Humboldt Penguin at PERU LNG Marine Terminal

Authors: Anibal Diaz[1]; Martha Ly[2]

[1]Associate, Marine Biologist, Senior Environmental Consultant - Golder Associates Perú
[2]Associate, Biologist, Socio-Environmental Team Leader – Golder Associates Perú

Abstract

Humboldt Penguin (*Spheniscus humboldti*) has a distribution predominantly along the coasts of Peru and Chile. In recent years, six main breeding colonies have been observed in Peru and approximately ten in Chile. The species has undergone large fluctuations in numbers in the last 25 years, but with an overall downward trend. The El Niño Southern Oscillation (ENSO) and anchovy overfishing are considered the main cause. The species is listed as vulnerable by IUCN.

Penguins started to visit the PERU LNG (PLNG) marine facilities area after it was constructed. The species has now colonized the breakwater at the terminal and is using the complex concrete structure as a breeding site. Other species of birds also use the breakwater, and marine life is also associated with the underwater structure, creating a unique green marine infrastructure.

The use of a Project facility by a listed species has been a chance occurrence. However, the presence of the species indicates an increased biodiversity in the Project area. While the presence of a listed species on a Project site represents new challenges to PLNG, it also represents an opportunity to create an environment that support biodiversity. This paper summarizes the current biodiversity created around the breakwater and analyzes their positive impacts.

Introduction

The PLNG's Liquefied Natural Gas Plant in Pampa Melchorita is located on the coastline, south of Lima, Peru. PLNG has an Environmental Impact Assessment (EIA) approved by the Peruvian Environmental Authorities. PLNG marine facilities consist of a 1.3 km long trestle, at the end of which the liquefied natural gas (LNG) shipping facilities for tankers, an access navigational channel and a breakwater are located. The breakwater is in front of the LNG loading dock (at 14 m depth) and was built by stacking large rocks (up to 3 tons). The breakwater is 800 m long and 8 m above sea level. It resembles an island, where an area protected from waves has been created.

The EIA (Golder 2003) predicted that the breakwater installation would favor the establishment of new biological communities and increase commercially important species in the surroundings of the marine terminal. After 2010, some penguins were observed in the area, swimming and visiting the breakwater. Therefore, PNLG commissioned an

assessment of the marine biodiversity in the terminal to determine the effect of the breakwater and marine operations.

Background

Due to its geographical and oceanographic conditions, the Peruvian sea is home to tropical and sub-tropical species (Paredes et al. 2004) and is estimated that it is inhabited by around 3368 species (Tarazona et al. 2003). However, this number may be underestimated due to the lack of taxonomic information of some groups of invertebrates and the occurrence of the ENSO that changes the habitat conditions of the marine ecosystem, extending the distribution of tropical species to the central and southern coast of Peru (Tarazona and Valle 1998).

The first information on the coastal marine biodiversity (macrobenthos, plankton, fish, birds and mammals) in the marine terminal area was collected during the baseline study conducted in 2002 (Golder 2003). From 2006 to date, the conditions of the biological communities have been recorded in order to determine potential changes in these communities as a result of the operation. Thus, 19 monitoring surveys of the marine biodiversity have been conducted in the surroundings of the marine terminal.

These surveys have enriched the baseline taxonomic inventory. Between 20 and 65 taxa that make up the soft-substrate, intertidal and subtidal macrobentos, 124 phytoplankton taxa and 29 fish taxa have been recorded (ERT 2009, ERM 2013). Additionally, in 2007 (before the construction of the breakwater), Golder conducted a monitoring survey of birds and marine mammals in a larger area, which comprised 40 km of coastline. During this last survey, 39 bird species were recorded and five key species were identified, including the Humboldt penguin, which was considered a rare species in the area surveyed.

Methods

Golder established a marine sampling design of selected marine communities (macroalgae, macrobenthic and fish) to cover the habitats currently identified at the PLNG terminal: i) Breakwater – hard substrate habitat; ii) beach – soft substrate habitat; and iii) sandy/muddy – soft substrate habitat (control). The hard substrate habitat created by the breakwater was sampled for the first time. The soft sandy muddy substrate was already present at the area, mostly offshore beyond the breaking waves.

A bird survey was also conducted in parallel, covering the sandy beach area and breakwater. The emphasis of the bird survey was to describe the penguin population at the breakwater. The breakwater and sea surface were scanned in order to record their daily activity. All observed penguins were counted at the breakwater, the entrance of caves, and in the seawater.

Trained biologists conducted the marine sampling during the austral summer while the bird survey was conducted during the spring and summer. The criteria to establish the number of sampling stations (15) considered the extent of the marine facilities, access to the sampling stations, exposure to waves, and depth. In the intertidal and subtidal zones,

macroalgae, macrobenthos and fish were surveyed, while the supratidal zone was surveyed for birds.

Results

Table 1 shows the evolution of the marine biodiversity at the marine terminal. The species inventory has increased compared with baseline conditions (before construction), totaling 127 species.

Table 1: Marine Biodiversity at PLNG Marine Terminal

Groups	Number of Species	
	2003 Baseline Survey	2013-2014 Survey
Macroalgae	-	7
Intertidal Macrobenthos	18	23
Subtidal Macrobenthos	54	54
Fish	2	16
Birds	11	24
Marine Mammals [a]	2	3

[a] Although a marine mammal survey was not conducted, observed marine mammals were recorded.

Macroalgae was founded growing attached to the rock blocks. In the intertidal zone, macroalgae were scarce behind the breakwater. Macroalgae were located 1 m deep between the infra-littoral and subtidal zone.

The macrobenthic community at the intertidal zone of the breakwater was composed of 23 taxa, predominantly Annelida, Arthopoda and Mollusca. The average density in the rocky intertidal zone was 1417 individuals/m^2. Two species of barnacles accounted for 77.5% of the total abundance. Other abundant species were *Perumytilus purpuratus* (Mussels) (8.7%) and Clemantis (4.3%).

In the rocky subtidal zone, 54 taxa of macrobenthos were recorded, corresponding to Mollusca, Arthropoda, Annelida, Cnidaria, and Echinodermata. The average density in the rocky intertidal zone was higher compared with the intertidal (2381 individuals/m^2). At 2 m depth, large adults of *Concholepas concholepas* (Chilean abalone) were recorded. This species is considered of commercial interest for artisanal fishing.

In comparison, only three taxa from three phyla (Annelida, Arthropoda and Nematoda) were recorded at the sandy/muddy soft substrate (the natural habitat in the area), with an average density of 117.3 individuals/m^2. The most common groups were Annelida (Polychaeta), represented by *Paraprionospio pinnata*, Nematoda and Arthropoda.

A total of 16 fish species were recorded; six through subtidal visual surveys and ten were observed from the surface. A significant number of adult individuals of commercial interest were observed. The most abundant species were *Scartichthys gigas* (Giant blenny), with 109 individuals, *Cheilodactylus variegatus* (Peruvian morwong), with 65 individuals, and *Labrisomus philippii* (Chalapo clinid), with 48 individuals. Additionally, adult individuals of

Chalapo clinid and *Sicyases sanguineus* (Clingfish) were recorded, as well as juvenile individuals of Giant blenny, Combtooth blenny and Green blenny.

Nests full of eggs of Chalapo clinid were also observed attached to the macroalgae *Prionitis decipiens*. The recorded individuals were breeding. Males of approximately 40 cm length provided parental care. In a transect parallel to the breakwater, 14 nests located between the surface and over 1 m deep were counted.

The bird survey recorded 24 species, with eight species at the breakwater. The dominant species were the Inca tern, Peruvian booby, Guanay cormorant, Humboldt penguin and Peruvian pelican. The maximum number of penguins observed (juveniles and adults) were 381 on the 2nd day of the survey. The penguins were mainly juveniles observed either at the breakwater or at sea, and were found sparsely distributed and mixed with Inca terns, Guanay cormorants, Peruvian boobies and Peruvian pelicans.

Overall, the greatest concentration of penguins (90%) was observed in the north end of the breakwater, where there is more protection against waves. At sea, penguins were less numerous. The juvenile-adult ratio was about 50:50. During the daytime, the number of penguins varied, mainly because they moved away while feeding at sea and were not detected. Also, a total of 56 groups of penguins (292 individuals) were observed, two of them were resting and the other 54 groups were at sea.

Resting was the main activity displayed by penguins on the breakwater. At sea, 73% of the penguins (212) were swimming, 18% (54) were grooming, and only 1% (3) was fishing. Swimming and fishing were identified by their faster movements and frequent dives, while grooming was noted through the cleaning of wings and other body parts. Likewise, the penguins that were swimming moved in groups of 1 to 10 individuals. The average group size was 5 individuals, and consisted mainly of juveniles accompanied by 1 to 3 adults.

The penguins are breeding successfully on the breakwater. The nests (5) were recorded at both ends: three on the north and two on the southern end. Chicks were only recorded on the south. These chicks were fledged between 65 to 70 days after birth.

Discussion

The construction of the breakwater has generated a new complex rocky habitat, which has attracted the settlement of marine species, transforming the natural ecosystem. Several authors have indicated that at high complexity, the habitat can support increased diversity (Burt et al.2009; Hooker and Gonzales 2012; Ahmed 2009; Wilding and Sayer 2002; Fuchs 2013). The results suggest that the hypothesis of the EIA was correct, and it is probable that the settlement process will continue until it reaches carrying capacity.

Dominant species at the intertidal zone are mostly filter/detrital feeding-type echinoderms and mollusks. These species are considered “engineering” species by their capacity to congregate other species. Therefore, the change in the trophic level at the breakwater is related with hard rocky substrates, where organisms feed mostly from organic matter and plankton (Miller and Page 2012). As a result, some commercial species (Chilean abalone,

octopus, anglerfish, Peruvian grunt, Peruvian morwong, Chalapo clinid and Pacific beakfish) are present in higher densities and greater sizes compared with other locations. The Chilean abalone is under high fishing pressure and depleted in other coastal areas.

The number of penguin's recorded (381) indicates that the species has found food, protection/defense and favorable habitat conditions at the breakwater, supporting their reproductive activity. Physical features such as caves, fissures and slots observed within the rocks at the breakwater are used for nesting. The population source of the observed penguins cannot be determined. However, other nearby colonies are the Chincha and Ballestas Islands, where a total of 527 and 226 individuals were documented (McGill et al. 2008). Another close colony is Pachacamac Island with 333 penguins. Therefore, the recorded penguin population indicates that the breakwater is an important Humboldt penguin colony for the Peruvian central coast.

Conclusions

The following conclusions can be drawn from our analysis:

- The EIA hypothesis can be confirmed. It postulated that given the structural complexity and the new substrate/habitat offered, the breakwater would generate a new ecosystem (rocky habitat), increasing the local marine biodiversity.
- The breakwater acts as a substrate for species as ecosystem engineers that have settled into the structure, as it provides refuge and food for an increased number of species.
- The breakwater acts as a reproduction center (contains an increased number of reproductive organisms) of commercial species, exporting eggs, larvae and juveniles to nearby locations.
- The marine organisms at the breakwater have demonstrated larger sizes compared with commonly observed species inhabiting other coastal zones that are exposed to increased fishing pressure.
- A total of 381 Humboldt penguin individuals were recorded, mostly at juvenile stages. Humboldt penguins are reproducing at the breakwater, mostly influenced by the protection offered against the winds and waves.
- The Humboldt penguin, considered before the breakwater as scarce species, is now key species at the PLNG marine terminal.

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