DYNAMICS OF HUMBOLDT PENGUIN COLONIZATION ON PORT TERMINAL INFRASTRUCTURE IN SOUTHERN PERU

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ABSTRACT

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The use of artificial structures by seabirds is a globally recognized phenomenon driven by escalating human coastal development. Designed as maritime infrastructure, breakwaters, jetties, and bridges inadvertently offer nesting habitat and refuge for a diverse assemblage of seabird species. The construction of a detached breakwater at the port terminal of the PERU LNG natural gas liquefaction plant in Melchorita, Peru, provided a unique opportunity to observe seabird colonization of new habitat, in this case colonization by Humboldt Penguins *Spheniscus humboldti* from 2008 to 2024. The penguins founded a permanent breeding site within 3.5 years after cessation of human activity at the site, which had provided protection from terrestrial predators and human interference. Between 2012 and 2021, penguin numbers increased to 2091 birds, peaking during the January molt, although numbers fluctuated. By 2021, the breakwater harbored a substantial proportion of the penguin population in Peru. The breakwater exemplifies the potential of artificial structures in mitigating habitat loss and supporting seabird conservation, underscoring the need for proactive management strategies amidst escalating coastal development and environmental challenges.

Key words: breakwater, *Spheniscus humboldti*, marine infrastructure, colonization, man-made structures

RESUMEN

El uso de estructuras artificiales por parte de las aves marinas es un fenómeno reconocido a nivel mundial impulsado por el creciente desarrollo humano en las zonas costeras. Diseñadas como infraestructuras marítimas, los rompeolas, espigones y puentes ofrecen inadvertidamente hábitat de anidación y refugio para una diversa variedad de especies de aves marinas. La construcción de un rompeolas sin conexión a tierra en la terminal portuaria de la planta de licuefacción de gas natural PERU LNG en Melchorita, Perú, brindó una oportunidad única para observar la colonización de nuevos hábitats por aves marinas, en este caso, la colonización por parte de los Pingüinos de Humboldt *Spheniscus humboldti* desde 2008 hasta 2024. Los pingüinos fundaron un sitio de reproducción permanente dentro de los 3.5 años después del cese de la actividad humana en el lugar, lo que proporcionó protección contra depredadores terrestres e interferencias humanas. Entre 2012 y 2021, el número de pingüinos aumentó a 2091 aves, alcanzando su máximo durante la muda de enero, aunque los números fluctuaron. Para 2021, el rompeolas albergaba una proporción sustancial de la población peruana de pingüinos. El rompeolas ejemplifica el potencial de las estructuras artificiales en la mitigación de la pérdida de hábitat y el apoyo a la conservación de aves marinas, subrayando la necesidad de estrategias de gestión proactiva en medio del creciente desarrollo costero y los desafíos ambientales.

Palabras clave: rompeolas, *Spheniscus humboldti*, infraestructura marina, colonización, estructuras artificiales.

INTRODUCTION

The use of artificial structures by seabirds is a well-documented phenomenon observed across coastal regions worldwide, attributable to escalating human development (Yrjölä *et al*. 2016, Rauzon *et al*. 2019, Muller *et al*. 2020, Marinao *et al*. 2024). Breakwaters, jetties, bridges, and other marine and coastal infrastructure provides new habitat and refuge for a variety of seabird taxa such as gulls (Simeone & Bernal 2010, Turner 2010), terns (Marinao *et al*. 2024), cormorants (Capitolo *et al*. 2019, Rauzon *et al*. 2019, Daniel *et al*. 2020), and penguins (Giling *et al*. 2008, Preston *et al*. 2008). Generally, these structures offer elevated platforms, crevices, and ledges that mimic natural breeding habitats. Additionally, the surrounding waters near these structures can be rich in forage prey, providing a readily available food source (Connell 2001). For example, the tourist breakwater of St. Kilda in Melbourne, Australia, hosts a significant breeding population of Little Penguins *Eudyptula minor* (Giling *et al*. 2008, Preston *et al*. 2008). In Algarrobo, Chile, a breakwater connects the mainland with Pájaro Niño Island, allowing the existence of colonies of Humboldt Penguin *Spheniscus humboldti*, Peruvian Pelican *Pelecanus thagus,* and Kelp Gull *Larus dominicanus* (Simeone & Bernal 2000). The interstices, crevices, and holes generated by ancient, superimposed stone walls, created for guano on some of Peru's guano islands, serve as breeding areas for storm petrels (Ayala *et al*. 2004). As well, metallic structures that are part of jetties and bridges have also been successfully used by seabirds to perch and nest, as seen in the Red-footed Booby *Sula*

sula in Hawaii (Rauzon & Drigot 1999), Double-crested Cormorant *Nannopterum auritum* on the San Francisco bridge, USA (Stenzel *et al*. 1995, Rauzon *et al*. 2019), and Black Guillemot *Cepphus grylle* in the ports of Northern Ireland (Leonard 2017).

In Peru, large artificial structures on guano islands have served as nesting sites for seabird species. For example, Neotropic Cormorants *Nannopterum brasilianum* have utilized wooden load platforms to build their nests (Galarza 1968). Humboldt Penguins and Inca Terns *Larosterna inca* have also been observed nesting beneath wooden platforms and inside abandoned buildings (CZ pers. obs.). Recently, Guanay Cormorants *Leucocarbo bougainvilliorum* were seen nesting on abandoned oil rigs on the northern coast (CZ pers. obs.). Although Peru's breakwaters and port infrastructure are widely utilized by pelicans, gulls, terns, cormorants, and frigatebirds as roosting sites, there are no recorded cases of nesting, which may be attributed to the high levels of human disturbance and the presence of terrestrial predators.

Humboldt Penguins are endemic to the cold waters of the Humboldt Current, with colonies spread from Isla Foca, Peru, to Isla Metalqui, Chile (De la Puente *et al.* 2013). It is globally categorized as Vulnerable (BirdLife International 2020), but in Peru it is considered Endangered (MINAGRI 2014). In Peru, Humboldt Penguins breed year-round, pausing only during the annual molt period between January and March (Zavalaga & Paredes 1997, Paredes *et al*. 2002). They nest in guano burrows, but also use rock crevices, sea caves, and surface nests atop cliff edges (Paredes & Zavalaga 2001). The population of Humboldt Penguins in Peru has experienced significant fluctuations, largely attributed to reduced food availability during El Niño events (Hays 1986, Paredes & Zavalaga 1998, Paredes *et al*. 2003), entanglement in gillnets (Simeone *et al*. 1999, Majluf *et al.* 2002), habitat degradation from guano extraction (Murphy 1925, 1936, Hays 1984, Sifuentes-García *et al.* 2020, Doig-Alba *et al*. 2023), human disturbance (Hays 1984), and resource competition with the fishing industry (Murphy 1981, De la Puente *et al*. 2013). As a response to these pressures, they have sought refuge in remote and undisturbed locations.

On Peru's central coast, one detached breakwater resembling an artificial inshore island was constructed as part of the marine infrastructure of a liquified natural gas (LNG) port terminal. The breakwater was built with a combination of rocks and concrete blocks, thus creating crevices suitable for nesting and sheltering during rough sea conditions. This detached breakwater is devoid of terrestrial predators and minimizes human disturbance. This study chronicles Humboldt Penguin colonization on this port terminal infrastructure. Through systematic counts, we delineate a chronological timeline of occupation events and population trends from the inception of the breakwater construction in 2008 to the present day.

METHODS

Study site

This study took place on the marine infrastructure of the PERU LNG port terminal located on the Peruvian central coast (13.256°S, 76.309°W; km 169 South Pan-American Highway; Fig. 1).

Port terminal

The construction of the port terminal, the only LNG terminal in South America, began in 2007. The terminal facilities consist of a 1.4-km-long jetty that supports the gas pipeline and ends in a loading platform, an offshore breakwater (hereinafter, detached breakwater) for allowing safe mooring of methane tankers, and a small breakwater connected to a concrete platform (hereinafter collectively referred to as RLOF, i.e., Rock Load Out Facility) that is attached to the jetty (Figs. 1, 2). The role of this entire infrastructure is to ensure the efficient and safe berthing and loading of gas from the inland LNG plant to the docked methane tankers. Since construction, the infrastructure has provided new habitat to marine invertebrates (Tasso *et al*. 2018), fish (Pacheco *et al*. 2023), and seabirds (Ponce 2022).

Detached and RLOF breakwaters

The detached breakwater protects the port terminal by dissipating wave energy. It is 800 m long and 35 m wide, positioned approximately 1.3 km offshore and parallel to the coastline, and is oriented from southeast to northwest. It creates a 350-m navigation channel between the harbor side of the breakwater and the loading platform at the end of the jetty (Figs. 1, 2). It reaches 26 m from the seabed and 11 m above sea level. Its underwater foundation is composed of natural rocks and boulders from 1 kg to 6 metric tons (Rojas 2009), supporting a superstructure of riprap and 8 m^3 precast concrete blocks. Above the waterline, the arrangement of boulders is oblique on the harbor side and flat on the top at a height of approximately 6 m. A first row of packed, aligned concrete cubes lie on their bases along the flat surface, positioned ~2 m from the edge of the rocks, leaving a narrow corridor on the harbor side of the breakwater (see Fig. 1). Above this, a second level of cubes is placed randomly, resulting in a total concrete cube height of approximately 5 m (Fig. 1). This combination of boulders and concrete cubes creates numerous interstices, galleries, and crevices that provide shelter and nesting habitat for the penguins. The construction was completed in January 2010 and achieved full operational status in May 2010. The first tanker load occurred in the following month. Notably, the primary characteristic of the detached breakwater is that it resembles a lengthy and slender artificial island (see Figs. 1, 2).

The RLOF is located ~300 m offshore (Fig. 1), and its construction was completed by December 2008. It comprises a 200-m L-shaped breakwater, which is connected to a concrete platform that is attached to the north side of the jetty (Figs. 1, 2). It was built with the same materials and characteristics as the detached breakwater and features a wider flat base (10 m) on its eastern side and a minor bay delineated between the breakwater and the concrete platform. It is ~11 m above sea level and, years ago, served as a berth for tugboats, small barges, vessels, and refueling operations. Currently it is no longer operational.

Penguin sightings and counts

Before construction of the two breakwaters in April 2008 and November 2009, two systematic annual surveys of penguins and other seabirds were conducted as part of an Environmental Impact Assessment. Penguins were sighted using binoculars from a boat along one 50-km transect to the coast and 2 km offshore, centered in front of projected marine infrastructure. Between 2010 and 2012, opportunistic sightings of penguins were documented by personnel at the terminal, logged in daily reports, and reviewed for this study. The date of each sighting and an estimate of the number of penguins observed (considered

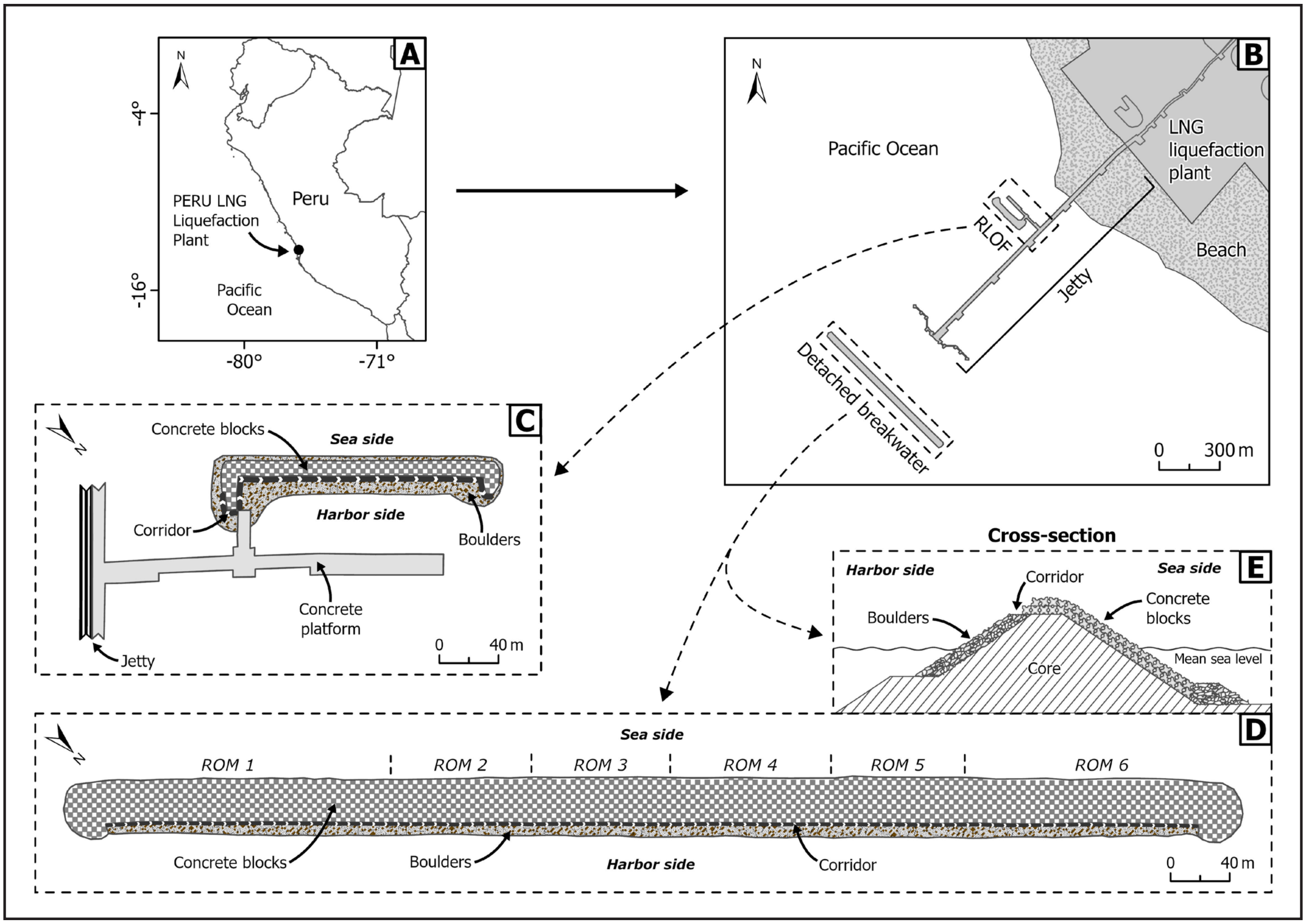

Fig. 1. (A) Location of the PERU LNG Liquefaction Plant and port terminal in Peru; (B) map depicting the infrastructure of the LNG port terminal; (C) schematic representation of the Rock Load Out Facility (RLOF) breakwater; (D) detached breakwater showing its division into six sections from south to north (ROM 1–6); and (E) cross-section of the detached breakwater.

a minimum number as sightings usually involved a sector of the breakwaters) were recorded. Between November 2013 and January 2017, 10 complete surveys (one to three per year) were undertaken on the two breakwaters, the jetty, and the beaches of the port terminal (Appendix 1, available online) as part of a comprehensive seabird monitoring program.

The entire harbor side of the detached breakwater was surveyed by direct visual observations using a spotting scope. The breakwater was divided into six sections from south to north: ROM 1 (220 m), ROM 2 (95 m), ROM 3 (95 m), ROM 4 (110 m), ROM 5 (90 m), and ROM 6 (190 m). Observations were made from various vantage points along the loading platform at hourly intervals between 09h00 and 16h00. Penguins on the RLOF breakwater's harbor side were counted from the RLOF concrete platform and the bridge structure. For this study, only the count data collected between 09h00–10h00 were used, as they consistently yielded the highest recorded number of penguins.

In November 2016, a complete check of nests in the detached breakwater was undertaken for the first time by direct inspection of holes and crevices in the rocky and concrete block sections. The search was suspended in 2017 to minimize disturbance. From July 2017 onwards, penguin counts were conducted monthly using aerial imagery captured by DJI drones: Phantom 3 Professional (Jul 2017–Jul 2019), Mavic 2 Pro (Aug 2019–Jan 2020), and Mavic 2 ED (Feb 2020–Mar 2024). Drones were controlled to take overlapping orthophotos as well as lateral photos of the breakwaters' sides, at flight altitudes of 10–60 m above sea level (asl). Photos were stitched and all penguins were identified and counted by eye. Adults were distinguished from juveniles in the counts from August 2019 onwards. Flights were canceled in 24 out of 81 monthly counts due to the presence of tankers, operational restrictions, maintenance in the port terminal, and during the COVID-19 lockdowns.

RESULTS

During monitoring from April 2008 to November 2009, two penguins were observed swimming in the vicinity of the infrastructure. No breeding sites were identified in the nearby area, indicating that these penguins were likely commuting or foraging. The first recorded arrival of penguins on the detached breakwater was in 2012, when ~60 penguins rested among the boulders (Fig. 3). By November 2013, the penguin population had grown to 381 individuals, mostly juveniles (n = 337),

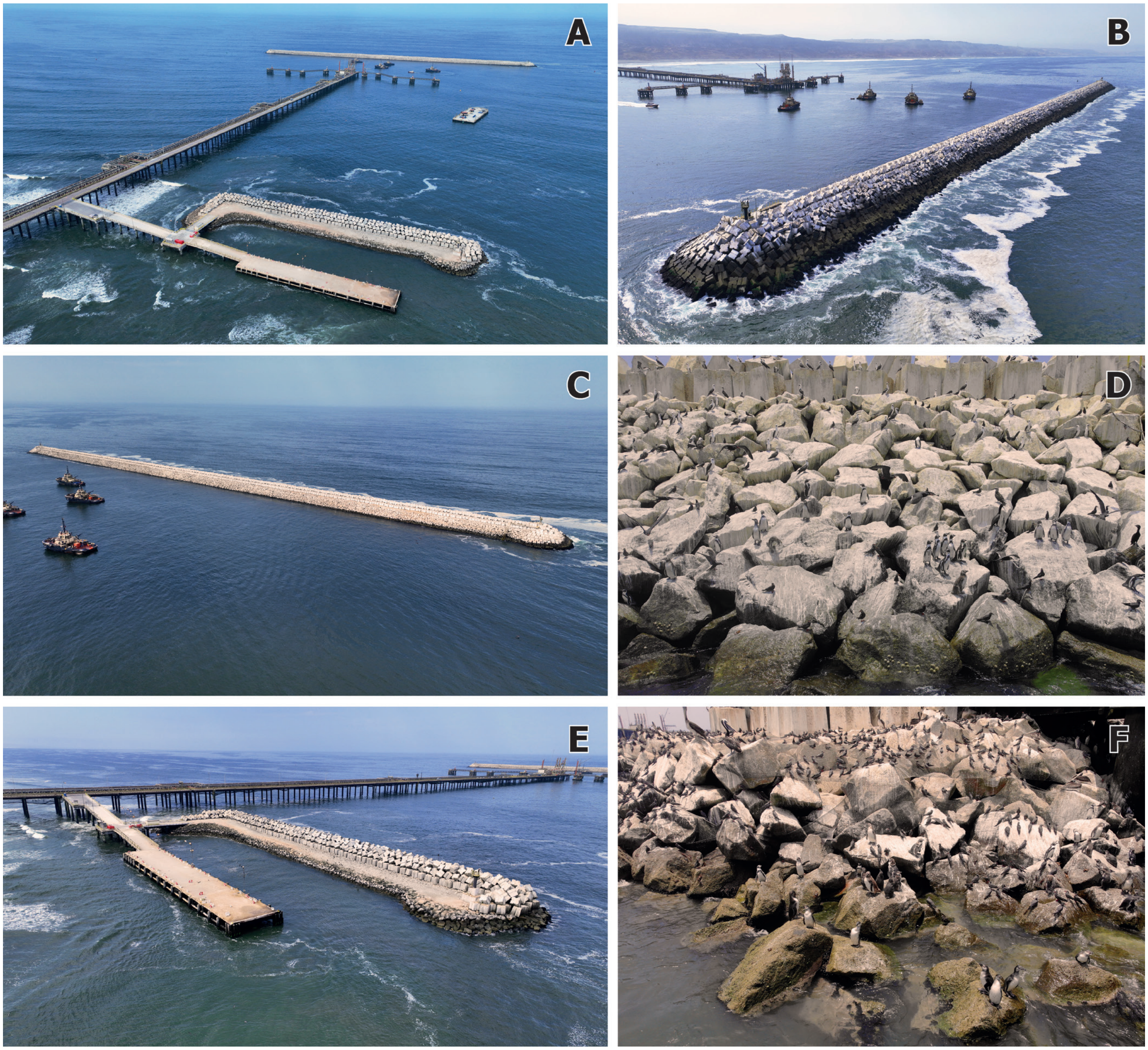

Fig. 2. Aerial views of the LNG port terminal infrastructure: (A) Rock Load Out Facility (RLOF) breakwater attached to the jetty (LNG loading platform and detached breakwater shown at the upper side of the photo); (B) lateral view of the sea side of the detached breakwater; (C) harbor side of the detached breakwater, also showing the navigation channel; (D) penguins resting on the rocks and boulders of the detached breakwater harbor side; (E) lateral view of the RLOF breakwater and concrete platform; (F) penguins resting on rocks and boulders of the RLOF breakwater harbor side.

and breeding was confirmed for the first time (Fig. 3). Two nests contained large chicks of ~60 days of age, still having downy feathers around the neck. A retrospective analysis of breeding events suggested that egg-laying occurred in August 2013, 3–3.5 years after the detached breakwater was fully operational and undisturbed by workers. In November 2016, in the only thorough count of active nests, 59 active nests and 216 penguins were counted. The first sighting of penguins on the RLOF breakwater occurred in October 2015 (Fig. 3), and in September 2021, 36 active nests were identified. However, it is likely that first breeding occurred during 2016–2020, judging by the regular presence of adults. Between November 2013 and January 2017, the penguin population remained relatively stable in the port terminal infrastructure (400–550 birds), with a higher concentration noted on the detached breakwater.

Monthly counts were implemented in July 2017 and revealed significant intra-annual variation in penguin numbers, with a peak in January, which coincided with the annual molt (Fig. 4). Penguin numbers continued to increase, reaching a peak of 2091 birds in 2021 (Figs. 3, 4). Based on the available habitat and the occurrence of penguins in the breakwaters, we estimated that 35.3% (1.1 ha; 0.011 km^2) and 83.2% (0.5 ha; 0.005 km^2) of the total surface area of the detached breakwater and the RLOF

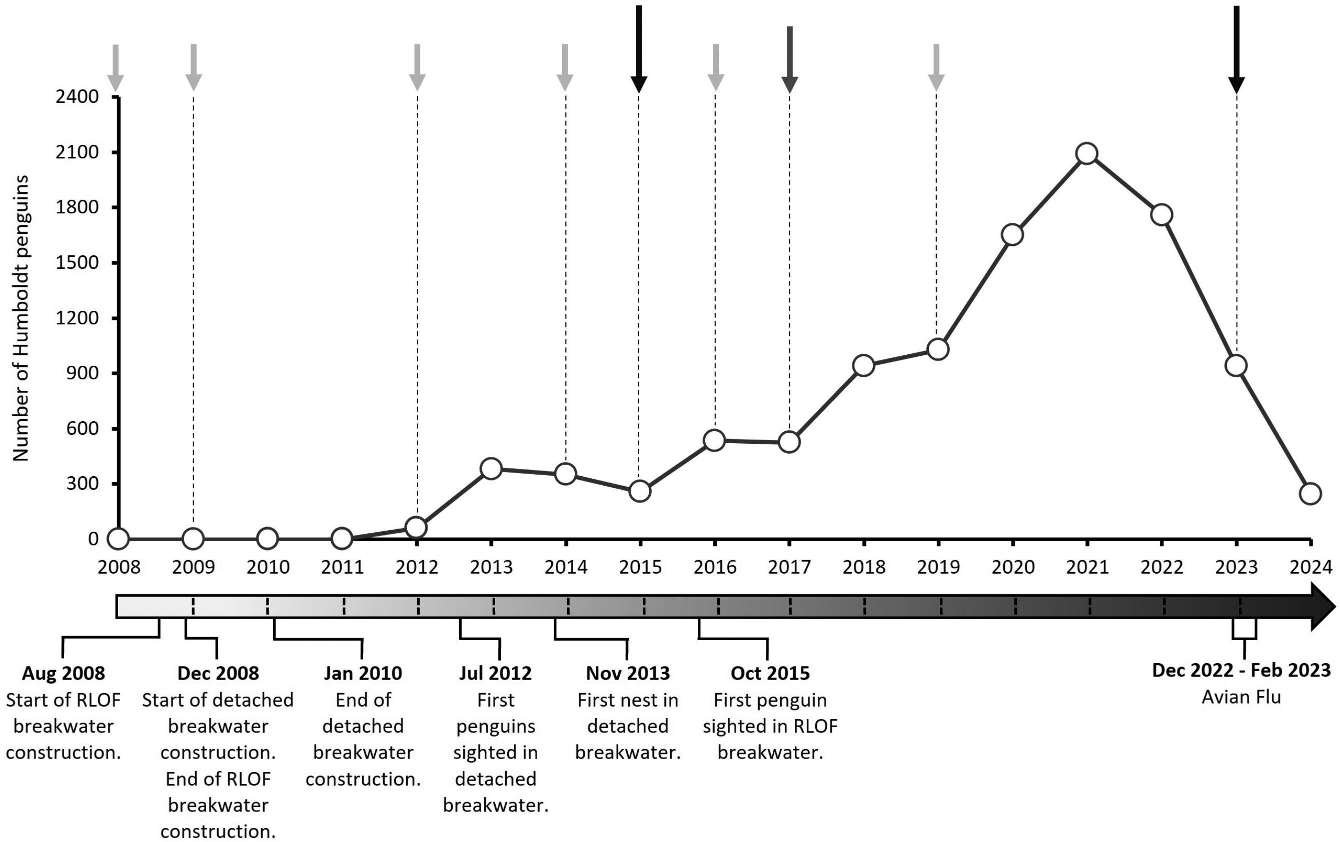

Fig. 3. Inter-annual variation of the total number of Humboldt Penguins *Spheniscus humboldti* on the detached and Rock Load Out Facility (RLOF) breakwaters at the port terminal facilities of PERU LNG. The intensity of El Niño events is indicated with arrows: short-silver (weak), medium-gray (moderate), and long-black (strong), and is categorized according to the ICEN indexes (i.e., Coastal El Niño Index, Takahashi *et al*. 2014). A timeline of major events is shown in the lower bar. All numbers from 2018 onwards correspond to counts in January. In years when no counts in January were available, numbers were selected from counts in months closer to January (Nov 2013, Nov 2014, Oct 2015, and Feb 2016).

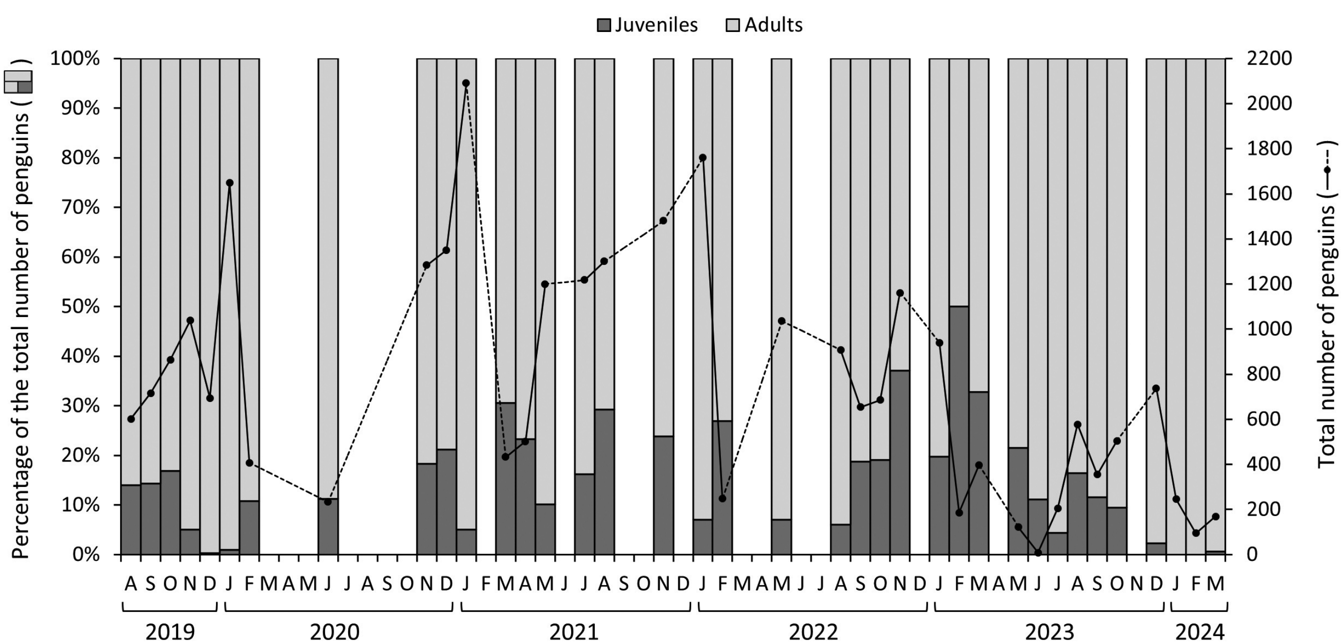

Fig. 4. Monthly variation in the proportion (%) of juveniles (gray bars) and adults (silver bars), and total number of Humboldt Penguins *Spheniscus humboldti* (point and lines) on the detached and Rock Load Out Facility (RLOF) breakwaters at the port terminal facilities of PERU LNG.

breakwater, respectively, were used by the penguins. During the population peak in January, 2091 penguins were tallied (n = 1921 birds in the detached breakwater, n = 170 birds in the RLOF breakwater; Appendix 1), which constitutes an overall penguin density of 1 bird/6 m^2 in the detached breakwater and 1 bird/30 m^2 in the RLOF breakwater. From 2022 to 2024, a drastic decline in numbers occurred, with only 245 individuals counted in January 2024 (see Discussion; Fig. 3).

The median proportion of juveniles in the count from August 2019 to March 2024 was estimated at 14%, but there was both intra- and inter-annual variation (Fig. 4). In February 2023, nearly 50% of observed birds were juveniles, whereas no juveniles were sighted in January–March 2024.

The number of penguins was higher on the detached breakwater (mean = 585, standard deviation [SD] = 428) compared to the RLOF breakwater (mean = 95, SD = 73) (paired t-test, $t = 8.99$, $P < 0.0001$, $df = 57$). Because the sections of the detached breakwater were not equal in length, we aggregated ROM 1, ROM 2, and ROM 3 as the south section (410 m in length), while ROM 4, ROM 5, and ROM 6 were combined as the north section (390 m in length). This facilitated a reliable comparison of penguin distribution within the detached breakwater. We estimated that the north section (mean = 329, SD = 238) exhibited a higher proportion of penguins compared to the south section (mean = 255, SD = 205) (paired t-test, $t = 4.79$, $P < 0.0001$, $df = 57$).

DISCUSSION

This study provides a chronological account of Humboldt Penguin colonization following the establishment of a detached artificial breakwater at an LNG port terminal on the south-central coast of Peru. Our results highlight the adaptability of Humboldt Penguins in swiftly and effectively colonizing new habitats to establish a permanent breeding site just 3.5 years after the breakwater construction. It is noteworthy that traditional attraction techniques (e.g., decoys, mirrors, and playbacks) known to facilitate seabird colonization in new areas (Jones & Kress 2012, Spatz *et al*. 2023) were not required. The new colonizers ventured into favorable resting conditions and discovered suitable nesting sites. The breakwater provided harbor areas to rest and crevices to breed, and it opened new, although artificial, subtidal ecosystems beneath the structures, enhancing marine productivity and providing abundant prey for predators (Tasso *et al*. 2018, Chunga-Llauce *et al*. 2023, Pacheco *et al*. 2023). Additionally, stringent infrastructure surveillance and fishing exclusion around the area deterred external human disturbance, rendering the habitat suitable for penguins. Ainley *et al*. (2024) considered what we report here as an example of what happens when a ‘floating population,’ representing a surplus of breeding-capable adults, especially among cavity-nesting species, takes advantage of newly available nesting habitat. Indeed, the Humboldt Penguin population is limited by availability of nesting habitat; competition for nesting cavities prevents a portion of the population from breeding.

This unplanned settlement event is of utmost importance for the conservation of Humboldt Penguins, as habitat degradation, disturbance, the introduction of rodents into natural colonies, and the ongoing threat of entanglement with fishing gear around breeding sites are escalating due to human expansion and urban development in coastal areas off Peru (De la Puente *et al*. 2013). Undisturbed, predator-free artificial structures such as detached breakwaters represent a viable alternative for nesting habitat. With 2091 birds in 2021, the colony accounted for 18% of the Humboldt Penguin population in Peru (n = 11 563 birds); the remaining 82% occurred at 24 protected sites as of 01 February 2021 (Burga & Valencia 2021). Thus, it constitutes the second-largest colony of the species in Peru, the first one being Isla Guañape Norte with 2402 individuals (Burga & Valencia 2021). While the majority of Humboldt Penguins in Peru are found at various locations outside marine protected areas, a significant proportion are concentrated on partially- to fully-protected sites including the guano islands and headlands (McGill *et al*. 2021). Clearly, port terminal breakwaters are an important Humboldt Penguin breeding habitat in Peru. This is further supported by the overall declining trend observed in the Peruvian penguin population, which reduced by ~50% from ~20 000 birds in 2010 to < 10 000 birds in 2019 (McGill *et al*. 2021).

Since the first monitoring of seabird diversity was implemented in 2015, up to 44 species of birds, 20 of which were seabirds, both resident and migratory, have been reported in the port terminal (SL-S unpubl. data). Port infrastructure has offered resting and breeding conditions for other seabird species including the Inca Tern, Peruvian Booby *Sula variegata*, Neotropic Cormorant, and, occasionally, the Peruvian Pelican. Although direct evidence is lacking, most penguins and other seabirds settling on the breakwaters likely originated from the nearest breeding colonies on the Chincha Islands to the south and Asia Island to the north, located 40 and 60 km away, respectively.

Numerous breakwaters connected to the mainland exist along the Peruvian coast, primarily designed for docking facilities or wave protection. However, none of these structures are used by Humboldt Penguins as nesting sites (CZ pers. obs.). The RLOF breakwater is an exceptional case. Despite its connection to the jetty, the level of disturbance at the breakwater remains relatively low and is primarily restricted to sporadic maintenance activities carried out by port personnel. Additionally, the facility maintains consistent rodent control measures within its installations, including the placement of tube traps at various locations. While the use of port infrastructure by penguins is important to conservation, it can also pose challenges. Accumulation of bird droppings on the infrastructure can lead to health issues and corrosion of materials (Forr *et al*. 2022), necessitating regular maintenance. Furthermore, penguins may be at risk of injury or mortality from collisions with tankers or other vessels (Yrjölä *et al*. 2016).

The systematic monitoring and census of active Humboldt Penguin nests was halted in 2017 to mitigate human disturbance on the detached breakwater. Consequently, no comprehensive analysis of population trends during the study period is available. Data obtained in November 2016 indicated the presence of 59 nests and 216 individuals on the detached breakwater. It is plausible that the number of nests increased in subsequent years. Even during the peak of 2021, it appears that the carrying capacity of the nesting area was not attained, given the maximum estimated density of penguins (1 penguin/6 m^2) and the distribution pattern observed along the breakwater. Introducing artificial nests along the corridor and flat areas in both breakwaters has the potential to further augment nesting opportunities for penguins, as occurs in other burrow-nesting penguin species (Lalas *et al*. 1999, Sherley *et al*. 2012, Sutherland *et al*. 2014).

The population of penguins at the port terminal exhibited a steady increase from 60 individuals in 2012 to 2091 individuals by 2021. This trend coincided with a decline in penguin numbers at neighboring Chincha Island (from 1470 in 2011 to 153 in 2020), where guano harvesting occurred during 2011–2013 and 2018–2019, destroying nesting habitat. Additionally, at neighboring Asia Island, where guano harvesting occurred in 2017, numbers decreased from 801 in 2011 to 603 in 2020 (McGill *et al*. 2021). These changes underscore the potential influence of anthropogenic activities on penguin distribution patterns and highlight the importance of considering human impacts in conservation efforts. It is also important to note that El Niño events of varying intensity during the rise phase (2012–2021) likely also exerted an influence on penguin numbers at the port terminal. Particularly important were the strong and moderate El Niño events, during which penguin numbers exhibited either a slight decrease or remained stable.

The period 2022–2024 was characterized by a sharp decline in penguin numbers at the port terminal. Two consecutive events took place in this period: (1) the H5N1 virus influenza outbreak in Peru in November 2022 killed hundreds of thousands of seabirds, including Humboldt Penguins (Gamarra-Toledo *et al*. 2023); and (2) the onset of a strong El Niño in March 2023 extended at least until May 2024 (Peng *et al*. 2024). Between December 2022 and August 2024, 41 penguin carcasses were found along a 4.6-km stretch of beach around the port terminal. This surge in mortality had not been recorded since the establishment of the infrastructure colony. High mortality of Humboldt Penguins has been previously reported during strong El Niño events of 1982–1983 (Hays 1986) and 1997–1998 (Paredes & Zavalaga 1998, Apaza & Figari 1999). However, this is the first reported instance of a catastrophic event (H5N1 outbreak) occurring alongside a strong El Niño.

CONCLUSIONS

The construction of an undisturbed and protected detached breakwater of an LNG port terminal infrastructure in central-southern Peru inadvertently served as an experiment to evaluate the feasibility and success of a Humboldt Penguin restoration program. The infrastructure created optimal conditions on land and at sea that were conducive to the swift occupation and establishment of a Humboldt Penguin colony. The existence of a 'floating population' (Ainley *et al*. 2024) apparently was revealed, obviating the need for conventional seabird attraction methods such as decoys, mirrors, and playbacks. The integration of disturbance- and predator-free breakwaters, thus, presents a promising avenue for potential penguin colonization, which is particularly significant given the threats faced by natural colonies, including guano harvesting, unregulated tourism, the presence of introduced rodents, and entanglement in fishing nets. The escalating pace of coastal port development in Peru underscores the potential for these installations to function as inadvertent attractors for penguins and other seabird species. Consequently, the implementation of robust management strategies aimed at minimizing human intervention and monitoring seabird populations within and around these locales is of paramount importance. Such efforts not only bolster existing conservation initiatives but also provide essential data for the preservation and sustainable management of Peru's coastal ecosystems amidst the inevitable and escalating coastal development.

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