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Testing of different rail designs to minimize conflicts with gulls resting on unmanned off-shore platforms

Arne Follestad and Nina Dehnhard

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Herring gull balancing on a test rail © Arne Follestad

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Abstract

Follestad, A. & Dehnhard, N. 2023. Testing of different rail designs to minimize conflicts with gulls resting on unmanned offshore platforms. NINA Report 2246. Norwegian Institute for Nature Research.

Unmanned offshore platforms can be attractive roosting and even breeding habitats for gulls. For the platform operators, bird droppings, regurgitates and dropped feathers cause work health and safety related issues as well as increased maintenance costs. Large gull species in particular have been observed to use handrails for perching and resting.

On behalf of Equinor, we tested five different handrail designs to identify which rail designs were the least preferred by gulls to perch on. Two of the rail designs were of the standard types currently used on Norwegian offshore platforms (square and circular). The other three were modified, with one rail being a square design turned by 45 degrees, so that the top was not flat but triangular ("45° angled square"), one rail type having a thin metal string (wire) mounted 10 cm above the standard circular rail ("string"); and one having a narrow metal edge mounted on top of the square design ("ridge").

Tests were conducted onshore at a fish handling facility in central Norway, where gulls were frequently visiting to feed on fish offal. Test rails were placed in a randomized order on the edge of a balcony, a place the gulls used to perch on to look over the harbour area. Both the frequency of gulls perching on the different test rails as well as the duration during which they perched on the different test rails were analysed from videos. For each gull landing, the section of the balcony, the species, age (adult / immature), and the duration during which the bird was standing on the edge of the balcony or test rails, respectively, were noted.

The handrail designs "ridge" and "string" appeared to be the designs least attractive to perch on, followed by the 45° angled square. The observations indicated that gulls in the first instance also attempted to perch on the less attractive rail types, but that they did not stay as long on the rail as on the regular square rail type. Gulls were able to stand on the 45° angled square, but both on this rail type, as well as the circular rail type, they had to balance more, especially under wet conditions.

Based on our findings we suggest the handrail designs with the edge or the string on top as the ones most suitable to reduce the number of gulls perching on handrails, but with some suggestions for adaptions to further improve the design.

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Sammendrag

Follestad, A. & Dehnhard, N. 2023. Forsøk med ulike rekkverksprofiler for å redusere konflikter med måker som sitter på ubemannede plattformer. NINA Rapport 2246. Norsk institutt for naturforskning.

Ubemannede offshore plattformer kan være attraktive rasteplasser og også hekkeplasser for måker. For operatørene kan avføring, oppgulp av matrester og fjær forårsake helse- og sikkerhetsmessige problemer og medføre økte kostnader til vedlikehold. Især store måker er observert når de bruker rekkverk på plattformer som sitte- og hvileplass.

På oppdrag fra Equinor har vi testet fem ulike design for rekkverk for å finne hvilke utforminger av rekkverkene som måkene minst foretrekker å sitte på. To av rekkverkene var av standard utforming som nå brukes på plattformer i norske farvann (runde eller firkantede). De tre andre var modifiserte, der et rekkverk hadde en tynn wire festet 10 cm over et standard rundt rekkverk, et hadde en smal kant festet på toppen av et firkantet rekkverk, og et var et standard firkantet vridd 45°.

Testene ble utført på land på et fiskemottak i Midt-Norge, som måkene ofte oppsøkte for å spise fiskeavfall. Rekkverkene ble plassert i tilfeldig rekkefølge på kanten av en balkong, der måkene ofte satte seg for å få oversikt over havneområdet. Både frekvensen av måker som satte seg på de ulike testrekkverkene og hvor lenge de satt der, ble analysert ut fra videoopptak. For hver måke som landet, ble hvilket rekkverk de satte seg på, art og alder (voksen / ungfugler) og hvor lenge de satt på rekkverket, notert.

Rekkverkene med en kant eller wire viste seg å være de minste foretrukne utformingene å sitte på for måkene, etterfulgt av det som var vridd 45°. Observasjonene indikerte at måkene i første omgang forsøkte å sette seg også på de minst komfortable utformingene, men at de ikke satt der så lenge som på de standard runde eller firkantede typene. Måkene var klart i stand til å sitte på rekkverket som var vridd 45°, men både på dette og det runde rekkverket måtte de balansere mer, særlig når rekkverkene var våte og glatte. Vi har derfor foreslått at rekkverkene med kant eller wire på toppen er de mest egnede for å redusere antall måker som setter seg på rekkverk på plattformen, men vi har foreslått noen tilpasninger for å forbedre designet.

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Foreword

For this study, the Norwegian Institute for Nature Research was commissioned by Equinor to test different designs of handrails to be used on unmanned offshore installations in the North Sea. The aim of this study was to find a rail design that was less attractive for gulls to perch on, and thus contribute to conflict reduction and less maintenance for personnel when entering and working on installations. The report is based on field studies conducted at Roan fish handling facility.

Our contact person at Equinor has been Ingunn Nilssen. In addition, Liv-Torill Austgulen took part in the discussions on the design of the handrails, and Arnfinn Killingberg made the final layout of the rails. We thank all of them for good co-operation and useful discussions.

We also thank Jon Edvin Forfod and his staff at Roan fish handling facility (‘fiskemottak’) for letting us perform the tests on their balcony outside their office and meeting room.

Trondheim 06.03.2023, Arne Follestad

1 Introduction

1.1 Background

Unmanned installations such as automated offshore oil- and gas installations are designed to primarily be operated remotely without the presence of personnel. The number of such unmanned solutions for offshore development is increasing (Christensen-Dalsgaard et al. 2019a). Unmanned installations offshore may therefore create a form of artificial land habitat. Previous research has shown that birds may be attracted to offshore platforms both due to foraging opportunities (Fowler et al. 2018), and as a resting and roosting site (Ronconi et al. 2015). Black-legged kittiwakes (*Rissa tridactyla*) may also settle on platforms to breed there (Christensen-Dalsgaard et al. 2019b). For the operators of offshore platforms, the presence of birds and of bird droppings, regurgitates and dropped feathers form a severe work health and safety aspect and may also cause increased maintenance costs due to corrosion effects or blockage of drainage pipes (Christensen-Dalsgaard et al. 2019a).

Gulls were the most frequent avian species group observed on offshore installations (including manned installations) in Norway during the period of 2010-2019 (Christensen-Dalsgaard et al. 2019a). Equinor, the largest operator of offshore installations in Norway, has also observed large numbers of gulls roosting on unmanned offshore platforms. Pictures and videos of surveillance cameras confirmed that rails appear to be highly attractive for gulls to roost on. Christensen-Dalsgaard et al. (2019a) reviewed potential mitigation measures to minimize conflict with gulls on unmanned offshore platforms. Among the recommendations made by Christensen-Dalsgaard et al. (2019a) was the suggestion of a different handrail design that would make it harder for gulls to perch and rest on rails.

This idea was taken further by Equinor. Besides the original suggestion by Christensen-Dalsgaard et al. (2019a) for triangular handrails with the sharp edge pointing up, several other handrail designs were also considered as possible candidates by Equinor. We here report the results of an onshore testing of various profiles for handrails (**Figure 1**) under consideration for use on unmanned installations. The rail designs were based on the two types that are commonly used on platforms, either square (type 1; 5 x 5 cm) or circular (type 2; 5 cm in diameter; **Figure 1**). Three new designs, that could be less attractive for the gulls to perch on, were to be tested: Type 3 (45° angled square) is a variation of the square type angled by 45° with the edge on top. Type 4 (string) is a round rail (as type 2) with a thin wire approximately 10 cm above main rail. Type 5 (ridge) consisted of a thin metal edge (1 cm wide, 4,5 cm high) welded on top of a standard square design. The underlying question behind designs 3, 4 and 5 was if gulls would manage to stand on the rails and bend their foot so much that they could balance (applying particularly to designs 3 and 5). All designs were deemed acceptable for Work Health and Safety of personnel working offshore.

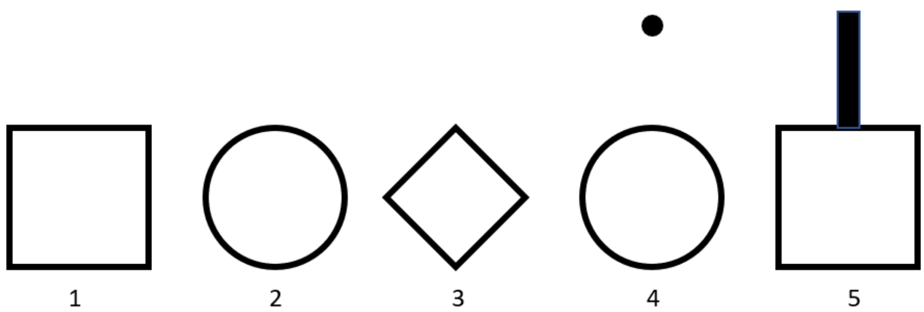

Figure 1. *Test design of rails. 1 = Square, 2 = Circular, 3 = 45° angled square, 4 = String, 5 = Ridge*

1.2 Aims

The overall aim of the onshore testing of handrails was to identify which profiles were less attractive for gulls to rest on. In order to do so, we assessed if gulls were more likely to perch on rails with a specific design than on other rail types, and whether the duration during which gulls perched on rails differed with rail design.

Figure 2. *The balcony overlooking Roan fish handling facility, where the rails were mounted.*

2 Methods

2.1 Fieldwork

All fieldwork was conducted at Roan fish handling facility (‘fiskemottak’) on Fosen, Trøndelag county, central Norway (64.17°N, 10.21°E). Local fishermen deliver their catch to this facility, where the fish is gutted, filleted and packed for transport and/or direct sale. Gulls are attracted to the facility since fish offal from the production may occasionally become available to them.

Several other fish handling facilities were contacted to ask for permission to perform the project but turned out to be unfit for onshore testing of the handrails for several reasons. For example, by the time testing was to be started, the fish delivered to one fish handling facility was already gutted and frozen, so that no fish offal was available to the gulls, and there were few gulls in the vicinity. At other facilities, gulls were sitting on roofs and other high positions nearby, making it difficult to carry out the test of rails. At Roan, staff from the fish handling facility suggested that the best place for us to test the rails would be on the balcony of the fish handling facility, on top of the existing balcony rails. This is where gulls used to sit and overlook the activity in the harbour, waiting for an opportunity to get some fish offal (**Figures 2**).

Great black-backed gulls *Larus marinus*, lesser black-backed gulls *Larus fuscus* and herring gulls *Larus argentatus*, with the latter being the most numerous species, were observed perching on the outer edge of the balcony of the fish handling facility. The edges of the balcony consisted of a ca. 15 cm broad flat wooden frame, which made it easy for the gulls to stand on. On this existing wooden rail, the test rails could easily be mounted and shifted out. Gulls on the edge of the balcony could be observed from within the building. The balcony edge was of rectangular shape, with a long outer side (7.26 m) and two shorter side parts (3.80 m each).

Preferences of gulls to perch on a certain part of the balcony could have interfered with our test design and biased our results. To identify if certain parts of the rectangular-shaped balcony edge were preferred by the gulls, the balcony was observed for 6:50 hours without any test rails being present, and every gull perching on the balcony edge was recorded as an observation. The balcony was divided into five sections: short side right, short side left, and the long side was divided into three sections (right side, middle part and left side). For each observation, the section of the balcony, the species, age (adult / immature), and the duration during which the bird was standing on the balcony were noted. Since individuals were not ringed, it was impossible to know if the same or different individual birds were observed, and if individuals had specific preferences as to where on the balcony rails to perch.

For each rail profile shown in **Figure 1**, we obtained two prototypes of a length of 2 m each. For the onshore tests, rails were designed so that they were attachable to a flat surface or to an existing rail.

To test different rail designs, test rails were set up on top of the existing wooden balcony. A first trial of the test rails was conducted at the fish handling facility in Roan between 23rd of May and 3rd of June 2022. However, the trials conducted in May and June 2022 turned out to be suboptimal and did not lead to robust results due to weaknesses in the test design.

The main experiment to test different rail types was conducted in October 2022 (10, 13 and 21st of October). As wind speed may affect if the gulls could perch on the rails or not, we avoided testing on days with wind speeds of more than 9 m/s, which is equivalent to a fresh breeze. Wind conditions were obtained from www.yr.no for the hours when tests were conducted. In October, herring gulls were again the dominating species, and only one great black-back gull was observed. We placed rails following five different test setups (**Figure 3**). Test rails were only set up along the long edge of the balcony, which is the part that was preferred by the gulls in the trials in May (see Results). The length of the middle part (the square shown in grey) was adapted, so that rails could be placed along the whole long side of the balcony. The test rails on the outer sides (shown in blue in **Figure 3**) were each 2 m long, the middle section was 3.26 m long. Rails were placed on top of narrow-squared pieces of wood, so that they were approximately 10 cm above the balcony's edge (**Figure 4**).

Gull activity and the number of gulls perching on the balcony depended on activity at the fish handling facility. The duration during which the different test setups were installed also depended on the activity at the fish handling facility. In general, the setup was changed once ~50 observations were obtained (see **Table 1**). Changing rails in between setups took only about 5 min, and we did not employ an embargo period after changing rails,but continued with observations straight away (see Table 1). Once gulls were observed flying around the balcony, a video camera mounted on a tripod was started, and the gulls landing on the rails were filmed. Videos were afterwards analyzed manually, and observations transferred into an Excel-sheet. All observations and video analyses were done by the same researcher (AF). The rail type which the gull stood on, species and age (adult/immature) were noted, as well as the time when the gull perched and the time when it lifted off again. Duration (in sec.) was calculated. In few cases (N= 8), technical issues prevented us from recording either start or stop-time, so that the duration data is missing. We obtained between 47 and 178 observations of gulls per setup (N = 449 observations in total), here counting only gulls that perched on the long side of the balcony. Additional gulls that perched on the outer (short) sides of the balcony were registered in addition (76 in total, ranging from 5-34 per setup).

Table 1. *Duration during which rails were tested and number of observations per setup. The setup number refers to **Figure 3**, the rail type to the rail type of interest in each setup.*

Date	Start	Stop	Setup	Number of observations
10.10.2022	11:16	12:38	5 - ridge	53
10.10.2022	13:00	13:48	4 - string	59
10.10.2022	13:55	14:25	2 - circle	10
13.10.2022	09:00	12:12	2 - circle	28
13.10.2022	12:30	15:00	3 - 45° angled square	23
21.10.2022	08:35	12:20	3 - 45° angled square	89
21.10.2022	12:35	13:55	2 - circle	140
21.10.2022	14:00	14:55	1 - square	47

2.2 Statistics

To test if certain parts of the balcony were preferred by the gulls (without having any test rails in place), we ran a Generalized linear model (GLM) with number of observations per balcony section. We further ran a Cox proportional hazard model to test if the duration during which birds perched on the balcony edge differed between balcony sections. This was based on the observations done in May and June. No gulls were observed on either of the short sides of the balcony (see Results). The long edge of the balcony was divided into 3 different categories (left side, middle part, right side).

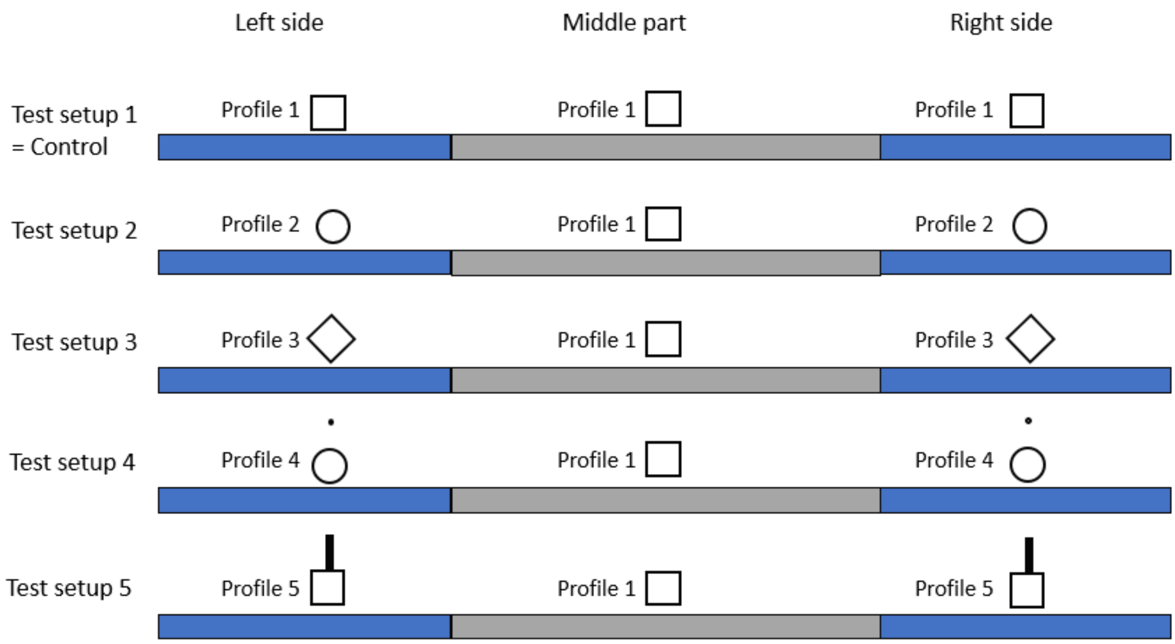

Figure 3. *Visualization of test setups, placed along the long side of the balcony. Within each test setup, the same rail type was used on the right side and left side (2 m long each, shown in blue). The middle part always consisted of the square rail (3.26 m long, shown in grey), but the rails used to the right and left varied between test setups.*

Figure 4. *Showing the improved test-setup in October, with rails being placed on top of narrow squared timbers. This meant gulls could not cheat by placing one foot down on the balcony edge.*

For both types of models (GLMs and Cox proportional hazard models, respectively), we ran one model each with section of the balcony as explanatory variable (as category; right side, middel part, left side). P-values for GLMs were obtained from likelihood ratio tests. For Cox proportional hazard models, we compared the model the null model (without the explanatory variable) and present Chi-square test results and p-values.

To test if the number of gulls perching differed between different test rails, a GLM was run, with test setup (as category: 1-5, as in **Figure 3**) and the section of the balcony (as category: outer edge = test rail, middle = square profile) as fixed factors as well as their two-way interaction. To test if the duration during which gulls perched on the different test rails differed, we ran two sets of Cox proportional hazard models. Firstly, we used only those observations of gulls on the right and left side of the balcony's long edge (i.e. omitting the middle part with the square rail), and included rail design as only fixed effect. Secondly, for each test setup, we ran a Cox proportional hazard model and included the balcony section (categorical, either middle part = control of outer section = test rails) as factor. All statistical procedures were conducted in R (R Core Team 2022). GLMs were run in the stats package (R Core Team 2022) and Cox proportional hazard models in the R package survival (Therneau 2015).

3 Results

3.1 Preference of perching location on the balcony without test rails

Without test rails present, a total of 55 gull observations were made, of respectively 50 herring gulls, 3 great black-backed gulls, and 2 lesser black-backed gulls. Gulls perched on the balcony edge for a duration of 1 to 585 seconds (average ± SD: 109 ± 151 sec) and used only the long side of the balcony. There were no observations of gulls standing on either of the short sides, reflecting a clear preference for the long side of the balcony, which offered the best lookout position over the area where fish offal occasionally was available.

Although visually it appeared that gulls perched more frequently on the outer edges of the long side of the balcony compared to the inner part (**Figure 5**), this was not significant (GLM: Dev. -3.10, df = 2, p = 0.212). Similarly, perching duration visually appeared to be longer on either the outer left or outer right side of the balcony compared to the inner part of the balcony's long side (**Figure 6**), however the Cox proportional hazard model with balcony section as explanatory variable did not receive more support than the null model (Chi-square = 0.237, df = 2, p = 0.888). Thus, gulls did not have a clear preference area along the long side of the balcony.

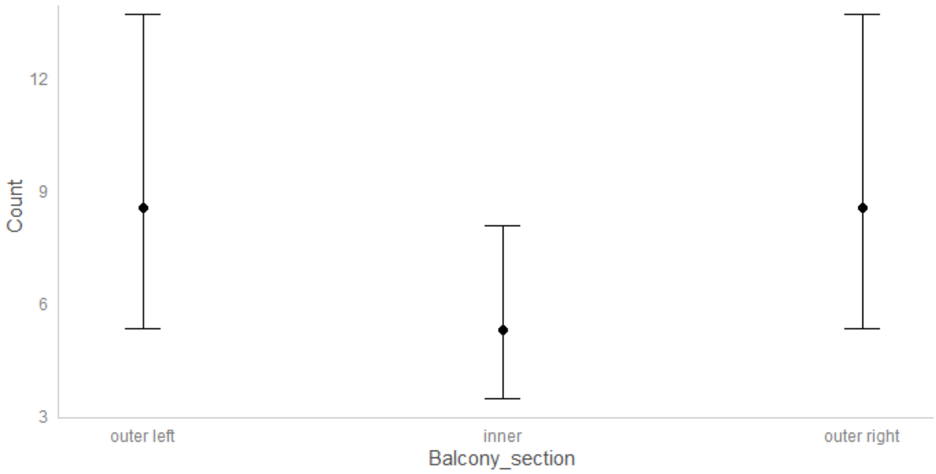

***Figure 5.** Predicted values for number of birds perching on the different sections of the balcony based on GLM results. This was tested in the absence of testing rails.*

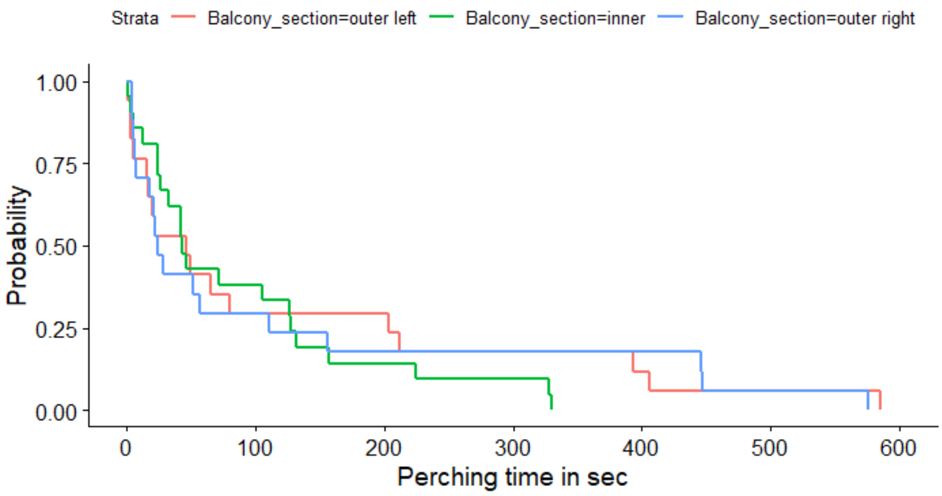

Figure 6. *Kaplan-Meier Plot visualizing the perching time of gulls on the long side of the balcony. This was tested in the absence of any testing rails.*

3.2 Test rails

When test rails were installed along the long side of the balcony, we could observe gulls perching also on the short sides of the balcony (N = 76 out of 525 observations with test rails, equalling 14.5 % of observations).

Our observations of birds perching on the rails suggested that gulls had no problems standing on the square and circular rails (design types 1 and 2, respectively: **Figure 7**). However, when wet or windy, gulls had to balance more when standing on the circular rails than on the square rails, and similar so when standing on the 45° angled square (**Figure 8**). When perching on the ridge and the string, birds had to balance by opening their wings and flapping (**Figures 9 & 10**). We also observed birds “cheating” when perching on the string (N = 23 out of 36 observations during which gulls perched on the string), usually by placing at least one foot down on the round metal part (N = 20), by landing on the round metal part, and then stepping up onto the string (N = 2) or by using the firm end part of the construction (N = 1) (**Figure 10**).

Figure 7. *Three adult herring gulls on classically used rail types (type 1, square and type 2, circular, respectively), where it is easy for them to perch for longer periods. This picture was taken in May and June 2022 during trials.*

Figure 8. *Examples of three herring gulls (adult in the middle, immatures on the left and right), which managed to stand on rail type 3 (45° turned square). This picture was taken in May and June 2022 during trials.*

Figure 9. *Examples of adult herring gulls standing on the rail type 5 (ridge). It was typical for this rail design that birds managed to perch but had to frequently use their wings to keep balance. These pictures were taken in May and June 2022 during trials.*

Figure 10. *Examples of herring gulls perching on rails of design 4 (string). Note the open wings of the bird on the top indicating it has trouble to hold its balance. The birds in the pictures in the lower part found a way to not stand on the wire by either putting one foot down on the round rail (left), using the end point where the wire is attached (middle) or standing completely on the lower round rail (right). These pictures were taken in May and June 2022 during trials.*

For the number of gulls perching on the long edge of the balcony, we found a significant interaction effect between the test setup and the section of the balcony (GLM: Dev = 4.58, df = 6, $p = 0.032$).

In order to interpret the results, we split the dataset by test setup, and repeated GLMs separately for each test setup, thus comparing the number of gulls that perched on either the middle section (= control, with the square rail) or either of the outer sections with the different test rails (**Figure 11**). Significantly more gulls perched on the 45°-angled square than the regular square rail (GLM: Dev = 19.46, df = 1, $p < 0.001$; **Figure 11**), and a similar effect was found for the circular rail compared to the regular square rail (GLM: Dev = 50.8, df = 1, $p = 0.0242$; **Figure 11**). We found a trend for more birds perching on the string compared to the regular square rail (GLM: Dev = 2.89, df = 1, $p = 0.089$). The number of birds perching on the ridge did not differ between those perching on the regular square rail (GLM: Dev = 0.019, df = 1, $p = 0.891$), and finally in the control (test setup 1) we found no difference in the number of gulls perching on the middle square compared to any of the outer square sections on the balcony edge (GLM: Dev = 0.53, df = 1, $p = 0.464$).

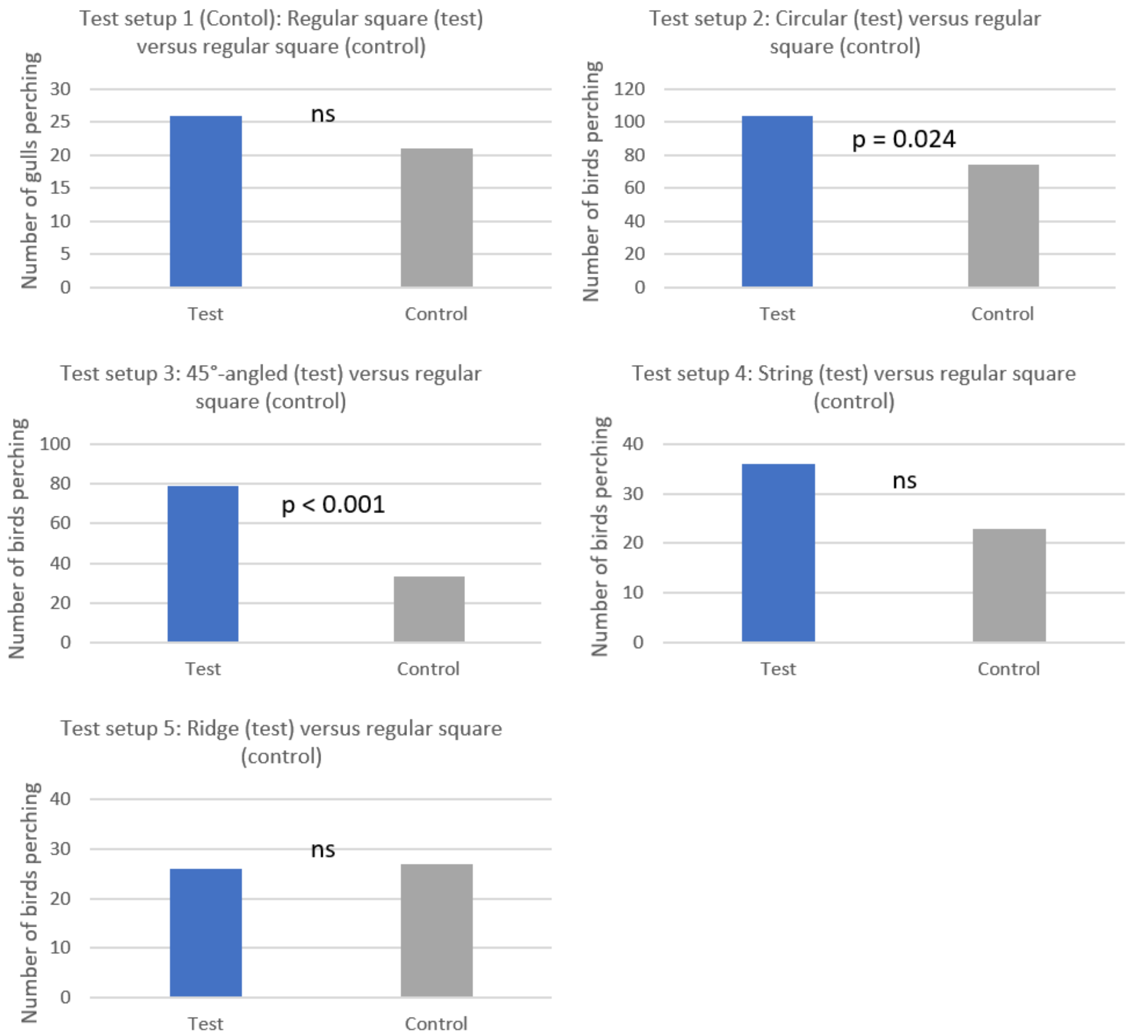

Figure 11. *Number of gulls perching on the test or control section of the different test setups as specified in Figure 1. Test statistics are based on GLMs run separately per test-setup.*

The duration for which gulls perched on the outer sections of the long balcony's edge was significantly affected by the rail design (Cox Proportional Hazard model, X^2=2240, df = 4, p = 0.004). The visualization of this model revealed that perching time was shortest on the rail type ridge, followed by the rail type string, 45°-angled, circular, and finally square (**Figure 12**). Notably, these observations did not distinguish between gulls cheating when standing on the string or not.

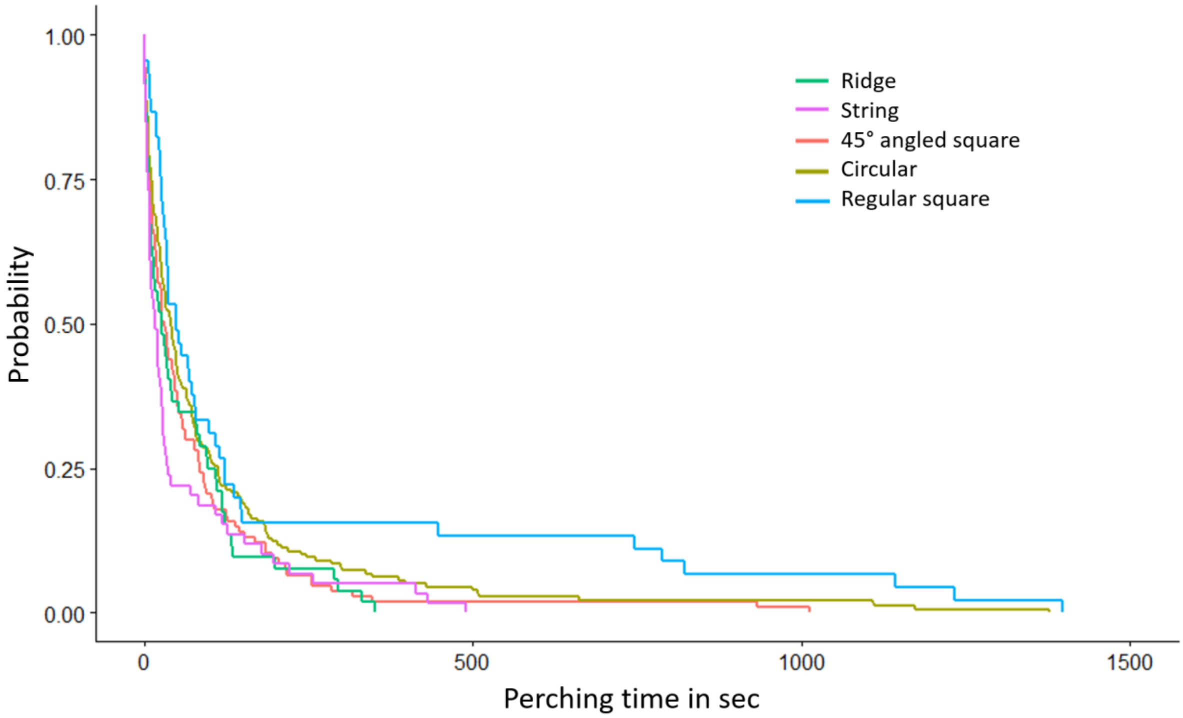

Figure 12. *Kaplan-Meier Plot to visualize the perching time of gulls on different test rails placed on the long side of the balcony. Only gulls perching on the outer section of the long side of the balcony were considered for this analysis.*

When comparing perching time within setups, we could find a significant difference in the perching time between string and square rails (Cox Proportional Hazard model, X^2=8.25, df = 1, p = 0.004), but not for any of the other combinations (i.e. ridge versus square, 45°-angled square versus regular square, circular versus square and square versus square; Cox Proportional Hazard models, all X^2<1.716, df = 1, p > 0.190; **Figure 13**).

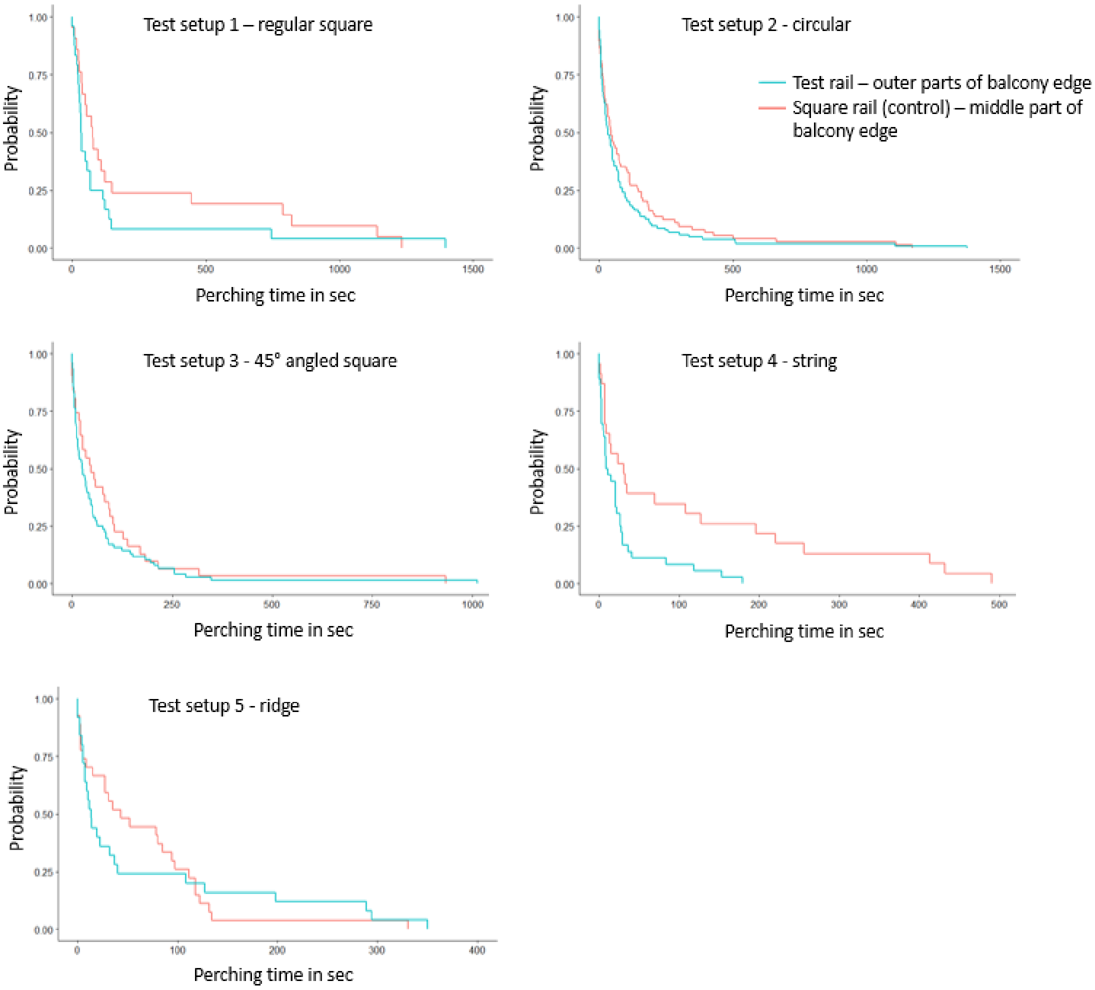

Figure 13. *Kaplan-Meier Plots to visualize the differences in perching time of gulls within each setup, thus comparing the perching time on test rails mounted on the outer parts of the long balcony edge with the perching time on the square rail mounted as control on the middle part of the balcony. In the case of test setup 1, both test and control consisted of the same rail type, i.e. the regular square.*

4 Discussion

In contrast to the pre-trial without test rails, gulls perched on the short sides of the balcony when test rails were installed. This gave a first indication that at least some of the test rails may have been less easy to perch on than the boards of the balcony, so that the gulls rather perched on the normally apparently less attractive short sides of the balcony. Alternatively, some gull individuals may have been avoiding perching on the rails since these were novel objects to them, i.e. reflecting a shy "personality" (see Patrick & Weimerskirch 2014).

Our results about the number of gulls perching on the test rails are somewhat surprising. For the control setup (setup 1), our results showed no difference in the number of gulls perching on the outer versus the middle section of the long side of the balcony. This confirmed the results of the pre-trials without any test rails (section 4.1) and thus that gulls did not prefer the outer sections of the long side of the balcony. However, proportionately more gulls landed on the outer (test) sections of the balcony, when the 45°-angled square and the circular test rails were installed, but not when the ridge and the string test rails were installed (**Figure 11**). This raises the question whether gulls perceived the 45°-angled square and the circular test rails as more attractive to perch on than the regular square. Given the results about perching durations, it seems unlikely that this is the case. It seems more likely that gulls tried to land, failed to stand on the test rails, lifted, and possibly tried to land again. Our test design did not allow identification of individual gulls, thus it is likely that multiple observations of the same individuals were included. Furthermore, we did not consider inter- and intra-specific competition for perching space, and thus if a gull was chased up by a conspecific or not, or whether there was still space on the test rails or not.

During the observations, typically multiple gulls were perching on the long edge of the balcony at the same time. Thus, a gull that perched on the 45°-angled square and gave up balancing after a short while and flew up, could not be sure of finding a free spot to land on the middle section (on the regular square) of the balcony, and might thus have landed a second time on the 45°-angled square. Perching times were shortest for the ridge and the string, and thus these rail designs apparently were the most difficult ones to perch on. Possibly, gulls that lifted from these rail types did not re-attempt to land on these again. Altogether, our results show that different rail designs do not have the desired effect to reduce the number of birds perching on them, since the number of gulls perching on even those test rails considered as least attractive did not differ (or was even higher in the case of the 45°-angled square) compared to the square rail control.

Our results clearly shows that perching duration was shorter on certain test rails than others when comparing perching duration on the outer (test) sections of the balcony. Perching duration was shortest on the ridge, followed by the string (including observations of gulls that were cheating when perching on the rail type string) and the 45°-angled square (**Figure 12**). It thus seems the rail type ridge is the least attractive one to perch on. Somewhat surprisingly, since both rail types are in use by Equinor, it seemed the standard circular rail type is also somewhat less attractive for gulls than the square rail type.

The direct comparisons of perching durations between test rails and the regular square rail, results were again somewhat surprising, since the results were significant only for the rail type string, but not for the ridge and 45°-angled square. Given the overall differences of perching durations on the test rails, we had expected to find significant differences in perching time between the ridge and the regular square as well as the 45°-angled square and the regular square. For these results, as for the number of birds perching (above), inter- and intra-specific competition for perching space may be the most likely explanation. Overall, perching times were shorter for gulls perching anywhere along the long edge of the balcony for the setups that involved the string, ridge and 45°-angled square (see **Figure 12**). This may support the argument of inter- and intra-specific competition playing a role: with string, ridge and 45-angle square being less attractive to perch on (as **Figure 12** and the Cox Proportional hazard models comparing the test rails directly with each other suggest), gulls on the outer edges may lift off faster. This would increase the competition for space in the middle section, leading to more interactions and aggression, which usually leads to birds lifting up, i.e. shorter perching durations also for gulls on the square rails in the middle – and more perching attempts as well, as described above. In contrast, this competition and aggression would have been lower with more possibilities to perch comfortably on when circular and square rails were mounted also on the outer edges of the balcony's long side.

4.1 Conclusions

Taking our results and observations into account, the ridge and the string seem to be the rail types least attractive to perch on, followed by the 45° angled square. It seems as if gulls in the first instance attempted to perch also on the less attractive rail types, but then did not stay as long as on the regular square rail type. Gulls were definitely able to stand on the 45° angled square, but both on this rail type, as well as the circular rail type, they had to balance more, especially under wet conditions.

Our experiments were conducted under relatively low wind conditions (average wind speeds: 1-9 m/s). We expect that under the typically stronger winds offshore, gulls will experience even more challenges to balance on the rails. In the case that none of the three experimental rail types (string, ridge and 45° angled square) proofs feasible for serial production or fails HMS requirements for offshore installations, we suggest using the circular rail type instead of the regular square rail type.

Regarding the design, we observed that about 50 % of the gulls that perched on the rail type string cheated in one way or the other (see **Figure 14**). By placing the string higher, we suggest from 10 to at least 15 cm, one might improve the effectiveness of this rail type even more. However, despite the cheating, the string seemed to be among the two least comfortable rail types to perch on for a longer time.

During the pre-trials in May and June, we also observed gulls cheating on the ridge, by placing one foot down onto the square base. We did not observe this behaviour during autumn. One could easily improve the design of this rail type by removing the square base below, or change it to an angled basis, such that birds cannot stabilize anymore by placing one foot on the base.

***Figure 14**. Herring gulls standing on the base of the rail type string. Arrows point at the string, which is just below the belly of the gulls, allowing the gulls to have the string close into its feet. By increasing the height of the string to breast height it will probably be much more difficult for the gulls to stand on the basis.*

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