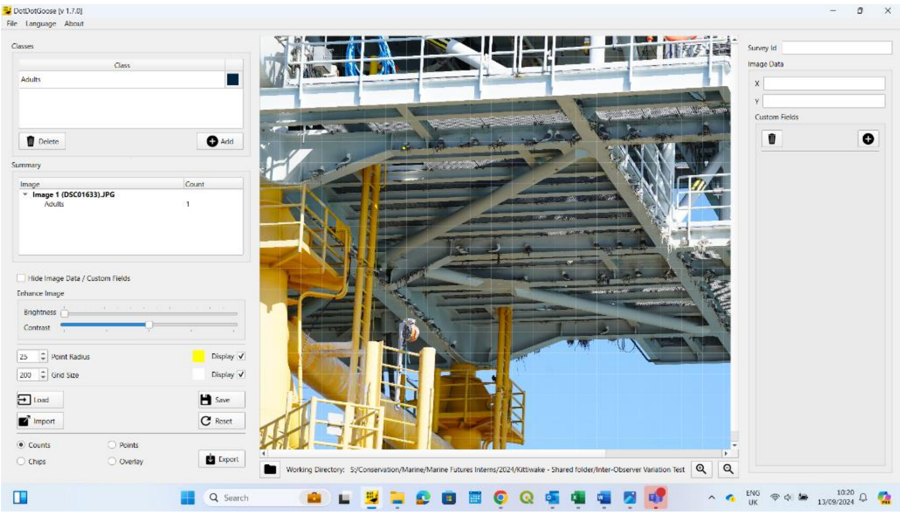
Appendix 1: Instructions Given to Participants for the Inter-Observer Variation Test

To conduct the counts for each image:

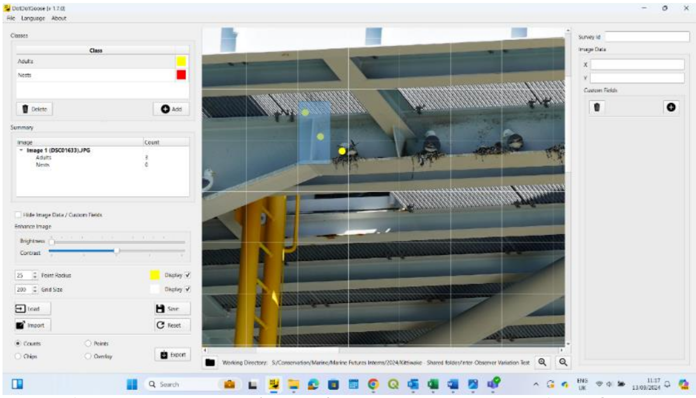
1. Download DotDotGoose software (version 1.7) from https://biodiversityinformatics.amnh.org/open_source/dotdotgoose/. We are using DotDotGoose to conduct our counts. It is a free, open-source tool to assist with manually counting objects in images and regularly used by ecologist to conduct surveys from images.
2. Open the folder sent to you which contains four images.
3. For each image in turn, upload the image into DotDotGoose. (See screenshot below). The easiest way to do this is to select the image and drag it into the display tab of DotDotGoose.



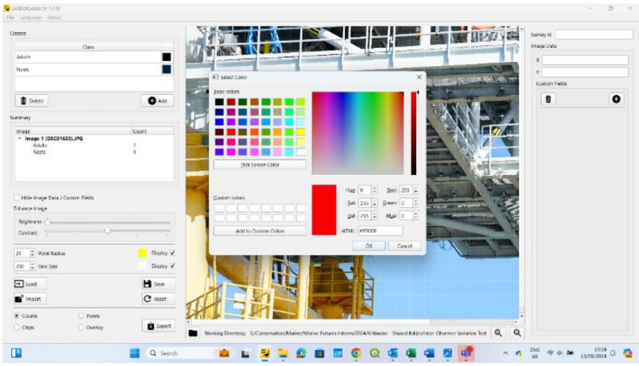
4. Count the number of adults in the image. To do this, click '+ Add' to add a class. Name the class 'adult.' Hold Ctrl key and click on an adult in the image to create a dot and you will see it is added to the count for that class in the 'Summary' tab.



Scroll in and out with your mouse to zoom in and out of the image or use the zoom options in the bottom right. To delete a dot and remove it from the count, hold Shift key and drag your cursor over the dot to select the dot. Once it is selected, press the Delete key.

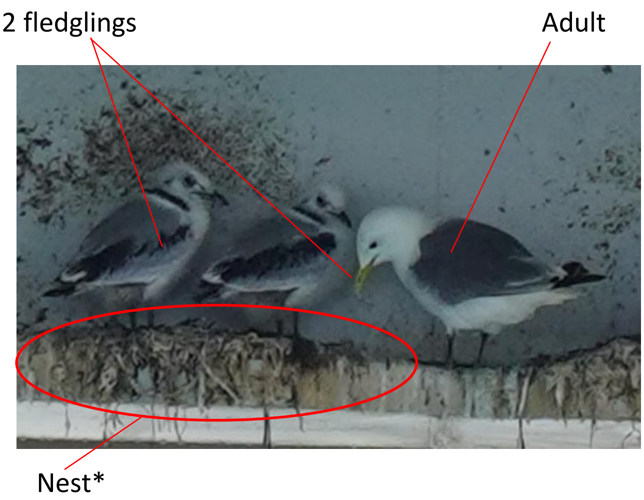


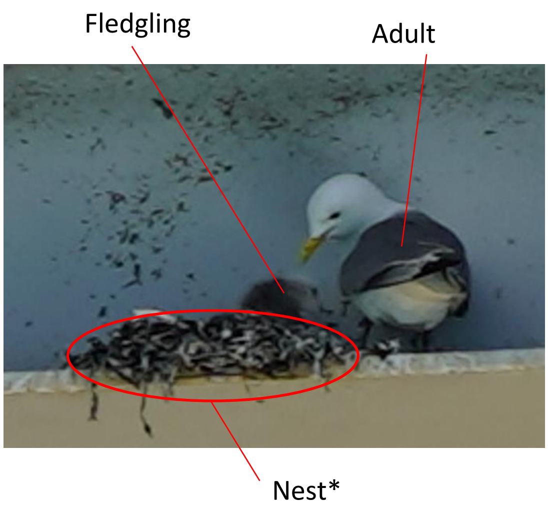
5. To count the nests, press ‘+Add’ again and add a class for nests. Count the nests in the same way. To change the colour of the dots for one class click on the box in the class tab and select a colour.



6. Repeat this method for the fledglings (note some images may not include fledglings).
7. Repeat the counts for adults, nests and fledglings for each of the four images.
8. Record your results in the excel spreadsheet (in the folder).
9. Send the excel spreadsheet back to us by Friday 11th of October.

Don’t worry if you’re unsure whether to count an adult/nest/fledgling that you cannot see properly in the photograph. We want to understand the differences in different observers’ interpretations, so use your own discretion to decide what should be included in the counts. For a general guide see the images below:





*Include unattended nests as nests in your counts.

Appendix 2: Results from the Inter-Observer Variation Test

Table 1. Counts from the Inter-Observer Variation Test

Observer	Image	Adults	Nests	Fledglings
1	1	94	108	8
	2	29	34	0*
	3	45	21	0*
	4	43	61	26
2	1	93	91	8
	2	29	34	0*
	3	47	23	0*
	4	44	66	26
3	1	75	65	7
	2	29	27	0*
	3	44	19	0*
	4	35	35	23
4	1	80	59	5
	2	28	26	0*
	3	44	17	0*
	4	44	46	25

Note: Observer 1 and Observer 2 had no previous experience conducting the kittiwake counts from these images, whilst Observer 3 and Observer 4 had conducted the kittiwake counts from the 2024 surveys before undertaking the inter-observer variation test.

Table 2. Calculation of inter-observer variation (i.e., standard deviation between the different observers' counts in Table 1).

Image	Standard deviation between the observers' counts		
	Adults	**Nests**	**Fledglings**
1	8.20061…	19.80372…	1.224745…
2	0.433013…	3.76663…	-*
3	1.224745…	2.494438…	-*
4	3.774917…	12.26784…	1.224745…
Inter-observer variation (Average of the 4 standard deviations)	3.4	9.6	1.2

*Where no fledglings were counted in the images this was excluded from the calculation for standard deviation, since there was no inter-observer variation were images included no fledglings.

Appendix 3: Full Results of Surveys Undertaken in 2024

3.1 Surveys of WOW02 OSS

Table 3. Survey results for Survey 1 (29.05.2024) of OSS02

Side	Layer	Nests	Adults	Fledglings
North	Top	0	10	0
	Middle	0	15	0
	Bottom	11	31	0
	Total	11	56	0
East	Top	0	0	0
	Middle	1	10	0
	Bottom	5	35	0
	Total	6	45	0
South	Top	0	0	0
	Middle	0	0	0
	Bottom	0	10	0
	Total	0	10	0
West	Top	0	0	0
	Middle	0	0	0
	Bottom	3	18	0
	Total	3	18	0
Underside	Total	N/A	N/A	N/A
All sides	All layers	40	258	0

Table 4. Survey results for Survey 2 (08.07.2024) for OSS02

Side	Layer	Nests	Adults	Fledglings
North	Top	4	5	0
	Middle	17	17	0
	Bottom	27	34	0
	Total	48	56	0
East	Top	0	0	0
	Middle	6	10	0
	Bottom	21	26	2
	Total	27	36	2
South	Top	0	1	0
	Middle	0	0	0
	Bottom	2	7	0
	Total	2	8	0
West	Top	0	0	0
	Middle	0	0	0
	Bottom	25	25	0
	Total	25	25	0
Underside	Total	139	142	14
All sides	All layers	241	267	16

Table 5. Survey results for Survey 3 (30.07.2024) for WOW02 OSS

Side	Layer	Nests	Adults	Fledglings
North	Top	4	2	2
	Middle	16	13	10
	Bottom	24	19	14
	Total	44	34	26
East	Top	0	0	0
	Middle	5	3	2
	Bottom	20	16	16
	Total	25	19	18
South	Top	0	0	0
	Middle	0	0	0
	Bottom	0	10	0
	Total	0	10	0
West	Top	0	0	0
	Middle	0	0	0
	Bottom	24	23	14
	Total	24	23	14
Underside	Total	128	117	138
All sides	All layers	221	203	196

3.2 Surveys of WOW01 OSS

Table 6. Survey results for Survey 1 (29.05.2024) for WOW01 OSS

Side	Layer	Nests	Adults	Fledglings
North	Top	0	2	0
	Middle	0	6	0
	Bottom	1	7	0
	Total	1	15	0
East	Top	0	0	0
	Middle	0	2	0
	Bottom	8	26	0
	Total	8	28	0
South	Top	0	0	0
	Middle	0	0	0
	Bottom	0	2	0
	Total	0	2	0
West	Top	0	0	0
	Middle	0	0	0
	Bottom	0	0	0
	Total	0	0	0
Underside	Total	N/A	N/A	N/A
All sides	All layers	9	45	0

3.3 Surveys of WODS OSS

Table 7. Survey results for Survey 3 (30.07.2024) of WODS OSS side.

Side	Adults	Fledglings	Nests
North	25	9	20
East	0	0	0
South	6	1	2
West	0	0	0
Underside	4	0	1
Total	35	10	23

Table 8. Survey results for Survey 3 (30.07.2024) of WODS OSS by layer.

Layer	Adults	Fledglings	Nests
Top	0	0	0
Middle	7	1	5
Bottom	24	9	17

Appendix 4: The OFTO Technician Questionnaire Questions

We are investigating the presence of kittiwakes nesting on the substations at Walney offshore wind farm. The aim of this questionnaire is to gain a better understanding of how technicians feel about the kittiwake's presence, and whether there are health and safety concerns associated. All answers are anonymous but if you are happy to be contacted following the questionnaire, please leave your email address at the end. Thank you for participating.

1. How long have you worked as a technician on the substations?
2. How often do you carry out work at Walney 1 or 2 Offshore Substation?
3. How would you describe the overall impact the kittiwakes have on you while conducting your work?
   - A positive impact
   - No impact
   - A negative impact
4. If you consider the kittiwakes to have an impact, how significant is this?
   - Negligible
   - Little impact
   - Moderate impact
   - Significant impact
   - Extreme impact
5. How close would you say you normally come to the kittiwakes while working on the substation?
   - Less than 1 meter
   - 1-3 meters
   - 3-5 meters
   - More than 5 meters
6. While working on the substation have you ever: (select all that apply)
   - Felt your tasks were made more difficult by the presence of kittiwakes
   - Been concerned for your physical health and/or safety as a result of the kittiwakes
   - Experienced the kittiwakes flying close to you
   - Had guano (faeces) land on you
   - None of the above
7. Has the presence of guano (faeces) on the structures of the substation ever: (select all that apply)
   - Caused you concern
   - Made surfaces slippery
   - Affected your ability to carry out jobs
   - None of the above
8. Have you ever reported or logged an incident or near miss involving the kittiwakes?
   - Yes
   - No
9. If you answered yes, please describe the incident or near miss
10. If you answered no, are you aware of anyone else who has experienced an incident involving the kittiwakes? If so, please describe.
11. Have you ever observed any other wildlife while on the substation? Please describe if so.
12. Do you have any additional comments about the kittiwakes?
13. If you are happy to be contacted about your responses please provide an email address.

Appendix 5: List of Contacts Who Contributed to the Project

Contact	Organisation	Contribution
Bart Donato	Natural England	Participating in the preliminary survey and providing recommendations for future surveys Providing expertise on kittiwake ecology and wider guidance and advice
Laurence Browning & Connor Hinchcliffe	Natural England	Providing expertise on kittiwake ecology, protected areas, legislation, interpretation of the results and wider guidance and advice Report draft feedback
Emma Ahart	Ørsted	Facilitating the project Providing expertise on the project scope and direction, kittiwake ecology and wider guidance and advice
Tom Brady	Ørsted	Mentoring the interns Providing expertise on wind farm operations and the project scope Communications with internal personnel Organisation of surveys Participating in the preliminary survey Internal communications Communications with the OFTO Wider guidance and support Report draft feedback
Toby Naylor	Ørsted	Providing expertise on wind farm operations Communications with internal personnel Report draft feedback
Emma Darnell	Ørsted	Providing expertise on kittiwake ecology and ecological compensation
Georgia de Jong Cleyndert	North West Wildlife Trust	Participating in the second survey Providing expertise on relevant policies, environmental impacts of wind farms and wildlife monitoring techniques
Beth Churn	North West Wildlife Trust	Mentoring the interns Participating in the third survey

		Providing expertise on wildlife monitoring techniques Report draft feedback Wider guidance and advice
Florence Peyton-Jones	The Crown Estate	Mentoring the interns Report draft feedback Guidance on project management and interpretation of the results
Grace King	The Crown Estate	Mentoring the interns Providing guidance and advice on project management
Dave Shackleton, Dave Blackledge, Mhairi Maclauchlan	RSPB	Providing expertise on wildlife monitoring techniques and kittiwake ecology Providing recommendations for the standardised survey method and comparisons with the kittiwake colony at St Bees

Annex 1: Standardised Method

This document has been created to assist with further years of kittiwake monitoring. This standardised method is authored by the 2024 North West Marine Futures Interns and pulls together our recommendations based on lessons learned through conducting our study, and tips we feel would make future study easier and more robust. The intended audience of this standardised method is future surveyors, which is likely to be future interns. Hence, the instructions are written in way to make them as accessible and simple as possible for unexperienced surveyors.

First steps:

1. The first thing you should do is read the 2023 and 2024 reports and familiarise yourself with the methods used.
2. Discuss the priorities of the survey with the stakeholders involved and work out what will be feasible within your timeline.
3. Make sure you and the other surveyor know what the priorities are on your survey date, and if you can, practice using the camera before heading out (DSLR camera with 70-300mm stabilised lens.)

Taking Photographs

Before heading out on your survey dates, familiarise yourself with the layout of the substation, focusing on the distinguishable features of each side (Figure 1). Try to work out which sections you will need to photograph on an angle, and which can be taken straight on. We would like to emphasise the importance of taking good quality photos that capture the entirety of the substation. If you manage that, the task of counting and understanding the results becomes much easier.

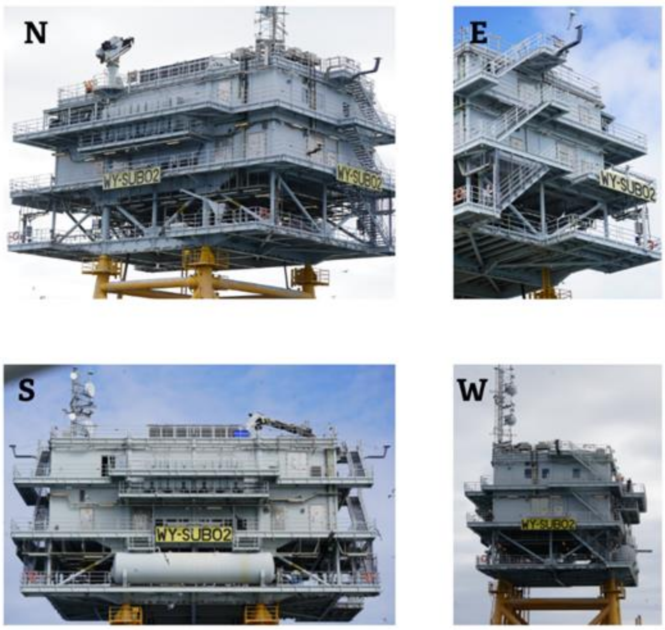
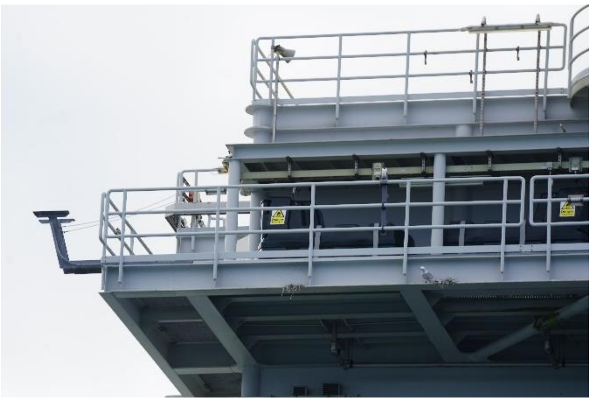


Figure 1 WOW02 OSS sides with their identifiable features. N- North face, identifiable as one of the larger sides with a crane at the top and no tank. E- East face, mooring ladders on yellow structural supports and stairs going up the left side. S- South face, large side with a storage tank at the bottom. W- West face with satellite tower on top and stairs up the right side.

We found that conducting counts from photographs was a more effective method of capturing the number of birds present in a single instantaneous moment. Therefore, we recommend using the time on the vessel to ensure photographs are suitable, then conducting on-site counts only if time allows. For each aspect, a full image should be taken first, capturing all ledges and distinguishable features of the side. This should be taken face-on if possible (Figure 2). If you are too close to the substation to capture this, you may find it easier not using the big zoom lens. In your camera roll after the survey, you will find it helpful to have this full side image at the start of each series of pictures so that you know which side you are looking at. Have a look over the method for top, middle and bottom sections of each side; this is important when conducting counts.

Figure 2: Full, face-on aspect image of the south side of WOW02 OSS.



Following this, further zoomed in images should be taken of the different horizontal sections (Figure 3). These should allow the images to be analysed more accurately as the quality will remain even when zoomed in.

Figure 3: Zoomed in image of the upper left section of the north face of WOW02 OSS.

As the vessel motors around the platform, images should be taken on an angle, to try and capture birds and nests on the ledges that are not visible from a face-on angle (Figure 4).

Figure 4. Photograph taken at an angle to capture the ledge jutting out from the body of the substation, east face of WOW02 OSS

When photographing the underside, a similar approach should be taken, capturing images from face on and then from angles to show the beams running in various directions. You may need to vessel to move closer to the substation in order to capture photos from this angle. The underside layout should be studied prior to the survey dates, and a copy taken on the vessel so that it can be used as a reference to ensure the photographs being taken are capturing all ledges (Figure 5 and 6).

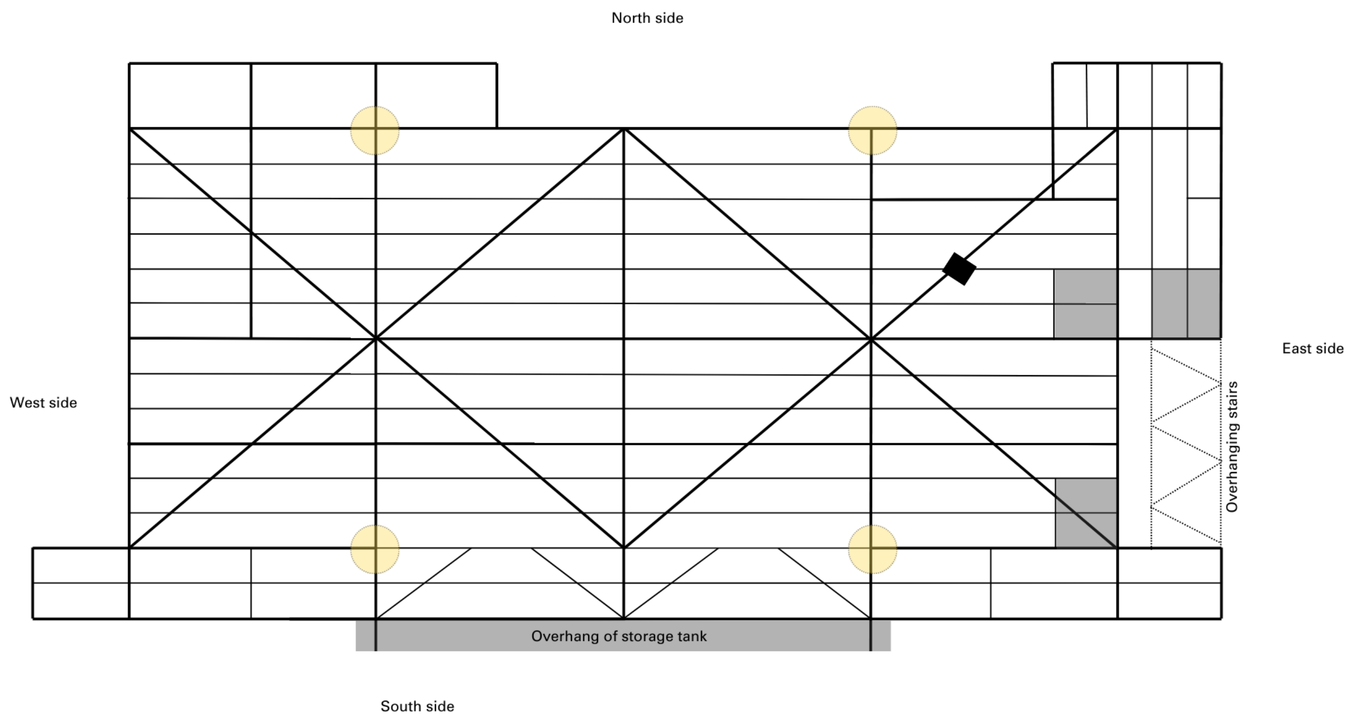


Figure 5. Underside map of WOW02 OSS.

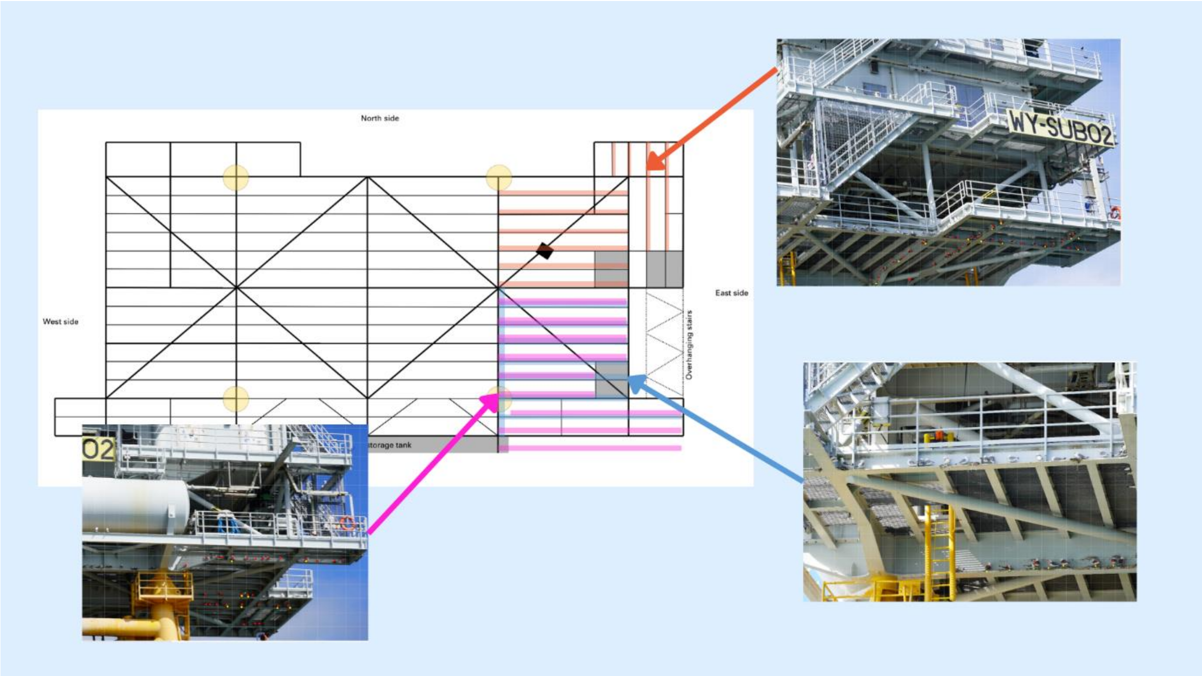


Figure 6. Using the underside map of WOW02 OSS to check that each ledge has been viewed and counted.

If possible, the use of drones could be considered, with an upwards facing camera capturing images of the underside of the substation. However, this has the potential to cause disturbance to the birds and would require careful navigation between the structures of the platform and the sea surface below.

Survey Date Specifics

Effort should be made to avoid surveying a substation when there are technicians present on the substation, or when another boat is moored to the platform as this causes birds to fly off and change their behaviour. This would require further communication with the OFTO to ensure the survey date chosen does not coincide with operations on the substation. Alternatively, it may be possible to set the survey day timeline to work around the substation technicians plans i.e., visit WOW01 OSS in the morning when it is not occupied and swap over to WOW02 OSS in the afternoon after technicians have finished working there.

A preliminary survey date should be carried out in May, to determine how far into the breeding season the birds are and the timeline for further survey dates should be set based on that information.

Following this there should be at least two more survey dates (more if you adapt the method, e.g., to map apparently occupied nests). We found the peak timing for fledglings both years was end of July, but this may vary.

Multiple Observers

As the surveys and subsequent counts, are carried out by different observers, there is likely to be some degree of error in the data outputs. For example, with no set distinction on boundaries of nests, one observer may count three individual nests on a ledge, while another classes it as two due to their close proximity. Because of this variation, we developed an Inter-Observer Variation Test to generate error bars for our counts. We would recommend repeating this test with a larger number of participants to get a better understanding of variation that may occur between observers. You can find instructions for this inter-observer variation test in Appendix 1 of the 2024 Report.

Analysing images taken by other observers also proved difficult as it can be hard to determine what is being shown on the image, without distinguishable features captured. This is another reason we emphasised taking photos with the distinguishable features at the start. One way of helping with this would be to sort through your photos post survey and name each one according to the side, storing them in folders for each substation.

Image Analysis

When analysing images, a distinction needs to be made about the boundaries of neighbouring nests (Figure 7 shows an example of a photo with lots of nests that are hard to distinguish). On some well-populated ledges, nesting material is spread across the surface to a degree where it becomes difficult to determine where one ends, and another begins. This is why, unsurprisingly to us, nests had the highest standard deviation representing IOV. It may also be necessary to decide how much material constitutes a formed nest. Based on recommendations from contacts within the RSPB, it may be worth only counting 'apparently occupied nests' (AONs). This would require more survey dates, beginning at the end of May, identifying nests that are in use and following these throughout the season to determine breeding success. This method of nest mapping is described by the JNCC in their *Seabird Monitoring Handbook* as the most suitable method of monitoring kittiwake populations. In this methodology, an AON is defined as "a well-built nest capable of containing eggs with at least one adult present." They also make the distinction here of what a trace nest or unoccupied nest is, and what these may indicate.

Figure 7: Crowded ledges on the East face and underside- demonstrating difficulty with distinguishing individual nests apart.

DotDotGoose is the software used for counting adults, fledglings and nests. We would recommend setting aside several hours after the survey dates for conducting these counts. It takes a while to figure out which photos to use and make sure each ledge has been captured. The outputs from the counting software leave you with a spreadsheet containing the numbers and you can also download the images with count overlays. (We would recommend doing this so you can keep track of images used.)

A digital version of the underside map has been made available to Ørsted and Cumbria Wildlife Trust.