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Displacing Black-legged Kittiwakes *Rissa tridactyla* – First experiences from the Kittiwake hotel in Røst, northern Norway

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Abstract

Black-legged Kittiwakes *Rissa tridactyla* inhabit many bird cliffs in the North Atlantic but their numbers are rapidly declining. In Norway, reduced access to food during breeding is an important cause for the negative trends. Higher breeding success in urban areas indicates that human presence helps Black-legged Kittiwakes avoid other stressors, such as avian predators. Actions to maximise the success of urban populations include building facilitated breeding structures. Without common standards for such constructions, sharing experiences is essential to help others allocate limited resources optimally. We present the construction and first-year success of a "Kittiwake hotel" raised in the harbour of Røst, northern Norway, where a roof-breeding section of a population established in 1928 was displaced to preserve a historically important fishermen's house. We found that two-thirds of displaced colour-ringed breeders relocated to the Kittiwake hotel. The use of old nests was critical for attracting birds, with 72% occupancy of platforms supplied with old nests and no occupancy of empty platforms. Nevertheless, egg laying and hatching were only observed in 10% and 1%, respectively, of the occupied nests, with no successful breeding in the first year. Breeding performance elsewhere in the harbour colony was also low, but in places higher than on the Kittiwake hotel. These results show that artificial breeding structures, combined with reusing old nests, can successfully attract displaced kittiwakes. However, occupancy alone is not a reliable indicator of conservation gain. Continued monitoring of vital rates will be essential to determine whether this structure, and others of its kind, contribute to long-term population persistence.

Keywords:

Seabird conservation, Urban nesting, Colony displacement, Breeding facilitation, Breeding dispersal

Introduction

Seabird numbers are dwindling worldwide (Paleczny *et al.* 2015) and the Black-legged Kittiwake *Rissa tridactyla* (hereafter 'Kittiwake') is no exception. This conspicuous seabird inhabits bird cliffs along the boreal and Arctic coasts of the Northern Hemisphere but after extensive population decline at many breeding sites over the last 40-50 years, the species is currently classified as Vulnerable (VU) on the global red list (IUCN 2025) and Endangered (EN) in mainland Norway (Stokke *et al.* 2021). Reduced access to food is likely a key driver of their declines (Anker-Nilssen *et al.* 2023; Christensen-Dalsgaard *et al.* 2018, 2019; Frederiksen *et al.* 2024; Reiertsen *et al.* 2014; Sandvik *et al.* 2014). Kittiwakes are conspicuous seabirds that only breed in colonies on open habitats. They are also exclusively surface-feeders that usually forage in pelagic waters where they pick or plunge-dive for small fish or crustacean prey within the upper 1–2 m of the water column (Coulson 2011). This specialised breeding and foraging strategy makes them highly sensitive to anthropogenic, climate-mediated, or weather-driven reductions in food availability near the surface (Massaro *et al.* 2001; Frederiksen *et al.* 2004; Olsen *et al.* 2025). With limited opportunities for accessing alternative prey, they are more likely than diving birds to experience reduced foraging efficiency and to spend more time away from the nest, thereby increasing both their offspring's risk of starvation and exposure to predation at the breeding site (Furness & Tasker 2000; Frederiksen *et al.* 2004; Smout *et al.* 2013; Anker-Nilssen *et al.* 2023). In declining colonies, such effects are also likely to be exacerbated by a parallel reduction in population density and, consequently, the efficacy of collective predator defence.

The rapid loss of Kittiwake colonies at natural cliffs has triggered mitigation measures to facilitate breeding conditions for the species in the vicinity of human populations (Gill & Hatch 2001; Frantzen 2021; Benjaminsen *et al.* 2022; Wilson 2025). This includes a wide variety of constructions spanning from simple breeding ledges mounted on the walls of buildings, to larger standalone rigs with breeding platforms. More than 20 different facilities for Kittiwakes are now provided in at least 13 urban areas along the coasts of Norway (6), UK (5), France (1) and USA (1) (see Christensen-Dalsgaard *et al.* 2025 for a summary). Understanding how successful these projects are, and which features of the constructions seem to successfully attract or facilitate breeding, or conversely to deter the birds, is crucial to ensuring the success of future projects. To date, information on the performance of artificial nesting sites has primarily been reported in newspaper and website articles with limited detail, access and reach (see Christensen *et al.* 2025 for a short review), making it difficult to fully assess the pros and cons of different constructions and their placement. In urbanised areas, Kittiwakes are better protected against raptors such as Peregrine Falcons *Falco peregrinus* and White-tailed Eagles *Haliaeetus albicilla*, often also corvids and large gulls, but other factors such as Brown Rats *Rattus norvegicus*, feral Domestic Cats *Felis catus* and disturbance from human activities may come into play. The lack of clear guidance on where and how to build facilitated structures underpins the importance of sharing experiences with a wider audience and assessing the key factors of success, or failure.

The motivation for this paper is to report on the background, establishment and first-year experiences with a nesting structure (hereafter called the "Kittiwake hotel") built in winter 2023/24 at Kårøya in the harbour of Røst, northern Norway (Figure 1). The first kittiwakes started to breed on buildings at Kårøya in 1928 and numbered ca. 25 pairs in 1939 (Schmidt-Nielsen 1940). From the 1970s, the larger part of the Kittiwakes at Kårøya bred on the roof of Nilssenhuset, the island's oldest fishermen's house ("rorbu" in Norwegian), which gradually suffered serious decay from long-term lack of maintenance, exacerbated by its increasing number of Kittiwakes. The slate roof of the building hosted 355 breeding pairs when the population peaked in 2018. This raised major concerns both for how to maintain this historically valuable building in the longer term and for the well-being of the Kittiwakes breeding there.

Renovating Nilssenhuset would first require repairing the leaky and partly rotten roof, which could only be accomplished by removing all the Kittiwake nests. We therefore decided to build a new structure, the Kittiwake hotel, 30 m away to accommodate the Kittiwakes and hopefully replace their colony on the roof of Nilssenhuset. Building on 47 years of population monitoring of all Kittiwake colonies in the Røst archipelago, we here detail the construction and features of the Kittiwake hotel and how local birds responded to it in the first breeding season following its construction. More specifically, we present data on (i) the colonisation of the Kittiwake hotel at the start of the breeding season, (ii) the breeding dispersal of colour-ringed birds to new breeding sites, including the Kittiwake hotel, in relation to their exposure to the renovation work (i.e. bred initially on the roof of Nilssenhuset, elsewhere on the building, or on other buildings), and (iii) the Kittiwakes' breeding performance on the Kittiwake hotel, using the other breeding sites in Røst harbour as a control group.

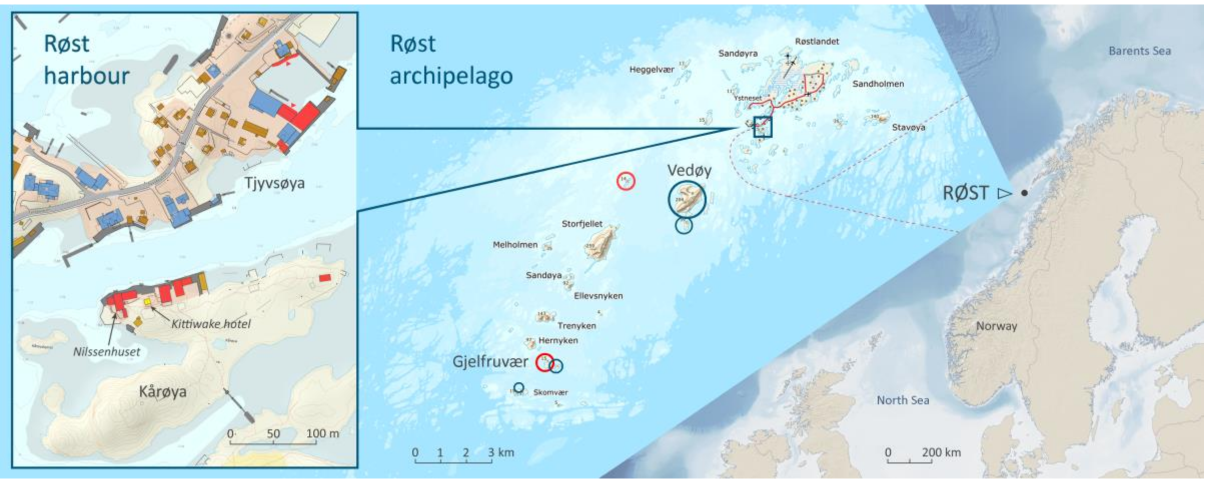

Figure 1. The location of Røst and the distribution of extant breeding sites (in red) for Black-legged Kittiwakes *Rissa tridactyla* in Røst harbour (buildings in red and two waterfront rock walls indicated by red triangles) and on natural cliffs elsewhere in the Røst archipelago (red circles). Blue circles indicate colonies now extinct. The positions of Nilssenhuset and the Kittiwake hotel (yellow square) are indicated by arrows.

The Supplementary Materials (SM) file presents a chronological overview and documentation of the project with further details on the Kittiwake hotel architecture, construction and setup for autonomous surveillance.

Methods

Study area and population trends

Situated 100 km west of the Norwegian mainland and 50 km southwest of the Lofoten Islands (Figure 1), the municipality of Røst is a remote offshore 20×10 km archipelago in the Norwegian Sea that used to hold some of Europe's most iconic seabird cliffs (Anker-Nilssen 2009). The monitoring of seabirds in Røst started in 1960 and has been expanded and maintained by the Norwegian Institute for Nature Research (NINA) since 1988. Today it covers 15 different species (Fayet *et al.* 2025) and is one of the key study sites in the national SEAPOP programme established in 2005 (www/seapop.no/en). This activity has included near-annual monitoring of population size and breeding success of Kittiwake colonies in Røst since 1979 and 1980, respectively, following international standards for such work (Walsh *et al.* 1995).

The main Kittiwake colony in Røst was situated in the almost 200 m high cliffs on Vedøy (67°28′N 12°00′E, Figure 1), which had about 25,000 pairs when monitoring started in 1979 (Figure 2A). From the late 1990s it did, however, decrease rapidly by a combined effect of poor food availability and increasing predation from White-tailed Eagles, until the colony went completely extinct in 2020 (Anker-Nilssen *et al.* 2023). The remaining Kittiwake population in Røst then counted only 1,182 pairs, 60% of which were breeding on/near buildings in the Røst harbour, four km northeast of Vedøy, and another 38% on a 15 m high natural cliff at Gjelfruvær (67°25′N 11°53′E), 12 km southwest of the harbour (Figure 1), where breeding numbers had varied substantially over the years (Figure 2B). The Røst harbour colony is spread across buildings on Kårøya (67°30′N 12°04′E) and the neighbouring island Tjyvsøya (67°30′N 12°04′E).

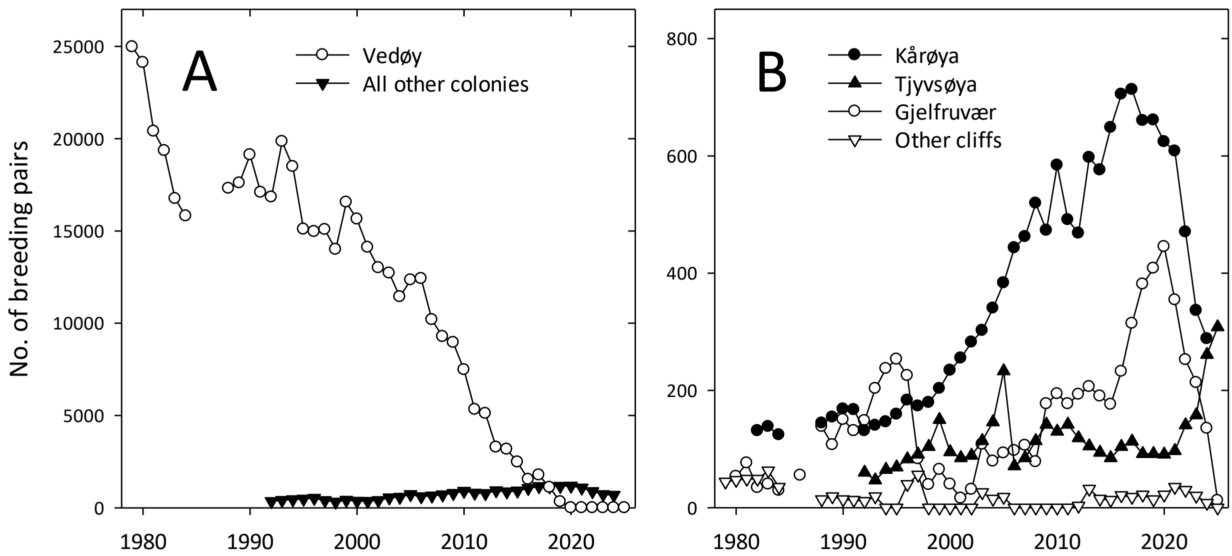

Figure 2. Annual population sizes (breeding pairs) of Black-legged Kittiwakes *Rissa tridactyla* in the Røst archipelago since monitoring started in 1979, except in 1985–1987 (few counts). A) The colony on the main bird cliff, Vedøy (open symbols), went extinct in 2020. B) Trends for the other colonies, separated by the two islands inhabited in Røst harbour (black symbols) and populations on natural cliffs (open symbols).

Since 2003, many of the adult Kittiwakes breeding at Kårøya have been marked with individually coded colour rings, allowing us to identify them in the field without recapture. Although aimed at documenting survival rates, it also provided a useful setup for studying how the Kittiwakes responded to losing their nest sites and document in detail the attraction of the replacement construction and other parts of the colony.

The Kittiwake hotel

The Kittiwake hotel was built in winter 2023/24 in the 50 m wide centre yard between Nilssenhuset and the largest rorbu building on Kårøya, placed on top of an existing concrete wall used to support two big fuel tanks in the 1930s (SM, Figure S2). Given Røst's extreme marine climate and to reduce maintenance to a minimum, the building was made solely of pressure-treated wood. To withstand exposure to heavy winds, the shell was constructed from doubled 48×198 mm wood beams connected with solid galvanised bolts, whereas all other parts were fitted together using only stainless-steel screws (SM, Figures S3–S4 and S6–S8). The final building, which allows air and water to pass through around all nest sites, measures 6.7 × 6.2 m, is 5.6 m high, and is supported in front by 2.2 m high pillars (Figure 3). To match the building style at Kårøya, the seafront wall is topped with a designated "takkelhus", a traditional shelter historically used to house manual devices for hauling fish nets and catch ashore. All nest platforms are 36 cm deep and ordered in rows separated in height by 36 cm. The upper part of each platform back wall is attached with two machine screws with wing nuts and can easily be opened when needed, e.g. to measure eggs or ring chicks. The 120 platforms on the roof and the 90 on the side walls are 54 and 45 cm wide, respectively, and provide nesting opportunities for up to 210 pairs of Kittiwakes. In 2025, another 37 individually separated, slightly smaller (48×24 cm) platforms were mounted on the seafront wall. The opposite side has no platforms but a lockable door allowing access to the nests from the inside of the building, which is equipped with easy-access safe-guarded galleries and a top floor.

Figure 3. The Kittiwake hotel at Kårøya on 10 June 2025, when nest platforms had also been mounted on the seafront wall. The building in the background is Nilssenhuset, featuring its new roof. *© Tycho Anker-Nilssen.*

Moving nests

On 19-20 September 2023, when the repairs on Nilssenhuset started, all remaining Kittiwake nests on the roof were carefully detached, taken down and stored in wooden fish boxes inside a warehouse overwinter, before being placed out on breeding platforms in the Kittiwake hotel in March 2024 (Supplementary Materials, Figures S5 and S9).

Manual monitoring

At the Kittiwake hotel, checking nest contents and the ID of ringed adults were usually made manually from inside the building by inserting a small, inexpensive USB inspection camera (endoscope) into a small hole (Φ 10 mm) drilled in the back wall above each nest platform (SM, Figure S10). Occasionally, checks were made from the outside, either from the top of a ladder raised against the nest-free entrance wall, or with binoculars or high-resolution cameras from a distance. We primarily used a Nikon Z9 camera fitted with an AF-S Nikkor 200-500 mm f/5.6 ED VR, though less specialised equipment could suffice as this depends largely on observation distance and angle rather than picture resolution. During the 2024 breeding season, the nest sites on the Kittiwake hotel and elsewhere on Kårøya were inspected every second day between 7 June and 18 July. Outside this period, manual nest checks were performed only sporadically in early May and early August. Nests on Tjyvsøya were checked on four occasions: 14 and 25 June, and 1 and 12 July 2024.

Automatic surveillance

The Kittiwake hotel is equipped with a 220 V AC power supply and a CCTV surveillance system designed for remote monitoring of the nests (SM, Figure S11). We installed two zoomable, 4K weather-proof (IP67) cameras (Provision-ISR I6-380IPEN-MVF-V3), connected to an 8-channel network video recorder (Provision-ISR NVR8-8200N). This setup can thus accommodate six more cameras. The cameras operate continuously but are programmed to record regular snapshots using a Python script (SM, Table S1) installed on an in-situ laptop PC. The system is accessed remotely via a network switch (®Teltonika TSW200), enabling remote adjustment of the time-lapse frequency and the automatic downloading of pictures or videos to a remote server. The interval was set to download a UHD image (3840 × 2160 pixels) every 15 minutes. One camera is placed on top of a tiltable mast mounted at the entrance side of the building, providing a top-down view of the nests on both sides of the roof. The second camera is placed inside the “takkelhus”, covering the majority of the nests on the front wall (Figure 4). Furthermore, the system incorporates a router (Teltonika RUTX50) that facilitates live monitoring of the cameras over a cellular network (5G/LTE/3G) via a dedicated mobile application (Provision CAM 2).

Figure 4. Examples of the 4K pictures of the Kittiwake hotel roof on 1 June 2024 (left, slightly cropped) and, exactly one year later, the seafront wall (right) taken by the CCTV cameras and downloaded to the NINA server in Trondheim at fixed intervals (set at 15 min for the first two years).

Measures of breeding performance

We compare four annual variables of breeding performance on different Kittiwake nesting structures in Røst harbour: (i) ***platform occupancy*** (Kittiwake hotel only), calculated as the proportion of platform nests registered to be attended by adult(s) on at least one occasion and having faecal matter and/or new nest material present at most nest checks; (ii) ***clutch size per occupied nest***, calculated as the maximum number of eggs registered at any visit per occupied nest (including nests not known to have contained eggs); (iii) ***hatching success***, calculated as the proportion of clutches that hatched; and (iv) ***breeding success***, calculated as the average number of large chicks (i.e. close to fledging) produced per occupied nest.

Statistical analyses

Adult survival was estimated by applying the four default Cormack-Jolly-Seber (CJS) models (with and without temporal variation in survival and/or re-sighting rates) in Program MARK (v. 10.1, Cooch & White 2022) to all re-sighting data in 2004–2025 for the 570 Kittiwakes individually colour-ringed at Kårøya as breeders in 2003–2024. We used the SIN link function with no environmental covariates and selected the best model based on the Quasi-Akaike information criterion corrected for small sample sizes (QAICc) after adjusting for over-dispersion (c-hat) (Burnham & Anderson 2010). Statistical tests were otherwise carried out using IBM SPSS Statistics (v. 27, IBM Corp 2020), whereas plots and curve-fits were produced and modelled in SigmaPlot (v. 14.5, Systat 2020). Chi-square tests were made with Yates's (1934) correction for continuity.

Results

First attendance on the Kittiwake hotel

Except for the seafront wall, most breeding platforms on the hotel were in place before the end of February 2024, i.e. within 2–3 weeks after the first Kittiwakes returned on 10 February (captured by a time-lapse camera covering Nilssenhuset). As an experiment to assess the value of extant nests to attract kittiwakes to new nesting structures, old nests were first put in place on 8 March at the 85 nest sites installed by then on the Kittiwake hotel's west side: 50 on the roof and 35 on the wall. Ten days later, nests were deployed on the corresponding 50 sites on the east side of the roof, whereas no nests were put out on the east wall. The CCTV cameras were installed on 4 April 2024, but unexpected software issues prevented the automatic picture download until 31 May. However, occasional pictures of the Kittiwake hotel taken by local contacts in the area prior to that, in the last weeks also supplemented by twice-daily screenshots taken remotely by LA via the online connection with the roof camera, made it possible to reconstruct the Kittiwakes' first responses. Similar data cannot be constructed for the side walls, but only a third (15) of the platforms on the west side were occupied in 2024 and none on the east side.

Notably, no birds were seen establishing on empty platforms in 2024. The carpenters working on Nilssenhuset were the first to see and document Kittiwakes landing on the Kittiwake hotel. This happened on 14 March and only on the western side of the roof, i.e. six days after nests had been deployed there. Attendance then increased gradually over the next three weeks before levelling off when around 80% of the upper 50 nest sites were occupied at most times (Figure 5). A similar delay was registered on the eastern side of the roof, where around 60% of the equally many nests were occupied within three weeks. A temporary drop in attendance in the second half of April was evident at both sides. We have no clear indications of why this occurred, but expect it was triggered by external factors, such as reduced food availability within reach of the colony.

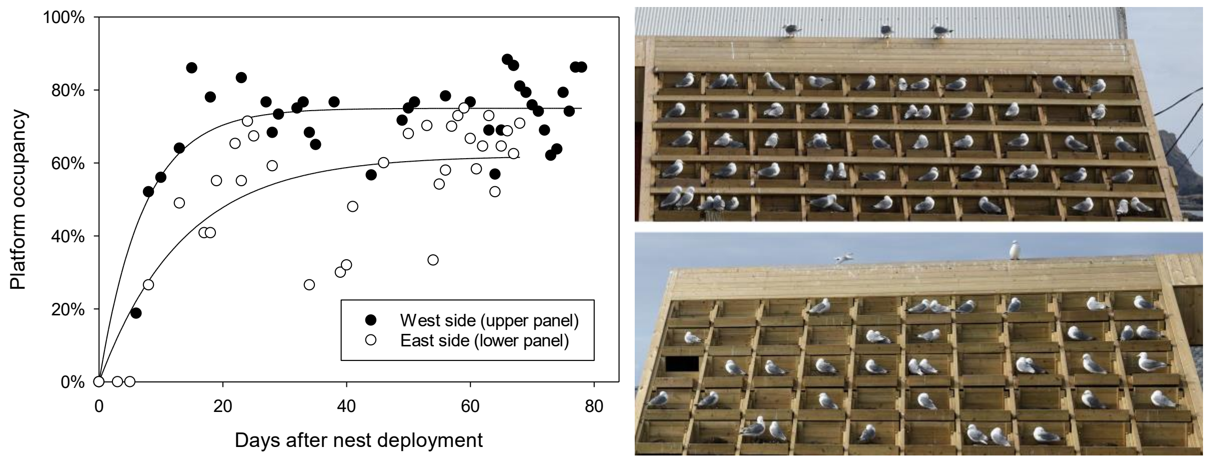

Figure 5. The proportion of nest platforms attended by Black-legged Kittiwakes *Rissa tridactyla* on the west (N = 60, filled dots, 0 = 8 March) and east (N = 50, open dots, 0 = 18 March) sides of the Kittiwake hotel roof during the first 10–11 weeks after the old nests were put in place. The counts were made on photographs taken irregularly by a variety of people and, from 10 May, also from CCTV screenshots. For illustration, the modelled lines indicate the exponential rise to maximum on each side, and the photographs show the attendance on the west and east side of the roof on 15 April, i.e. day 28 and 18 after nests were deployed, respectively (© *John B. Stenersen*).

Breeding dispersal

A total of 199 Kittiwake pairs bred on the old roof of Nilssenhuset in 2023. Unexpectedly, all of them lost their clutches during an unusually heavy storm that hit Røst in late May of that year. Strong wind gusts can dislodge brooding adults from the nest and even blow away small chicks (TAN personal observations) and may also provide easier access for large gulls and corvids to prey on eggs and chicks. Five to ten pairs of Herring Gulls *Larus argentatus* breed on Kårøya and frequently rest on the roof top of Nilssenhuset. In addition, single pairs of Great black-backed Gulls *L. marinus*, Hooded

Crows *Corvus corone cornix* and Ravens *C. corax* that breed close to the colony are regularly seen depredating eggs and chicks from the Kittiwakes. A few pairs re-laid but quickly lost their second clutch. Inopportunely, this extreme event also prevented our plan to colour-ring a larger sample of the birds breeding on the roof before their nests were removed. Without offspring to defend, unringed adults were not only difficult to capture, but their breeding status could not be determined with any confidence.

Ninety-three Kittiwakes colour-ringed as breeders on Kårøya in earlier years were spotted in Røst harbour in the breeding season of 2024. Among the 82 that were seen attending nest sites (Figure 6), 36 birds originated from the roof of Nilssenhuset. Of these, two-thirds (24) moved to the Kittiwake hotel, while the remainder spread to four other parts of the harbour colony. These included three sub-colonies on neighbouring island Tjyvsøya; the roof of the John Greger AS fish plant, the vertical shoreline rock wall underneath it and a similar rock wall along the seaside front of the Skomværkroa pub. Three of the six colour-ringed birds that bred on wall ledges on Nilssenhuset also moved, but none of them to the Kittiwake hotel. Only two (5%) of the 40 birds breeding on other buildings at Kårøya moved, both to the Kittiwake hotel.

Twenty (67%) of the 30 different individuals identified on the Kittiwake hotel were observed attending several nest sites. These apparently prospecting birds visited on average 5.3 (SE = 0.60, range 2–10, N = 20) platforms, making it difficult to determine the exact number of attending pairs. In order to assess the expected number of pairs, we estimated the adult survival rate for the Kårøya population between 2023–2024, as derived from the fully time-dependent CJS model for the whole data set (2003–2025) that had a low c-hat (1.138) and accounted for 99.7% of the variation in the data set (ΔQAICc of the second-best model = 11.8). When applying this estimate (0.871, SE = 0.046, 95% CI: 0.753–0.938) to all colonies and accounting for dispersal of displaced birds, the total count of the harbour colony in 2024 appeared to be 119 pairs higher than expected, only about half of which could potentially have been birds originating from the two fast-declining cliff colonies (Table 1, Figure 2).

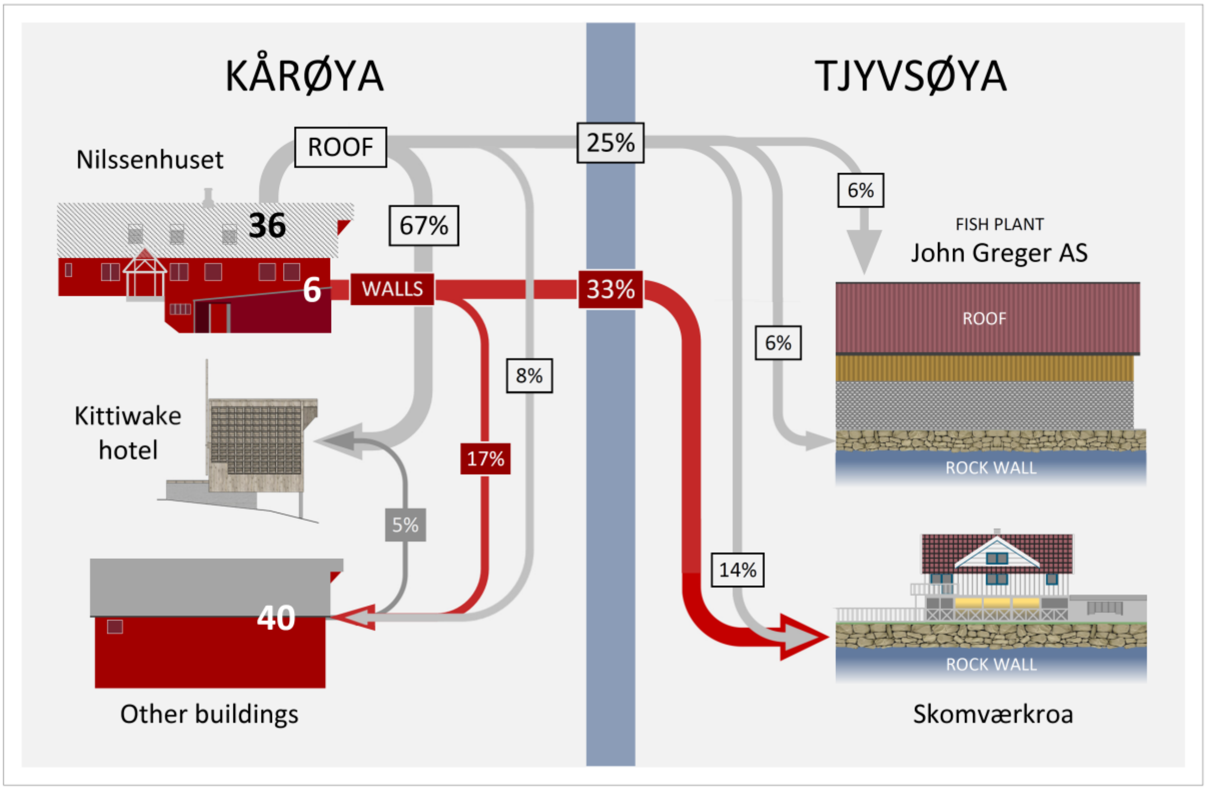

Figure 6. Breeding dispersal in 2024 of 82 Black-legged Kittiwakes *Rissa tridactyla* colour-ringed as breeding adults on Kårøya in previous years, expressed as the proportions of birds with similar origins: from the roof of Nilssenhuset (light grey arrows) where all nests were removed (N = 36), from the side walls of Nilssenhuset and connected warehouses (red arrows, N = 6), and from the two neighbouring rorbu buildings on Kårøya (dark grey arrow, N = 40).

Table 1. Counted and expected population sizes (no. of breeding pairs) of all Black-legged Kittiwakes *Rissa tridactyla* breeding in the Røst archipelago in 2023–2024, when accounting for an estimated survival rate of 87.1% and the dispersal registered between the two parts of the harbour colony: Kårøya and Tjyvsøya (Figure 6).

Sub-colony	Counted 2023	Expected to survive	Moving from roof	Moving from walls	Expected 2024	Counted 2024	Change not accounted for
Kårøya	336	292.7	-43.3	-16.3	233.1	288	+54.9
Tjyvsøya	158	137.6	+43.3	+16.3	197.2	261	+63.8
Cliff colonies	233	203.0			203.0	143	-60.0

Breeding performance and success

In total, 126 (72%) of the 175 nest platforms equipped with old nests on the Kittiwake hotel were occupied by Kittiwakes in 2024. Occupancy rate was higher on the west side (100%, 60 of 60 platforms) than on the east side of the roof (85%; 51 of 60) (χ^2_1 = 7.69, P = 0.006), and much higher on the roof (93%; 111 of 120) than on the west wall (33%; 15 of 45) (χ^2_1 = 60.2, P < 0.001). The 45 platforms without nests were never occupied.

Despite the high occupancy, egg laying was only recorded in 12 (10%) of the 126 occupied nests on the Kittiwake hotel (Table 2). Five of these were among the 15 pairs that established on the 45 west wall nests, a much higher proportion than the 7 among the 111 on the roof ($\chi^2_1 = 8.29$, $P = 0.004$). Only one pair (also on the wall) successfully hatched their clutch, but the two chicks disappeared within 3–4 days of hatching. Hatching success was equally low on the walls of Nilssenhuset (mean 0.08, SE = 0.08, N = 13) but much higher on the other buildings on Kårøya (mean 0.73, SE = 0.06, N = 51).

Table 2. Mean (± 1 SE) clutch size and overall breeding success in nests occupied by Black-legged Kittiwakes *Rissa tridactyla* on different structures at Kårøya in 2021–2024.

Variable	Sub-colony	Type	2021 (N)	2022 (N)	2023 (N)	2024 (N)
Clutch size	Kittiwake hotel	Roof	--	--	--	0.07 ± 0.03 (111)
		Wall	--	--	--	0.40 ± 0.16 (15)
	Nilssenhuset	Roof	1.65 ± 0.07 (66)	1.77 ± 0.08 (62)	1.54 ± 0.12 (59)	No nests
		Walls	1.26 ± 0.09 (106)	0.51 ± 0.09 (86)	0.76 ± 0.13 (51)	0.72 ± 0.16 (32)
	Other buildings	Roof	1.30 ± 0.09 (63)	1.33 ± 0.11 (63)	1.41 ± 0.11 (59)	1.35 ± 0.11 (63)
		Walls	2.00 ± 0.00 (2)	0.50 ± 0.50 (2)	1.00 ± 1.00 (2)	1.00 ± 0.00 (2)
Breeding success	Kittiwake hotel	Roof	--	--	--	0.00 ± 0.00 (111)
		Wall	--	--	--	0.00 ± 0.00 (15)
	Nilssenhuset	Roof	0.43 ± 0.03 (359)	0.26 ± 0.03 (285)	0.00 ± 0.00 (199)	No nests
		Walls	0.10 ± 0.03 (121)	0.00 ± 0.00 (92)	0.02 ± 0.14 (55)	0.00 ± 0.00 (38)
	Other buildings	Roof	0.29 ± 0.06 (96)	0.40 ± 0.07 (78)	0.49 ± 0.08 (74)	0.16 ± 0.05 (114)
		Walls	0.00 ± 0.00 (28)	0.00 ± 0.00 (15)	0.00 ± 0.00 (8)	0.00 ± 0.00 (10)

When collating data across roofs and walls (not shown in Table 2), clutch size on the Kittiwake hotel was less than one-sixth of that on the remaining nests on Nilssenhuset (one-way ANOVA, $F_{1,156} = 34.3$, $P < 0.001$), which in turn was roughly half of that on the other buildings ($F_{1,189} = 11.0$, $P < 0.001$). Clutch size per clutch laid was also much lower on the Kittiwake hotel (1.17 ± 0.11, N = 12) than elsewhere on Kårøya (1.75 ± 0.06, N = 63) ($F_{1,73} = 18.2$, $P < 0.001$).

Despite the total breeding failure on the Kittiwake hotel, the overall breeding success elsewhere on Kårøya was not significantly higher ($F_{1,73} = 2.16$, $P = 0.146$), with only 11 (17%) of 63 laying pairs succeeding in fledging young (Figure 7). In the three last years before the Kittiwake hotel was built, clutch size on Nilssenhuset varied significantly between years on the walls ($F_{2,240} = 18.1$, $P < 0.001$) but not on the roof ($F_{2,184} = 1.62$, $P = 0.201$) (Table 2). On average, nests on the roof had a clutch size almost twice as high ($F_{1,428} = 86.1$, $P = 0.201$) and five times higher breeding success ($F_{1,1113} = 47.4$, $P < 0.001$) than those on the walls. Nevertheless, the breeding success on the roof was much lower than its average level in the 1980s and 1990s, when it was equally high as in the main colony at Vedøy (Figure 7A). Despite the lack of harassment from White-tailed Eagles in the harbour colony, the marked decrease in breeding success in the mid-2000s was also evident there (Figure 7B).

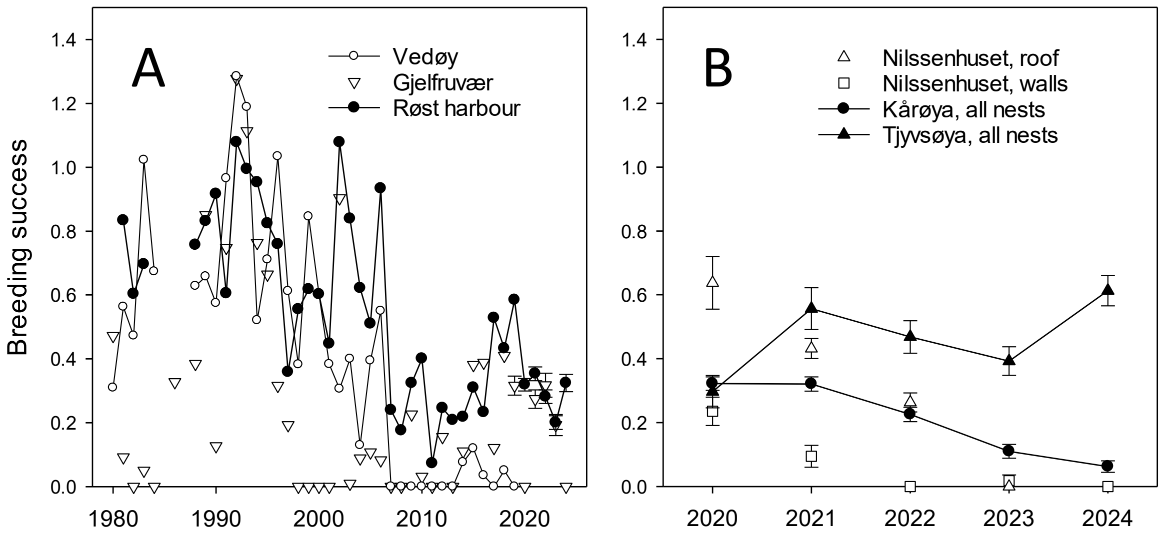

Figure 7. Annual breeding success (large chicks per pair) of Black-legged Kittiwakes *Rissa tridactyla* in the Røst archipelago since monitoring started in 1979, except in 1985–1987 (few counts). A) The colony on the main bird cliff, Vedøy, which became extinct in 2020, the second-largest natural colony on Gjelfruvær, and the colony in Røst harbour. B) The last years' contrasting success of the birds on the roof of Nilssenhuset and those breeding elsewhere on the same building, and the overall success for the colony in Røst harbour divided by the two islands the birds breed on.

Discussion

While it is still far too early to draw overarching conclusions on the overall success of the Kittiwake hotel in Røst, but we can nevertheless make some inferences based on our observations in the first year, 2024. Our data shows that the Kittiwake hotel successfully attracted the birds resulting in high nest occupancy in the first summer, although the number of breeding attempts was very low. We expect that breeding success will increase in subsequent years, as birds acclimate to the new structure and gather information from those already occupying it (Cadiou *et al.* 1994, Boulinier *et al.* 2008). The low breeding success in the other parts of the harbour colony (i.e. elsewhere on Kårøya and on Tjyvsøya) did, however, indicate that conditions for breeding were poor, continuing a general trend starting in 2007 (Figure 7). We also observed intense fighting for nests or mates among birds on the Kittiwake hotel, which likely reduced their ability to protect eggs and chicks and, ultimately, breed successfully. Based on multiple observations, we attribute the main cause of egg loss both at the Kittiwake hotel and elsewhere on Kårøya in 2024 to predation from local pairs of Common Crows and Ravens, and likely also from Herring Gulls and Great black-backed Gulls. When breeding numbers drop as extensively as seen in the Røst colonies, the Kittiwakes' collective defence against predators weakens and likely contributes to an Allee effect (Courchamp *et al.* 2008) that accelerates the population decline, a phenomenon also documented in several other colonial seabirds (Gilchrist 1999; Oro *et al.* 2006, Horswill *et al.* 2016).

The placement of old nests on the new nest sites on the Kittiwake hotel was a clear success factor which attracted the birds to the new structure. The wall nests were much less popular than those on the roof, perhaps because most birds originated from the roof of Nilssenhuset and were accustomed to breeding on a relatively similar structure. However, the proportion of breeding attempts was much higher on the walls. This may suggest a benefit of less disturbance from neighbours and/or that it was easier for the most well-established breeding pairs to set up there.

Storing the old nests under a roof for almost six months over winter caused the nests to desiccate, which slightly complicated the process of adjusting their sloped underside to fit a horizontal substrate. For similar situations we therefore recommend, where possible, keeping nests out in the open to maintain their natural consistency and hydration as much as possible. Nevertheless, this did not cause serious problems; the nests readily absorbed rainfall and gained sufficient weight to withstand heavy winds, eliminating need to secure them despite the smooth surface of the platform decking.

The higher number of pairs observed than expected in 2024 suggest that some birds from the two dwindling cliff colonies (Figure 2) might have moved to the harbour colony (Table 1). The estimated population sizes are, however, coarse and subject to various sources of bias that we cannot account for. For example, colony- and habitat-specific differences in disturbance and predation rates may trigger some birds to abandon the breeding attempt and leave the colony earlier than others. We expect that the extensive prospecting behaviour of displaced birds, with many birds visiting many of the nest sites, contributed to overestimating the population size in the harbour in 2024. Continued monitoring and research will likely enable us to estimate this more accurately.
Data from the North Sea area (Horswill *et al.* 2015) suggest that Kittiwakes there require an average productivity of more than 1 chick per pair to keep the population stable based on natal recruitment alone (Frederiksen *et al.* 2024). The breeding success of Kittiwakes in Røst has, however, only reached that level in three years since the monitoring started in 1980, all of which were in the early 1990s (Figure 7A). This was largely due to a combined effect of poor food availability and, since the late 1990s, predation caused by an increased abundance of immature White-tailed Eagles in the area (Anker-Nilssen *et al.* 2023). Nevertheless, even in the harbour colony, which is not harassed by eagles, the average productivity since the early 2000s has only been about a third of what is required to maintain the population. The massive population increase at Kårøya over two decades from the late 1990s can therefore only be explained by immigration from other colonies. Most likely this was mainly birds originating from Vedøya (Figure 1), although a few attempts to reduce breeding numbers at Tjyvsøya may also have had a local effect on the breeding distribution within the Røst harbour colony. Breeding success has also been higher on and near buildings at Tjyvsøya, where local business activity has involved a higher and more constant human presence than at Kårøya, where the "Rorbu-camp" hostel business ended in 2019 and the property was sold in 2021. The contrasting population trends of Kittiwakes on the two islands thereafter, with numbers on Kårøya being more than halved while those on Tjyvsøya tripled (Figure 2), also indicate the benefits of human presence. Unfortunately, there is no quick fix that can reverse the trends for Kittiwakes in the Northeast Atlantic, and the outlook for the Kittiwake hotel population in Røst remains highly uncertain. Without a substantial improvement in the availability of suitable food around the colonies, their prospects are exceedingly poor. While we may hope for changes in environmental conditions that favour recovery, conservation measures are essential to support the reproduction of Kittiwakes and counteract the negative trends for this highly threatened species. The Kittiwake hotel in Røst is one promising mitigation that may contribute to sustain the local population there, and we hope our experiences and a few early recommendations (summarised in Text Box 1) will also prove valuable for similar work elsewhere. The associated data on sex, age, pair-bonds and breeding success collected for

these birds over the years will also allow us to conduct further studies to explore how the birds' responses are influenced by intrinsic factors.

Text Box 1. Lessons learned: Recommendations for future Kittiwake nesting structures

Recommendation 1 – Use existing nests to attract birds to the new structure. We found that already built nests made a huge difference in attracting birds to the Kittiwake hotel in the first year. No birds landed on the structure before nest deployment, and platforms without a nest remained unused in the first season, whereas a majority of platforms with nests were visited.

Recommendation 2 – Store nests in the open before installation on the structure. We stored nests sheltered from rain for six months, which rendered them rigid and desiccated, and therefore more difficult to affix to the platforms.

Recommendation 3 – Consider exposure and orientation. Although we have not yet understood the causes, there were significant differences in occupancy rates between the east and west side of the hotel roof. Conversely, all platforms on the vertical north-facing wall were successfully occupied shortly upon their installation in the second year of the construction (Figure 3). When available, we therefore recommend placing out old nests in a randomised layout to enable more robust analyses of the Kittiwakes' choice of breeding sites in relation to a range of local and general factors.

Recommendation 4 – Deploy surveillance cameras. Time-lapse photography of the nesting structure can provide invaluable data for quantifying the birds' attraction to the structure and their subsequent breeding success.

Recommendation 5 – Utilise pinholes for nest checks with minimal disturbance. The closed construction of our hotel allowed easy inspections of nest contents and the identity of adults by inserting a low-cost USB pinhole endoscope through a small aperture (Φ 10 mm) in the rear wall of each nest site, monitoring without flushing the birds.

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Supplementary Materials

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