

Destruction of breeding habitat by guano harvesting, exploitation for food, overfishing and introduced predators have all contributed to the steep decline of this once abundant seabird of the coasts and offshore islands of Peru and Chile.

DISTRIBUTION The Peruvian Diving-petrel is endemic to the Humboldt Current occurring along the west coast of South America from Isla Lobos de Tierra (06°27'S) in Peru to as far south as Isla Chilóe (42°30'S) in Chile (Mayr and Cottrell 1979, Hays 1989).

Peru Insular colonies (from north to south) were previously known from Lobos de Tierra, Lobos de Afuera, Macabi, Guanape, Mazorca, Pescadores, Chincha Norte, Ballestas, San Gallán and La Vieja (see map in Hays 1989); this author appears to omit two islands where the species was believed to nest according to Murphy (1936), namely Isla San Lorenzo (12°05'S 77°15'W, in Stephens and Traylor 1983) and Isla Frontón (12°07'S 77°11'W, in Stephens and Traylor 1983) (see Remarks 1). According to Hays (1989), the bulk of the surviving colonies today may be restricted to San Gallán and La Vieja (see Population). Other localities where specimens have been either collected or observed and are not mentioned above are: Pacasmayo, November 1964 (specimen in USNM); Salaverry, undated (Murphy 1936); Ancón, a large series taken in April and May 1913 (specimens in AMNH and ANSP; see Remarks 2); Callao and Callao Bay, several dates (specimens in AMNH, ANSP and BMNH; also Godman 1907-1910); near Pucusana (12°29'S 76°48'W, in Stephens and Traylor 1983) in July 1987 (B. Haase verbally 1987); Chilca, and Pisco Bay, undated (Murphy 1936); Independencia Bay, July 1907 and January 1935 (specimens in LACM and USNM); c.65 km north of Mollendo and c.8 km offshore, September 1924 (specimen in USNM); near Islay, during austral summer, 1914-1918 (Pässler 1922).

Chile Most of the records refer to birds collected along the coast, the only recorded nesting places being Pan de Azúcar, Pájaros, Chañaral, Choros, and Mocha islands (see below), although the species was believed to nest on Isla Santa María in the Arauco Bay (Pässler 1922; also Murphy 1936). Localities where the species has been observed and/or collected are: Arica, undated (specimens in MNHNS), 1913 (Murphy 1936) and February 1990 (P. Roberts *in litt.* 1990); off Pisagua, where two birds were observed in June 1984 (B. Araya Mödinger *in litt.* 1991); Iquique, undated (Darwin 1841), August 1893 (Schalow 1898), 1913 (Murphy 1936) and July 1931 (Philippi 1941); off Iquique, where 16 birds were observed in May 1981 (after 175 minutes sailing northwards), and one bird in June 1984 (after 186 minutes sailing northwards) (B. Araya Mödinger *in litt.* 1991); off Antofagasta, where a bird was observed in June 1984 (after 63 minutes sailing northwards) (B. Araya Mödinger *in litt.* 1991); Taltal, 1913 (Murphy 1936), 1914-1918 (Pässler 1922); off Taltal, where a bird was observed in June 1984 (after 40 minutes sailing southwards) (B. Araya Mödinger *in litt.* 1991); close inshore at Pan de Azúcar National Park, where c.15 birds were observed close inshore on 27 January 1991 (M. Pearman *in litt.* 1991); Isla Pan de Azúcar (26°09'S 70°42'W, in Paynter 1988), currently breeding (Vilina *in press*); Caldera, March 1956 (specimen in MNHNS); near Isla Grande (27°14'S 71°00'W), where five birds were counted in September 1982 and 20 in June 1984 (after 92 and 128 minutes sailing from mainland to the island) (data and coordinates from B. Araya Mödinger *in litt.* 1991); Isla Chañaral, where two eggs (one fresh, one hard-set) were collected in December 1938 and December 1943 (see Remarks 3), and birds were observed near the island during periodic censuses conducted in 1989 and 1990 (Vilina *in press*; see Population); Isla Choros, where 51 nests (at least one containing an egg) were found in October 1982 and 18 birds were counted (after 25 minutes sailing from mainland to the island) in November 1984 (B. Araya Mödinger *in litt.* 1991), and 31 and 160 birds were counted respectively between the island and mainland in April and December 1991 (Y. A. Vilina *in litt.* 1991); Isla de los Pájaros, where four eggs were collected in October 1893 (Schalow 1898; see Remarks 4), and three and five birds were counted in November 1984 and June 1988 respectively (after 92 minutes sailing from mainland to the island on the former date and 12 minutes on the latter) (B. Araya Mödinger *in litt.* 1991); Coquimbo, where birds were observed and two collected in November 1881 (Salvin 1883, Godman 1907-1910); Zapallar, undated, where considerable groups have been reported (Goodall *et al.* 1951); Quintero, April 1940 (specimen in YPM); Valparaiso, 1893 (Schalow 1898), February 1903 (specimens in BMNH), July 1924 (specimen in USNM); Coronel, where a bird was collected on 26 March 1918 (Pässler 1922; also Stresemann 1922); Talcahuano, undated (specimen in MNHNS); San Vicente de Talcahuano (= Bahía de San Vicente, at 36°44'S 73°09'W), where considerable

groups have been reported (Goodall *et al.* 1951); Isla Santa María, where the species was believed to nest, as many birds were observed in summer in the vicinity of the island (Pässler 1922; also Stresemann 1922); Lebu, where considerable groups have been reported (Goodall *et al.* 1951); Isla Mocha, which according to Mayr and Cottrell (1979) would be the southernmost breeding station; Corral (Valdivia harbour), the southernmost known locality for the species as stated by Hays (1989) (see Remarks 5).

POPULATION The evidence is that the Peruvian Diving-petrel has suffered a massive decline throughout its range.

Peru Formerly quite numerous, the species is now in serious decline (Hays 1989; also Lesson 1828, Godman 1907-1910, Murphy and Harper 1921, Murphy 1936). Most of the surviving populations in Peru are now restricted to Isla San Gallán and Isla La Vieja, and although formerly they nested abundantly on Lobos de Tierra, Macabi, Gaunape, Pescadores and Ballestas they have drastically decreased and apparently now no longer breed there (Hays 1989; also Murphy 1936; see Remarks 6). On Isla San Gallán, recent studies found about 100 colonies with c.1,200 nests, of which 30% were active, and the number of nests per colony was generally less than 10 (Jahncke Aparicio and Riveros-Salcedo 1991). Hays (1989) estimated that the species's Peruvian population could consist of c.4,000 individuals, but more recently it was estimated at only 1,500 individuals (Vilina *in press*), the previous number of 10,000 given by Duffy *et al.* (1984) being considered an overestimate. Records of sightings at sea have also decreased, e.g. large concentrations were sighted in Independencia Bay during the 1960s, but on a recent trip (in November 1985) in the same area only two individuals were seen (Hays 1989), although the species still appears to be common at Paracas (Gardner 1986, P. K. Donahue *in litt.* 1987) and it was "abundant" near Pucusana in July 1987 (B. Haase verbally 1987).

Chile The same pattern of decline may have occurred although not as well documented as in Peru (Murphy 1936; also Goodall *et al.* 1951). The species was reported to be common early this century near Valparaíso (Nicoll 1904), and in July 1938 a large flock was noted at the entrance to Iquique harbour (Philippi 1941). Goodall *et al.* (1951) observed "considerable flocks" at various localities between 37° and 38°S (see Distribution). It nested in great numbers on Isla Chañaral, and one observer in 1938 reported that the island was a "swarming mass" of the birds, and the number of burrows that he found suggested that the colony "must have been enormous"; six years later (1944), after the introduction of a pair of foxes (in 1941), the same observer found "well over" 200,000 skeletons (Araya and Duffy 1987). Jehl (1973) reported scattered Peruvian Diving-petrels along the Chilean coast, but in the Golfo de Arauco and Isla Chañaral it was abundant with hundreds seen in June-July 1970; however, it is now very scarce at Isla Chañaral, no burrows were found in 1982 and no skeletons were seen during a visit to the island in November 1985 (Araya and Duffy 1987); subsequent visits between September 1989 and October 1990 failed to detect breeding signs on the island (see Remarks 7), and a maximum of 100 birds were counted near the island during periodic censuses conducted in 1989 and 1990 (dates and numbers of birds recorded are given by Vilina *in press*). The species is still being seen in Chilean waters (P. Roberts *in litt.* 1990, B. Araya Mödinger *in litt.* 1991, M. Pearman *in litt.* 1991), although relatively small numbers were counted during censuses conducted offshore in different areas (see Distribution) during the 1980s (B. Araya Mödinger *in litt.* 1991). The only known breeding populations are currently found on Isla Pan de Azúcar and Isla Choros; in October 1982 B. Araya Mödinger (*in litt.* 1991) found 51 nests on the latter, with at least one nest with an egg, and recently 300 active nests have been reported (Vilina and Capella 1991), while on Isla Pan de Azúcar B. Araya Mödinger (*in litt.* 1991) found 80 to 100 burrows on the north-east side of the hill in October 1990, and Vilina and Capella (1991) have recently found 220 active nests. The nesting pairs involved show a very small population when compared to previous numbers of breeding pairs reported for Isla Chañaral (see above).

ECOLOGY The Peruvian Diving-petrel occurs on the sea coasts of Peru and Chile, where it is mainly encountered in offshore waters near its breeding grounds and is closely associated with the relatively close inshore upwelling waters of the Humboldt Current (Murphy 1936, Hays 1989). It is only known to nest on offshore islands, although in Peru it has been reported nesting on the mainland (Duffy *et al.* 1984, Hays 1989; see Remarks 8).

Feeding is very much dependent on the rich stocks of the Humboldt Current; anchovies *Engraulis* and silversides *Odontesthes* constitute the main staple of the birds, which also congregate in areas of water discoloured by clouds of *Munida* and other crustaceans on which they may feed directly, e.g. the majority of twelve stomachs examined containing only traces of gravel and varying amounts of small crustaceans, identified merely as the megalops stage of a crab, of which more than 120 were in one stomach (Murphy 1936, Duffy *et al.* 1984, Hays 1989). Prey is captured during short, shallow dives from the surface using wing-propulsion (Murphy 1936). The diving-petrels moult their wing feathers simultaneously and thus lose the ability to fly, so for a time each year become exclusively aquatic; apparently this does not affect their ability to forage, since flightless petrels proved to be as full of crustaceans or small fish as flighted individuals (Murphy 1936). The birds often concentrate with other oceanic birds near shoals of fish, but are generally encountered in small groups flying just above the water and diving from time to time (Murphy 1936; also Lesson 1828). Their movements are mainly sporadic, although Murphy (1936) noticed that during the southern summer birds are commoner in the Peruvian and Chilean bays than in winter, when many of them were recorded as far as 20 km offshore.

The species nests on islands with a thick guano layer in which it excavates deep burrows, but it also digs in sandy soils or uses natural crevices in the salty substrate, or beneath rocks especially when guano extraction has been too intense (Coker 1920, Murphy 1936, Hays 1989). Jahncke Aparicio and Riveros-Salcedo (1991) found that on Isla San Gallán c.60% of current nests are placed in crevices. Nests are preferably situated windward (i.e. southerly), as this provides lift from their burrows, and gentle slopes (less than 30%) are preferred (Murphy 1936, Jahncke Aparicio and Riveros-Salcedo 1991). Recent studies on Isla San Gallán showed that colony size can vary from isolated nests to more than 30, but nowadays most colonies found (80%) comprised less than 10 nests (Jahncke Aparicio and Riveros-Salcedo 1991; also Murphy 1936). Breeding has been reported as occurring from January to March and from September to December (Hays 1989) but evidence from museum specimens and from the literature shows that breeding is also known from May to July, and even within the same colony breeding is frequently asynchronous (Coker 1920, Murphy and Harper 1921, Murphy 1936); whether there is year-round breeding or perhaps two peaks per year is not clear from present levels of information. The clutch-size is always one (Jahncke and Riveros 1989).

THREATS Guano extraction, direct exploitation and commercial fisheries can be mentioned as three of the major threats affecting the Peruvian Diving-petrel (Duffy *et al.* 1984, Hays 1989, Jahncke and Riveros 1989). Guano extraction has been one of the main reasons for its disappearance from some of the Chilean and Peruvian islands (Schlatter 1984; see Distribution), mainly through the removal of ancient layers which appear to be essential for nesting purposes (see Ecology); however, in the course of such activities, the capture of adults for sale as food by both harvesters as well as fishermen was once on a large scale and remains a serious problem (Coker 1920, Murphy 1936, Hays 1989, Vilina and Capella 1991). Commercial fisheries for many decades overexploited the rich anchovy shoals of the Peruvian and Chilean coasts, resulting in the collapse of the fish stocks in the early 1970s (e.g. Idyll 1973). Incidental catch in fishing nets is a further problem derived from fishing activities (Duffy *et al.* 1984, Hays 1989). Anchovies have never recovered from the 1972 collapse, yet overfishing of the surviving stocks has continued (Duffy *et al.* 1984). In El Niño years the anchovies become unavailable, causing massive mortality of seabirds (Barber and Chávez 1983), but although the seabirds endemic to the Humboldt Current have evolved to adapt to such unpredictable changes, various additional influences of man (Hays 1984) mean that the impact of El Niño events is greatly magnified. During the 1982-1983 El Niño, diving-petrels were found dead in considerable numbers on beaches throughout their range in Peru (Hays 1989).

Exploitation for food still occurs on the two last major breeding islands (San Gallán and La Vieja), where local fishermen use lanterns to attract the birds at night and during the guano harvest dig them out from their burrows (Hays 1989). Similar problems appear to occur as well at the Chilean seabird colonies (e.g. Isla Choros) (Vilina and Capella 1991; also Schlatter 1984), although nothing is known about the numbers affected by this practice. The impact of natural predators such as Peregrines *Falco peregrinus*, Kelp Gulls *Larus dominicanus* and Turkey Vultures *Cathartes aura* may now be substantially greater, given the species's overall population trend (Hays 1989). Introduced animals such as dogs on San Gallán (Murphy 1936) and rats on certain islands in Chile (Schlatter 1984) are further sources of concern. Introduced foxes have been blamed for the massive depletion of the once huge colonies at Isla Chañaral (Araya Mödinger and Duffy 1987). Despite certain initiatives in Peru (see Measures Taken), enforcement

has generally not been strict enough: fishing boats operate close to the islands, making them accessible for egg and trafficking in birds; airplanes, especially military craft, fly over them; and what is left of the fishing industry still sets its nets where birds are feeding (Duffy *et al.* 1984). Jahncke Aparicio and Riveros-Salcedo (1991) remarked that increasing tourism on Isla San Gallán threatens the species's preferred nesting habitat. In Chile, the formal protection of Isla Choros (see Measures Taken) has not proved effective (Y. A. Vilina *in litt.* 1991).

MEASURES TAKEN Measures taken so far have clearly been insufficient in maintaining a stable overall population.

Peru The government recognizes that this species is in danger of extinction (Pulido 1991). The two major Peruvian breeding sites, San Gallán and La Vieja islands, are both within the boundaries of the Paracas National Reserve, but the activities of fishermen on San Gallán are currently not controlled (Hays 1989).

Since 1909, the islands from which the Peruvian Diving-petrel has been recorded have been protected by the state-owned guano company, which has been responsible for the conservation of seabirds in Peru, with guards provided, headlands fenced off with predator-proof walls, and avian predators such as rats removed from the islands; laws prohibit all boats from approaching within two miles of the guano islands, fishing boats from operating within three to five miles, purse-seining at shoals of fish where birds were already present, and overflights of colonies by aircraft lower than 500 m (Duffy *et al.* 1984). In 1978 the company improved its administration of the guano islands, and radios were provided, cats and domestic fowl prohibited and dogs reduced; the few guards suspected of dealing in eggs and nestlings were moved (Duffy *et al.* 1984).

Chile The Peruvian Diving-Petrel is not included in any conservation plan (Vilina *in press*), but the two extant reproductive colonies are within protected areas (i.e. Pan de Azúcar National Park, which protects the Isla Pan de Azúcar, and Pingüino de Humboldt National Reserve, which includes the Isla Choros – but for the latter see Threats) (Y. A. Vilina *in litt.* 1991).

MEASURES PROPOSED The following proposals are mostly a slightly modified repetition of those in Duffy *et al.* (1984) and Hays (1989): (1) a life history study of the Peruvian Diving-petrel should urgently be carried out, with particular emphasis on determining the timing and frequency of breeding; (2) it is crucial to investigate and monitor the species throughout its range; (3) any remaining island or coastal breeding colonies should be located in both countries (see Remarks 8) and afforded effective protection, while those already under protection (e.g. San Gallán in Peru and Choros in Chile) should have their existing regulations enforced and, as noted by Jahncke Aparicio and Riveros-Salcedo (1991), tourism should be carefully controlled; (4) during the guano harvest at any of the islands where the species nests, labourers should be prevented from killing petrels, something that in Peru could be enforced by PESCA-PERU, the entity responsible for the protection and exploitation of the guano islands (when the timing of breeding is accurately determined, recommendations should be made to PESCA-PERU and the corresponding body in Chile to conduct the guano harvest outside the species's breeding season); (5) the guano harvest in those areas where the species has breeding colonies must be stopped, but in the absence of this a study to find the least harmful harvesting procedure would be valuable (see also Coker 1908); (6) better-trained guards are needed on the islands and training courses at regular intervals would improve their efficiency; (7) prevention of overfishing is urgent, existing laws in both countries should be effectively enforced, and catch levels should be sufficiently low for fish stocks to survive a year of recruitment failure; (8) a commission should investigate how the guano islands could be made greater tourist attractions without damaging them; (9) introduced predators such as foxes, dogs, rats, etc., should be eliminated from the islands.

REMARKS (1) Murphy (1936) gave these two islands together with San Gallán and La Vieja as possibly the only ones with Peruvian Diving-petrel colonies as they have considerable sand and soil deposits in contrast to those from which large amounts of guano have been removed, and which have thus been rendered unsuitable for breeding purposes (see also Population). (2) Forty-three specimens collected by R. H. Beck are labelled simply as Ancón, Peru, but as some of these birds were nesting (see Ecology) it is most likely that the collecting locality was in the Islas Pescadores which are just offshore of Ancón. (3) The identity of the species for these records is not in question as birds were seen at the colony for the 1938 record and a brooding bird was photographed in the nest for the 1943 record (information on labels in WFVZ). (4) This is the only known nesting evidence for the species on Isla de los Pájaros. (5) Records from Calbuco and Ancud (i.e. adjacent to northern Isla Chiloé) (Schalow 1898) appear to have been accepted by Mayr and Cottrell (1979), who include Isla Chiloé as the southernmost locality for the species, despite the fact that both Pässler (1922) and Hellmayr and Conover (1948) attributed these observations to the similar Magellanic Diving-petrel *Pelecanoides magellanicus*, which is known to occur in that area (Hellmayr and Conover 1948, Mayr and Cottrell 1979). (6) The species's nocturnal habits and extended breeding season (see Ecology) make it very difficult not only to make accurate censuses but also simply to ascertain whether colonies on certain islands have been abandoned or not. (7) The results obtained in this survey do not mean that the species does not breed on the island, since the inaccessibility of some sectors did not allow proper investigation; nevertheless, any nests would be few and scattered (Vilina in press). (8) The most likely mainland areas in Peru are in Paracas National Reserve (Hays 1989).