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More than just the driest desert in the world: a long and uncertain battle to conserve the storm petrels of the Atacama Desert

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ABSTRACT

The storm-petrels (Oceanitidae and Hydrobatidae) are a diverse and threatened group of marine birds. Three species of storm-petrels are breeding in the Atacama Desert: Elliot's Storm Petrel (*Oceanites gracilis*), Hornby's Storm Petrel (*Hydrobates hornbyi*), and Markham's Storm Petrel (*H. markhami*). After seven years of research and monitoring, here, we summarise the process of developing a conservation plan and discuss six research and management priorities needed for the conservation of the Atacama Desert storm-petrels.

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The storm-petrels are a diverse group of small pelagic birds with 27 described species in two main families, Oceanitidae and Hydrobatidae. This group is threatened at a global scale, with 13 species classified as Near Threatened or worse. The Chilean storm-petrels are not the exception. The Atacama Desert supports most of the world's known breeding populations of three poorly known storm-petrel species: Elliot's Storm Petrel (*Oceanites gracilis*; IUCN Data Deficient and Data Deficient in Chile), Hornby's Storm Petrel (*Hydrobates hornbyi*; IUCN Near Threatened and Vulnerable in Chile; Medrano *et al.* 2019), and Markham's Storm Petrel (*H. markhami*; IUCN Near Threatened and Endangered in Chile; Barros *et al.* 2019). To our knowledge, these storm-petrels are uniquely adapted among seabirds to breeding in an extreme desert environment. Storm-petrels usually reach sexual maturity in their 4th-5th year and show strong fidelity to their breeding sites, in which each pair lays a single egg per season (Brooke 2004). After fledging, the juveniles of these three species must often fly over large cities, mines, and highways with bright lights to reach the ocean. After 7 years of research and monitoring, here, we summarise the process of developing a conservation plan and discuss research and management actions needed for the conservation of the Atacama Desert storm-petrels.

The Atacama Desert, the most arid desert in the world, has been historically exploited by mining and electricity production. This particular ecosystem has

vast areas of salt flats, that date from the Late Miocene-Pliocene transition (8 million years ago), which provide unique breeding habitat for storm-petrels. The three species of storm-petrels do not build their nests, but instead use natural cavities found under the surface on the salt flats (Elliot's Storm Petrel also breeds between rocks on the small Chungungo Islet). An increasing number of salt and lithium mines and solar and wind powers farms in the salt flats are reducing available breeding sites. Once juveniles fledge from breeding areas (from 20 to 70 km inland), to reach the ocean they often fly over large cities (e.g. Arica, Iquique, and Antofagasta), roads, and illuminated industrial complexes, which results in high juvenile mortality. In an area comprising only 20% of the suitable storm-petrel nesting habitat within Chile, Silva *et al.* (2020) estimated annual mortality attributed to light pollution to be >17,500 Markham's Storm Petrels, >340 Hornby's Storm Petrels, and >20 Elliot's Storm Petrels. However, it is important to note that for the remaining 80% of ground area we still lack mortality data. Other important threats that have been identified include power lines, roads over breeding sites, waste disposal and military exercises.

Efforts to protect these Atacama Desert storm-petrels have been challenging, requiring a series of initiatives, which have been mostly supported by the American Bird Conservancy. First, we conducted an extensive search for new breeding sites, where we mapped colonies and estimated population sizes for Markham's

Storm Petrel (six breeding areas) (Barros *et al.* 2019; Medrano *et al.* 2019), Hornby's Storm Petrel (one breeding area) (Medrano *et al.* 2019) and Elliot's Storm Petrel (two breeding areas). Secondly, we identified threats to each species for both flight paths (light pollution from cities and industrial infrastructure and powerlines) and breeding sites (mining and energy infrastructure). Thirdly, we worked on classifying each species with a conservation category at the local level (i.e. Chile) and international level (i.e. IUCN) (all three species were previously classified by IUCN as Data Deficient, and in Chile, there were no national classifications). This work initiated the beginning of stronger conservation efforts and put the existence of breeding sites on the map for energy project planning. The next steps to conserve Atacama Desert storm-petrels requires a National Conservation Plan to be developed with the active participation of local non-governmental organisations, and local and national government agencies. For a national conservation plan to be successful, collaboration and commitment from industries will be essential. Finally, locating additional nesting colonies, identifying new threats, and quantifying the impacts of these threats are ongoing efforts needed to inform an effective national conservation plan.

We suggest six research and management priorities for the conservation of the Atacama Desert storm-petrels:

- (a) Formal protection of known breeding sites: two key areas for Markham's Storm Petrel are Chaca (700 ha) and Caleta Buena (51 ha), and one key area for Hornby's and Elliot's Storm Petrels is Pampa del Indio Muerto (6,000 ha).
- (b) Environmental planning: avoiding impacting breeding sites in i) the design of public roads and powerlines, ii) the location of energy and mining projects, iii) military exercises in army compounds (see Barros *et al.* 2019); and iv) household waste management.
- (c) Environmental impact assessments: strengthening monitoring requirements and breeding site detection during the environmental assessment of projects located in areas with known or potential breeding sites and flight paths.
- (d) Reduction of light pollution impacts, in at least four areas: i) improvement of national light pollution regulations, ii) work with local governments to reduce light pollution in public areas in key cities, iii) improvement of private lighting projects (we are currently working on guidelines for this), iv) reducing light pollution during critical periods when fledgling juveniles disperse to

the ocean, and v) rescue and release of grounded fledgelings in large cities (Arica, Iquique, and Antofagasta).

- (e) International collaborations: cooperation and governance between Peruvian and Chilean wildlife authorities to achieve joint protection of breeding sites in Peru and Chile.
- (f) Fill knowledge gaps to identify other unknown threats to storm-petrel flight paths or marine threats during their time at sea: i) identification of new breeding sites and flight paths, ii) breeding biology, iii) long-term monitoring of large colonies (Chaca, Caleta Buena, Salar Grande), iv) spatial ecology throughout their lifecycle.

Current environmental legislation in Chile is weak, favours industrial productivity and is insufficient to preserve the storm-petrels of the Atacama Desert. To achieve a robust national conservation plan in Chile, we urge industries and mine owners to consider the impacts of their projects on these storm-petrels. Moreover, we urge our national and local governments to protect the unique breeding areas in the Atacama Desert that are essential for the persistence of storm-petrels. Failure to act on these protective measures seems likely to lead to local extinction of populations of Markham's Storm Petrel in Arica or Iquique area, or Hornby's and Elliot's Storm Petrels in Pampa del Indio Muerto. The national conservation plan will be an important advancement in the conservation of Atacama Desert storm petrels, but its successful implementation will require the participation of numerous stakeholders.

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Disclosure statement

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