# Mammal predators as a factor contributing to breeding collapse in the largest Yellow-legged Gull (*Larus michahellis*) colony in the southeast part of the Bay of Biscay.

Juan Arizaga[1†*], Asier Aldalur[1†], Xabier Saralegi[2†]

*Correspondence author: jarizaga@aranzadi.eus

[1] Department of Ornithology, Aranzadi Sciences Society, Zorroagagaina 11, 20014 Donostia, Spain.

[2] Itsas Enara Ornitologi Elkartea, P.º de Anoeta, 28, 20014 Donostia, Spain.

[†]Equally contributed.

Predator-prey dynamics are among the main selective forces shaping population ecology, community structure, and species distributions in ecosystems (Lima & Dill 1990). Even though such interactions constitute natural components of ecological systems, the current anthropogenic changes are increasingly altering predator-prey relationships (Prugh *et al*. 2009; Estes *et al*. 2011). On islands and coastal ecosystems, where species often evolve in the absence of certain predators, the sudden appearance or colonization by new predators can have particularly severe consequences for several animal species, including seabirds (Jones *et al*. 2008; Hilton & Cuthbert 2010; Ozella *et al*. 2016; Baker *et al*. 2020; Raine *et al*. 2020).

Seabird colonies represent vulnerable ecological units given that they tend to concentrate in relatively small areas, with breeding success being tightly linked to disturbance, including predators (Oro *et al*. 1999). The Yellow-legged Gull (*Larus michahellis*) is the most abundant gull in the southwestern Palaearctic (BirdLife International 2021). Due to its ability to exploit predictable anthropogenic food (PAF), and its fast population growth linked to the exploitation of such PAF, including landfills or fishery discards among many other resources (Duhem *et al*. 2008; Ramos *et al*. 2009; Arizaga *et al*. 2013; Méndez *et al*. 2020), the species has been considered an ecological 'winner'. However, recent research demonstrates that many Yellow-legged Gull colonies are starting to decline, mainly caused by a decrease in food availability (associated with a general landfill closure) (Arcos *et al*. 2022). Increasing predator pressure in these circumstances could accelerate the rapid decline found in many colonies of the species' distribution range (McChesney & Tershy 1998; Towns *et al*. 2006; Banks *et al*. 2008).

The Yellow-legged Gull population breeding along the coast of the southeastern part of the Bay of Biscay is also suffering an important decline, assessed to be in the order of 56% during the period 2000-21 (Arizaga *et al*. 2022). One of the main breeding colonies in this region is found along the coastal cliffs of Ulia, near the city of San Sebastián (Basque Country, Iberian Peninsula). This colony experienced an exponential growth starting during the 1990s, becoming the largest breeding quarter of the Yellow-legged Gull on the Basque coast (Arizaga *et al*. 2022). However, recent research has revealed a decreasing population size also accompanied by a decrease in survival of all age classes, facts that have been linked to a decrease in food availability, mainly associated with landfill closures within the region (Delgado *et al*. 2021b;

Arizaga *et al*. 2022; Delgado *et al*. 2023). Furthermore, the colony has ultimately (years 2023-24) shown a dramatic collapse in breeding success, raising concerns on the possible underlying causes, which might go beyond a density dependent process linked to food shortage.

The recent colonisation of the Ulia mountain by terrestrial mammal predators, particularly the Red Fox (*Vulpes vulpes*), might be among the potential factors explaining the recently observed general failure on breeding output. This carnivore, previously absent in this mountain ecologically disconnected from other green areas by the grey matrix of San Sebastián (Azpiroz 2009), is presumed to have colonised this area during COVID-19 lockdowns, when the absence of traffic and people may facilitate this process (Ferreres *et al*. 2022). In contrast, the Stone Marten (*Martes foina*) was already present at least since 2008 (Azpiroz 2009), with no evidence supporting that its presence may have caused breeding failures within the colony (J. Arizaga, per. obs.). Other potential causes of this breeding collapse, however, may not be rejected, including active removals of eggs by humans or other types of predation, e.g., by pets or free-ranging dogs. To obtain direct evidence of predation or other types of nest- and/or egg-removals from the Ulia Yellow-legged Gull colony, we conducted field surveys using camera traps, together with nest monitoring, during the breeding season of 2025. The aim of the study was not only to quantify the magnitude of the impact of potential mammal predators on the colony but also to evaluate potential management strategies to mitigate predator impacts and enhance colony resilience, particularly given the current population decline (Arcos *et al*. 2022; Arizaga *et al.* 2022).

**Material and methods**
Study area and data collection
The study was carried out at the Yellow-legged Gull colony situated in Ulia (43°20'N, 1°57' W, Figure 1), a minor coastal ridge located within the municipality of San Sebastián (province of Gipuzkoa, Spain). Ulia extends in an east-west orientation and reaches a maximum elevation of 243 m above sea level, covering an approximate area of 500 ha. Its southern slopes, particularly at their lower altitude, are partially urbanized due to their proximity to the city and, in contrast, the northern slopes are rugged, more abrupt, remaining largely undeveloped. Their cliffs form a critical natural habitat, providing suitable breeding grounds for several seabird species, including the focal Yellow-legged Gull colony of this study. Moreover, the Ulia cliffs also host the only breeding pair of Great Black-backed Gull (*L. marinus*) in Gipuzkoa (Arizaga & Galarza 2020). A significant fraction of these cliffs fall within the boundaries of a protected area under the Natura 2000 Network (Site Code: ES2120014). This protection status underscores the ecological importance of the site and highlights its value for biodiversity conservation within the region.

The Yellow-legged Gull colony in Ulia already existed in 1967 (Noval 1967), probably with a size of less than 100-200 adult breeding pairs (bp). Its increase, starting during the 1980s, is attributed to the increasing amount of waste dumped into the San Marcos landfill, created around the 1970s, but used massively, including all the waste coming from the capital city of San Sebastián (>150,000 inhabitants) around 1990. The colony, therefore, reached its maximum size in 1990 with an estimate of 1300 bp. In 2025, the colony hosted 545 bp.

To carry out the fieldwork, a set of five camera traps, model GardePro A3S, together with an additional HAZA PR800 camera for one of the sampling points (ID 15) was deployed in a total of 18 sampling points within the colony. Of the 18 sampling points used in a long the study period, 13 were placed pointing directly at a nest, whilst the rest were placed in zones of passage or partial views over parts of the colony. In particular, the area where the study was conducted overlaps with the one where the Aranzadi team has been doing research since 2006 (Arizaga et al. 2020). This part of the colony comprises moderate slopes relatively accessible by humans and, consequently, also by mammal predators. During our visits, we visually detected at least 30 nests in this area. Part of these nests was finally sampled.

The camera traps were set up on 8 April 2025 and remained active until 22 June 2025. The cameras were configured: (1) up to 12 May, to take 2 photos when they detected movement, after which they remained inactive for 2 min, (2) from 12 May, to take one photo and one video, with this last used to detect with higher detail potential predatory events, after which they remained inactive for 2 min. They were checked periodically (approximately weekly) to replace the batteries and memory cards, and to assess whether relocation was necessary (e.g., because the nest had already been predated). Overall, we obtained 300 full recording days (24 h) from 13 specific nests together with five sampling points in zones of passage or partial views over parts of the colony (Table 1); 342 days if we also consider the days when each camera was placed and removed, omitting those in which the cameras were not active due to various logistics reasons (the camera had fallen, card failed at a given period, etc.). The mean number of full recording days per camera and site was 16.6 days (range: 0-56; SD: 15.8 days). The decision to relocate a camera was due to factors such as the nest being depredated or increasing vegetation height to the point that it obscured the camera's view of the nest.

Data analyses

Recorded images were reviewed to detect disturbances and the presence of predators. For every detected predator, we identified the species and scored the impact on given nests as (1) failed predation (the predator was seen in the nest but did not remove any egg, possibly startled by the camera or because of other unknown reasons), (2) confirmed predation (the predator was seen extracting an egg from the nest), or (3) presence (the predator was detected near a nest, without observing any predation attempt -failed or confirmed-).

**Results**

Overall, 40 records of predator presence were registered, corresponding to Red Fox (N = 22), Stone Marten (N = 17; Table 1). In addition, we also observed an event of conspecific predation by a Yellow-legged Gull (N = 1; Table 1). Predator presence was detected at 13 out of the 18 sampling points (72.2%). This included detections at 4 out of the 5 cameras not focused on nests, and at 9 of the 13 cameras that focused directly on nests. Predators, therefore, were detected both moving within the colony and taking (or trying to take) eggs from given nests. One of the nests was the one of the Great Black-backed Gull (ID = 01), where we found predation by both Red Fox and Stone Marten, and at least two breeding attempts that failed.

Failed predation was registered in seven cases at three sampling points, whilst confirmed predation was detected in 13 cases at nine sampling points (12 on eggs and one on an incubating adult; Table 1). We detected a predatory rate of 69.2% for the 13 sampling sites where cameras were focused on nests. It should be noted, however, that eggs were removed

from all monitored nests, as confirmed during field visits. The gap between the observed 100% failure within the colony area where the study was carried out and the 69.2% detected by cameras reflects missed detections caused by technical malfunctions, camera displacement, vegetation blocking the view and inactive recording intervals.

Of the 13 confirmed predation events, four were caused by Red Fox, seven by Stone Marten, and only one by a Yellow-legged Gull (Table 1; Figure 2). Predation involved eggs in all cases but one, where an adult Yellow-legged Gull was captured by a Red Fox. Thus, most observed egg predation events were attributed to Stone Marten (58.3%). The majority of the recorded predator presence was at night, with a peak during the third hour after dusk and another one during the 7th hour after dusk (i.e., before/around dawn; Figure 3).

**Discussion**

In terrestrial predator-free environments with sufficient food availability, Yellow-legged Gulls tend to form large, dense colonies conferring mutual protection against aerial predators and facilitate social information sharing (Clode 1993; Gaston 2004; Duhem *et al*. 2007). Such benefits, however, can disappear under ground-based predation (Oro *et al*. 1999; Kubetzki & Garthe 2007; Davis *et al*. 2018). Remote camera data used in Ulia, one of the main Yellow-legged Gull colonies along the coast of the Bay of Biscay, provided unequivocal evidence of direct predation by both Red Fox and Stone Martin on eggs (and one Red Fox was also able to catch an incubating Yellow-legged Gull). Predators were detected at more than a half of the sampling points, with confirmed predation documented at 69.2% of the sites where cameras were focused directly on depredated nests. Predation, in addition, provoked a repeated breeding failure in the single pair of Great Black-backed Gull in Gipuzkoa (Arizaga & Galarza 2020), thus compromising the consolidation of its settlement within the region.

It could be argued that the continued presence of observers in the colony may have left scent trails which facilitated predator access. However, we consider that this potential bias was low, probably negligible, because: (1) in 2024, a year in which the colony was barely visited during the breeding period (a single access in late June with the aim of ringing chicks), the predation rate was already similar to that observed in 2025; (2) the colony is located in a very rainy area, and visits to the colony were frequently interspersed with rainy days, during which observer scent trails are likely to be erased; and (3) predation was also recorded in the nests far from the points that were visited as a result of camera deployment.

As other long-lived animals, Yellow-legged Gull population dynamics depend more on adults survival than on reproduction success or first-years survival (Delgado *et al*. 2023). However, a sustained and abnormally low breeding output may also have a dramatic demographic impact (Newton 2013), especially in a population that is already in decline (Arizaga *et al*. 2022). Recently, we attributed the progressive decrease in the number of chicks within the colony of Ulia to food shortage, mainly linked to regional landfill closures (Arizaga *et al*. 2025). However, a productivity of zero in 2024 might still conceal additional drivers behind this phenomenon. We now know that the presence of meso-carnivores in the area was a key explaining factor. The Yellow-legged Gull, in spite of its generalist reputation, may be more vulnerable to sudden ecological shifts than traditionally assumed, especially when nesting sites offer limited protection against terrestrial predators (Dalrymple 2023). Moreover, predation occurred primarily at night when gulls would be less vigilant and unable to effectively defend their nests,

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a pattern consistent with findings in other colonies of seabirds (Oro *et al*. 1999; Mougeot & Bretagnolle 2000). This case proved that predators have a significant impact on a once-abundant and widespread bird even considered as a pest (Soldatini *et al*. 2008b; Fernández-García *et al*. 2015). Our findings reinforce the idea that the Yellow-legged Gull colonies can be very vulnerable to novel or expanding predators, echoing similar collapses found in other colonies of seabirds (McChesney & Tershy 1998; Oro *et al*. 1999; Hilton & Cuthbert 2010; Ozella *et al*. 2016; Russell *et al*. 2020).

Terrestrial predation is not a new phenomenon in Yellow-legged Gull colonies within the region, but the exceptionally high rates found in Ulia in 2024–25 appear closely linked to the recent arrival of the Red Fox, which might have contributed to the observed general reproductive failure in this colony. Although both Red Fox and Stone Marten were detected, the latter has been present in Ulia since at least 2008 (Azpiroz 2009), a period when no widespread breeding failure was recorded (Arizaga *et al*. 2025). However, its current impact may now be higher than in former times either due to a recent population increase, the specialisation of given individual(s) on gull eggs, or opportunistic exploitation of areas with lower nest density or disturbed by the Red Fox. Although the Red Fox may appear to have a higher impact (as it is a larger predator with a higher energetic demand than the Marten), our results may not support this assumption, since predation rates were quite similar between the two species. Results, therefore, add evidence for a cumulative pressure (Courchamp *et al.*, 1999), although at the same time we cannot rule out the hypothesis that the presence of the Red Fox may have been exploited by the smaller predator species (Sih *et al.*, 1998). The underlying rationale supporting this statement is that the entrance of the Red Fox into the colony may generate much higher disturbance (triggering a widespread abandonment of the nests due to the capacity of the Red Fox to prey upon adult gulls), a circumstance from which the Marten may take benefit (Schmidt, 2003). Thus, the Fox may act as a facilitating factor, even indispensable to explain the overall breeding failure observed within the colony.

Given the behaviour of both species and their particularly large home ranges, that can vary from 20 ha to >400 ha in the Stone Marten, and from 50 to >1000 ha in the Red Fox (Goszczyński 2002; Herr *et al*. 2009; Walton *et al*. 2017; Wereszczuk & Zalewski 2019), it is possible that the predation observed in the monitored colony area was caused by only a single individual of each species; however, in the absence of further information, this possibility remains purely speculative. Still, knowing the number of predators involved is crucial for the planning and development of management measures of predators in the colony's vicinity. Thus, we strongly recommend that future studies look into this matter.

The situation is particularly alarming if we also add the near-zero productivity recorded in 2025 in another of the main Basque Yellow-legged Gull colonies, situated at the island of Garraitz (Lekeitio), just 44 km to the west of Ulia. In this case, the predator was not identified, but the presence of the exotic Common Raccoon (*Procyon lotor*) was recently documented on the island (A. Galarza, per. com.). Such non-native predators also represent a threat to Yellow-legged Gull colonies (as well as other seabird species), especially in island ecosystems that lack native mammal predators. This apparently increasing predator-pressure on Yellow-legged Gull colonies within the region underscores a need to reassess predator management policies and the conservation status of key breeding natural habitats.

Persistent predation in the colony could have broad population and ecological consequences by increasing breeding dispersal, which until now was close to zero (Delgado *et al*. 2021a). Sustained reproductive failure is a well-known driver of dispersal in colonial seabirds (Oro *et al*. 1999; Hyun-Ju *et al*. 2018). In a population with a very high rate of residency (Delgado *et al*. 2021a), dispersal is expected to occur to nearby colonies. However, many of these would be at or near their highest natural carrying capacity (Arizaga *et al*. 2022), hence limiting their capacity to absorb additional breeders. Alternatively, adults might explore novel or suboptimal breeding habitats, such as rooftops in urban areas (Pais de Faria *et al*. 2023). Yellow-legged Gull urban-colonies are rather common in other areas (Méndez *et al*. 2020; Molina *et al*. 2022), but they are still scarce on the Basque coast (Arizaga *et al*. 2022). Any expansion into these environments could cause new human-gull conflicts or exacerbate the few existing ones (Rock 2005; Soldatini *et al*. 2008a; Arizaga 2023). Therefore, it is imperative to continue with systematic monitoring programs to track for the potential changes in nesting behaviour, which poses a new methodological and logistical challenge, particularly in terms of monitoring breeding at rooftops. This is essential for anticipating and managing emerging potential conflict zones.

In conclusion, our findings indicate how the new presence of predators of terrestrial origin can have dramatic consequences for the breeding performance of a resident Yellow-legged Gull colony, with a medium- to long-term potential high demographic impact. This phenomenon underscores the fragility of these populations which were once considered to be robust and over-abundant. A possible increasing breeding dispersal to alternative urban environments poses new ecological and social challenges. This scenario suggests the need for a reassessment of predator management strategies, strict conservation of the natural nesting habitat and long-term monitoring frameworks.

**Resumen**

La gaviota patiamarilla (Larus michahellis) presenta actualmente un acusado declive poblacional, especialmente tras el cierre de vertederos. En la costa vasca (España), la colonia de Ulia (una de las más importantes) ha sufrido un colapso reproductivo severo. Para evaluar si la depredación por mamíferos terrestres contribuyó a este fracaso general, se instalaron cinco cámaras trampa durante la temporada reproductora de 2025. Se registraron 40 detecciones de depredadores: zorro rojo (Vulpes vulpes; N = 22), garduña (Martes foina; N = 17) y depredación por congéneres (N = 1). (Vulpes vulpes, N =22), garduña (17) y un caso de depredación por congéneres. La depredación se produjo, fundamentalmente, en huevos y se confirmó para todos los nidos que fueron expresamente monitorizados. Los resultados evidencian que la depredación terrestre fue la causa directa del fracaso reproductor y subrayan la necesidad de revisar la gestión de depredadores y las estrategias de conservación a largo plazo.

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**Table 1**. Number of records in which a predator (RF, Red Fox *Vulpes vulpes*; SM, Stone Marten *Martes foina*; YLG, Yellow-legged Gull *Larus michahellis*) was detected at each sampling site (ID camera/site) (PD) and where predation was visually confirmed (CP). Counts in parenthesis refer to predation on adult Yellow-legged Gulls. The rest are all cases of predation on eggs.

| ID camera/site | RF PD | RF CP | SM PD | SM CP | YLG PD | YLG CP | Nest targeted | Date: from | Date: to | Invalid recording days | Full-recorded days |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01* | 2 | 0 | 8 | 1 | 0 | 0 | Yes | 08/04/2025 | 06/06/2025 | 1 | 56 |
| 02 | 2 | 0 | 0 | 0 | 0 | 0 | No | 08/04/2025 | 12/05/2025 | 0 | 33 |
| 03 | 5 | 0 | 1 | 0 | 0 | 0 | No | 08/04/2025 | 12/05/2025 | 0 | 33 |
| 04 | 1 | 0 | 1 | 0 | 0 | 0 | No | 08/04/2025 | 17/05/2025 | 15 | 22 |
| 05 | 5 | 0 | 0 | 0 | 0 | 0 | No | 08/04/2025 | 14/05/2025 | 0 | 35 |
| 06 | 2 | 1 | 0 | 0 | 0 | 0 | Yes | 12/05/2025 | 20/05/2025 | 4 | 2 |
| 07 | 0 | 0 | 0 | 0 | 0 | 0 | Yes | 12/05/2025 | 14/05/2025 | 0 | 1 |
| 08 | 0 | 0 | 0 | 0 | 0 | 0 | No | 14/05/2025 | 17/05/2025 | 0 | 2 |
| 09 | 0 | 0 | 0 | 0 | 0 | 0 | Yes | 17/05/2025 | 20/05/2025 | 2 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | Yes | 17/05/2025 | 23/05/2025 | 1 | 3 |
| 11 | 1 | (1) | 1 | 1 | 1 | 1 | Yes | 20/05/2025 | 12/06/2025 | 0 | 22 |
| 12 | 1 | 1 | 0 | 0 | 0 | 0 | Yes | 20/05/2025 | 12/06/2025 | 0 | 22 |
| 13 | 0 | 0 | 1 | 1 | 0 | 0 | Yes | 27/05/2025 | 29/05/2025 | 0 | 1 |
| 14 | 2 | 1 | 2 | 1 | 0 | 0 | Yes | 27/05/2025 | 22/06/2025 | 0 | 25 |
| 15 | 0 | 0 | 2 | 2 | 0 | 0 | Yes | 07/06/2025 | 12/06/2025 | 0 | 4 |
| 16 | 0 | 0 | 1 | 1 | 0 | 0 | Yes | 06/06/2025 | 19/06/2025 | 5 | 6 |
| 17 | 1 | 1 | 0 | 0 | 0 | 0 | Yes | 31/05/2025 | 22/06/2025 | 0 | 21 |

| 18 | 0 | 0 | 0 | 0 | 0 | 0 | Yes | 12/06/2025 | 26/06/2025 | 0 | 12 |
| TOTAL | 22 | 4+(1) | 17 | 7 | 1 | 1 | 13 | 08/04/2025 | 22/06/2025 | 28 | 300 |

*The camera in this location targeted the Great Black-backed Gull nest.

Mammal predators in Yellow-legged Gull colony



**Figure 1**. Location of the Yellow-legged Gull *Larus michahellis* colony in Ulia (red dot), near the city of San Sebastián, in northern Spain.

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**Figure 2**. Camera-detected predatory events on Yellow-legged Gull *Larus michahellis* eggs by Stone Marten *Martes foina* (above) and Red Fox *Vulpes vulpes* (below) within the Ulia colony, Basque Country, during the breeding season of 2025.
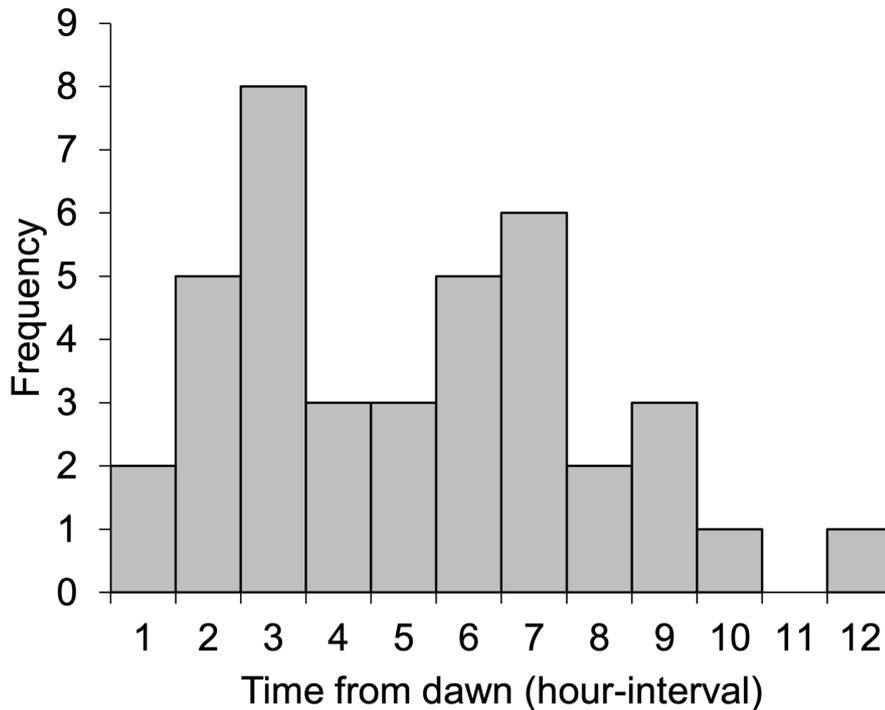


**Figure 3**. Frequency distribution of cases in which predators (Red Fox *Vulpes vulpes*, Stone Marten *Martes foina*) were detected at the Yellow-legged Gull *Larus michahellis* Ulia colony, starting at dawn (hour 1 was the first hour after dawn).