Status and conservation of shearwaters of the North Pacific

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Abstract

Of the shearwaters that breed in the North Pacific, the species in the most peril at present is Townsend's Shearwater *Puffinus auricularis*. Feral cats and pigs pose a threat on its breeding grounds. More information is needed on its current status, and that of the Black-vented Shearwater *P. opisthomelas*, most of whose nesting colonies have well-established feral cat populations. Efforts are being made to protect Newell's Shearwater *P. newelli* in the Hawaiian Islands. The single greatest threat to migrant shearwaters in the North Pacific is drift gillnet fisheries, which kill hundreds of thousands of birds annually.

Résumé

De tous les puffins qui se reproduisent dans le Pacifique Nord, le Puffin de Townsend *Puffinus auricularis* est l'espèce la plus menacée. Les chats et les porcs retournés à l'état sauvage détruisent ses lieux de nidification. Il faut recueillir davantage d'information sur sa situation actuelle et sur celle du Puffin cul-noir *P. opisthomelas*, dont la plupart des colonies comptent également des populations bien établies de chats féraux. On s'efforce actuellement de protéger le Puffin de Newell *P. newelli* dans les îles Hawaï. La pêche au filet maillant dérivant provoque la mort de centaines de milliers d'oiseaux chaque année et constitue la plus grande menace pour les puffins migrateurs qui séjournent dans les eaux du Pacifique Nord.

1. Introduction

Eleven species of shearwaters (*Calonectris leucomelas* and 10 *Puffinus* species) regularly occur in the North Pacific Ocean, north of the equator. Of these, six species breed on islands north of the equator, and the other five are trans-equatorial migrants that breed in the southern hemisphere during the austral summer. Audubon's Shearwater *P. lherminieri*, a tropical species with a small fringe population breeding on the Bonin Islands, Japan (slightly north of the Tropic of Cancer), will not be considered here.

Despite their relative abundance, little is known about the biology of shearwaters in the North Pacific. Most of the published information on life histories is anecdotal and often many decades old. Remote, rugged, and inaccessible islands are the preferred breeding locales for many species. Consequently, population estimates, where available, are frequently based only on educated guesses. Within the last 20 years, however, the level of effort expended on pelagic studies of many seabirds, including shearwaters, has increased dramatically, yielding many new facts on behaviour, habitat selection, migratory routes and timing, feeding habits, and mortality.

In this paper we discuss the general biology and status of each of the shearwater species occurring in the North Pacific, consider threats and hazards both on land and at sea, and offer recommendations for future study and conservation efforts.

2. Species accounts

2.1. *Calonectris leucomelas* Streaked Shearwater

This species breeds in the far-western Pacific at many locations from the Ryukyu and Bonin islands north to Qingdao Island in the Yellow Sea, islands off northern Honshu, Japan (Melville 1984; Hasegawa 1984), and has nested on Karamuzin Island in the former U.S.S.R. (Litvinenko 1976). Details on its breeding biology at Soviet and Japanese colonies are provided by Yoshida (1962, 1981), Okamoto (1972), Litvinenko (1976), and Tan (1977). The breeding season extends from February to November, and most eggs are laid in May and June. The birds nest in large, dense colonies in forested areas. After breeding, the birds disperse south to the East and South China seas, the Philippine Sea, and as far south as Borneo and New Guinea (Shuntov 1972). A few are regularly seen in winter off the north and east coasts of Australia (Blakers et al. 1984; Marchant and Higgens 1990).

Streaked Shearwaters are abundant within their range. The total population is perhaps 4–5 million individuals. Although there is no apparent cause for concern for the overall well-being of the species, "large numbers" of birds have been incidentally caught in fishing nets off Taiwan (Blackshaw 1978) and near Hong Kong (Melville 1984). Eggs and chicks have been sold in markets in Taipei (Blackshaw 1978) and Hong Kong (D.S. Melville, pers. commun.). We found no information on mortality in Japanese nearshore gillnet fisheries, but some incidental take is likely. Mass accidental deaths have taken place in anchovy crawls off Honshu, Japan (Nakamura 1974). Increased habitation of remote breeding islands by transient fishermen (Okamoto 1982) present potential threats warranting increased vigilance.

2.2. *Puffinus creatopus* Pink-footed Shearwater

This trans-equatorial migratory species breeds on Masatierra and Santa Clara islands in the Juan Fernandez group, Isla Mocha, and possibly a few other islands off southern Chile (Johnson 1965). What little is known about its breeding biology comes primarily from the notes of R.H. Beck (Bent 1922;

Murphy 1936) and D.S. Bullock (Murphy 1936; Johnson 1965). Birds return to the colonies in November and December, with egg-laying commencing in December and January. Fledging and departure from the islands apparently begin in March and April.

Birds disperse as far north as the Gulf of Alaska and southern Bering Sea (American Ornithologists' Union 1983). However, Vermeer et al. (1987) suggest that the west coast of British Columbia represents the northern limit of where they regularly occur. The species is essentially restricted to the eastern Pacific (Harrison 1983; Pitman 1986). Peak numbers occur in the North Pacific from July to October.

There are no population estimates, but the species is said to occur in "large numbers" on the breeding grounds (Schlatter 1984), and is certainly fairly common in migration. On the Juan Fernandez Islands the species is reportedly declining due to the destructive activities of coatimundis *Nasua narica*, feral cats, rabbits, and goats. No significant fishery-related mortality has been reported for Pink-footed Shearwaters.

2.3. *Puffinus carneipes* Flesh-footed Shearwater

Breeding colonies are found on islands off the south coast of western Australia, on Lord Howe Island (van Tets and Fullagar 1984), and on islands off the coast of New Zealand's North Island (Robertson and Bell 1984). In addition, 20–30 pairs breed on Saint Paul Island in the south-central Indian Ocean (Segonzac 1970).

Information on the biology of the species is provided by Warham (1958) and Serventy et al. (1971). Birds return to the colonies in late September, eggs are laid in November and December, and fledging occurs in April and May. This species is also a trans-equatorial migrant, with most of the population believed to winter in the western Pacific Ocean or Indian Ocean. The migratory route is poorly known, but some birds move along the west coast of the Americas (Murphy 1936; American Ornithologists' Union 1983; Pitman 1986). The size of the western Australia population is unknown but is estimated to be greater than 650 000 birds occupying at least 33 islands (Blakers et al. 1984). Another 20 000–40 000 pairs breed on Lord Howe Island (Fullagar and Disney 1981). The New Zealand colonies contain 50 000–100 000 pairs (Robertson and Bell 1984).

There is some concern over the destruction of lowland forests on Lord Howe Island, and the resultant reduction of breeding habitat (Robertson and Bell 1984). Introduced predators are also a problem on some islands, but some remedial efforts are under way (van Tets and Fullagar 1984). This species is a deep diver (Murphy 1936; Serventy et al. 1971) and as such is more vulnerable to fishing operations (Robertson and Bell 1984). In addition, some birds may still be taken from burrows for food. At present, none of these factors seems to present a serious or substantial threat to the species.

2.4. *Puffinus pacificus* Wedge-tailed Shearwater

This species is by far the most abundant and widespread breeding shearwater in the tropical Pacific and Indian oceans (Marchant and Higgens 1990; Warham 1990). Specific colony locations include Isla San Benedicto in Los Islas Revillagigedo, Mexico (at most a few thousand pairs; Pitman, unpubl. data), the Hawaiian Islands (ca. 575 000 pairs; Fefer et al. 1984; Harrison et al. 1984), Johnston Atoll (3000 birds; Amerson and Shelton 1976), Christmas Island (6000 birds; King 1974), Phoenix Islands (10 000 birds; King 1974), Taongi, Marshall Islands (12 000+ birds; King 1974), the Bonin Islands, Iwo and Marcus islands, Japan (breeds in "large numbers"; Hasegawa 1984). In Australia it breeds at numerous sites along both the west and east coasts, especially in the areas of Queensland and New South Wales (see van Tets and Fullagar 1984), with major colonies at North West Island (724 560 birds; Domm and Messersmith 1990), Heron Island (16 000 birds; Ogden 1979), Masthead Island (10 000+ birds; Jahnke 1977), Norfolk Island ("several hundred thousand birds"; Tarburton 1981), and Lord Howe Island (60 000; Fullagar et al. 1974). Other known breeding locations without estimates of numbers include Pitcairn, Gambier, Marquesas, Australs, Tonga and Niue, Fiji, and New Caledonia (see Garnett 1984). Wedge-tailed Shearwaters are also present on Jarvis and Howland islands in small numbers (Kirkpatrick and Rauzon 1986).

Breeding occurs mainly on low islands, where the species is primarily a burrow nester. Northern subtropical populations breed from April to November and southern subtropical populations breed from October to May (King 1974). Little is known about migratory movements. Rogers (1975) showed that birds departed waters off southeast Australia during the austral winter and returned in the spring to breed. Many banded birds from this population have been recovered in the Philippines, indicating that some individuals migrate to other areas. Pitman (1986) recorded large numbers of white morph Wedge-tailed Shearwaters in the far-eastern Pacific that presumably originated from central Pacific colonies. The only colony in the eastern Pacific (San Benedicto Island, see above) is small and comprises predominantly dark morphs (Jehl and Parkes 1982).

Wedge-tailed Shearwaters occupy relatively productive tropical waters, where they are often dominant in mixed-species flocks associated with foraging tunas and dolphins (Murphy and Ikehara 1955; King 1970; Au and Pitman 1986).

Although Wedge-tailed Shearwaters continue to be widespread and abundant in the tropics, it is likely that gillnet fisheries will result in some mortality. There have been some localized threats to individual breeding colonies where habitats have been altered or predators introduced (e.g., Johnston Atoll, Amerson and Shelton 1976; Jarvis Island, Rauzon 1985; Howland Island, Kirkpatrick and Rauzon 1986; Midway Island, Woodby 1988; Mariana Islands, Reichel 1991). Studies at Heron Island, Australia (Hill and Rosier 1989), suggest that well-managed development can, in some cases, be compatible with breeding colonies. However, it seems unlikely that rats can be kept off human-occupied islands indefinitely.

2.5. *Puffinus bulleri* Buller's (New Zealand) Shearwater

This subtropical, trans-equatorial migratory species is known to breed only on the Poor Knights Islands, off North Island, New Zealand. The total population is estimated at 2.5 million birds (Harper 1983). According to Harper (1983), birds arrive at the nesting islands in mid-September, refurbish burrows, and then leave for a 30-day pre-laying "honeymoon" at the end of October. They return to lay eggs at the end of November. The egg is incubated for approximately 51 days. Hatching occurs in mid-January and most fledglings leave the islands in early May. The majority of nests are in excavated burrows or in caverns under rocks.

By June, most of the birds have left New Zealand waters and travelled north to summer in the North Pacific (Jenkins 1988). Northward migration appears to be mainly through the western Pacific, as only small numbers have been observed migrating through the tropics in the central Pacific (Gould 1971; Cheshire 1974; Jenkins 1986). Only stragglers occur in

the eastern Pacific (Pitman 1986). Migrants travel quickly through the tropics, but will temporarily join feeding flocks they encounter along the way (Gould 1971; Pitman, unpubl. data).

Significant numbers of Buller's Shearwaters arrive in the North Pacific in June. During July and August they move increasingly northwards and eastwards as far as the Gulf of Alaska (Wahl 1985). By September most of the breeding birds have once again departed for New Zealand. A large build-up off the North American west coast during September and October probably comprises mainly lingering prebreeders taking advantage of abundant food resources (Wahl 1985; Briggs et al. 1987). By November most of these have moved south also, and only occasional stragglers are reported in the North Pacific during the winter.

Buller's Shearwaters have increased dramatically since the turn of the century after introduced pigs were eliminated from one of the major nesting colonies. Harper (1983) stated that the population at Aorangi Island increased from 100 pairs in 1938 to about 200 000 pairs in 1981. This increase is apparently responsible for a widening distribution reported in recent years in New Zealand waters (Jenkins 1988) and the North Pacific (Guzman and Myres 1983; Wahl 1985). Being less inclined to dive makes this species less vulnerable to gillnet entanglement than other species of shearwaters.

2.6. *Puffinus griseus* Sooty Shearwater

This species breeds in large numbers on both sides of the South Pacific, with large colonies on islands around New Zealand and off southern Chile. South American colonies in the Pacific include Chiloe Island (Marin 1984), Guafo Island (min. 200 000 birds; Clark et al. 1984a), Guamblin Island (Clark et al. 1984b), and islands around Cape Horn (Murphy 1936; Johnson 1965). New Zealand hosts numerous large colonies (Robertson and Bell 1984), including the immense Snares Islands population (2 750 000 pairs; Warham and Wilson 1982). Nesting also occurs on Macquarie Island (1770 pairs; Brothers 1984). Relatively small numbers breed off Australia (Lane and White 1983), the largest colony being 1000 pairs on Tasman Island, Tasmania (Brothers 1979).

The following phenology is from Warham et al. (1982) and pertains to breeding in New Zealand, but, as pointed out by the authors, appears to apply with slight differences to all the known populations. Birds arrive at the colony in early September and eggs are laid in mid-November. After an incubation period of 53 days, chicks hatch in mid-January. Adults raise the chicks until the third week of April and then depart. Most of the chicks depart between the last week of April and the first week in May.

At the end of the breeding season birds migrate to northern oceans for the boreal summer. The majority of birds that migrate to the North Pacific seem to make a clockwise circumnavigation, moving north past Japan in the spring, crossing south of the Aleutian Islands in summer, and then proceeding south along the west coast of the Americas during the fall (Murphy 1936). However, much still remains to be learned about this species' movement patterns (Briggs and Chu 1986). For example, flocks containing as many as 90 000 birds have been observed along the west coast of British Columbia in early May (Vermeer and Rankin 1984a).

There seems to be no immediate serious threat to birds at breeding colonies in New Zealand. Efforts are being made to eliminate introduced predators from many of the important seabird islands (Robertson and Bell 1984; Veitch 1985). Considerably less is known, however, about the status, or even distribution, of colonies off southern Chile.

The major hazard for birds at sea in the North Pacific at this writing is probably incidental take by gillnet fishing. Relatively few Sooty Shearwaters were killed by drift gill nets in the high-seas Japanese salmon mothership fishery during 1981–1984, presumably because the fishery operated north of the main migratory route for this species (Jones and DeGange 1988). DeGange et al. (1985) estimated that Sooty Shearwaters constituted only 0.3% of the total incidental bird kill in that fishery between 1981 and 1984. However, the preliminary information on the North Pacific drift gillnet fishery for squid, which operates at a lower latitude, suggests Sooty Shearwaters may currently sustain losses of up to 400 000 individuals annually (Gjernes et al. 1990). There is also very little specific information available on incidental shearwater mortality in gillnet fisheries off California (Hernick and Hanan 1988), where the species numbers in the millions at times and is often the most abundant seabird species present during the summer months (Briggs et al. 1987). A cooperative observer program operated by the National Marine Fisheries Service and California Department of Fish and Game began in spring 1990, and observers placed on gillnet boats have been collecting data on seabird mortality during fishing operations.

2.7. *Puffinus tenuirostris* Short-tailed Shearwater

The Short-tailed Shearwater breeds only in Tasmania and on islands off southeast Australia. Skira et al. (1985, and references therein) estimated 11.4 million burrows from 167 colonies in Tasmania, 1.45 million burrows in Victoria, 1.5 ± 0.5 million burrows in South Australia, 25 700 breeding pairs in New South Wales, and 250 burrows in Western Australia. The total world population is roughly 23 million birds.

According to Serventy (1967), birds first arrive on the breeding islands the last week in September and for the next four weeks they prepare their burrows. After a two week pre-laying exodus, most egg-laying occurs in the last week of November. Males and females share incubation duties in shifts of 10–16 days. The single egg hatches in about 53 days and the chicks depart from mid-April to the first week in May, after spending about 94 days in the burrow (Skira et al. 1985).

The trans-equatorial migration of this species apparently takes it north through the far-western Pacific past Japan to its main wintering (austral) grounds off the Aleutian Islands and in the Bering Sea. The return migration, in August and September, is thought to take place primarily through the central Pacific (Lindsey 1986; Pitman 1986; Warham 1990).

Populations at managed breeding colonies appear stable despite the annual combined commercial and noncommercial harvest of an estimated 700 000 chicks (Skira et al. 1985, Skira 1987). Substantial numbers of Short-tailed Shearwaters perish each year in high-seas drift gillnet fisheries in the North Pacific Ocean (King 1984; DeGange et al. 1985; Atkins and Heneman 1987; Jones and DeGange 1988; Gjernes et al. 1990). The incidental kill is in the hundreds of thousands of birds annually, and undoubtedly millions have perished since the fisheries began. Although the species is apparently still abundant, the combined effects of incidental kill, harvesting, and natural mortality could eventually decimate and jeopardize the species.

2.8. *Puffinus nativitatis* Christmas (Island) Shearwater

Confined to the Pacific Ocean, this little-known species breeds at Easter Island (Johnson et al. 1970), Oeno, Ducie, and

likely Henderson islands, the Pitcairn group (Williams 1960; Schubel and Steadman 1989), Gambier (Thibault 1973), the Tuamotus and Austral group (Holyoak 1973), Taongi Atoll in the Marshall Islands (Amerson 1969), the Marquesas (King 1967), Johnston Atoll, and the Hawaiian Islands (Harrison et al. 1984); it apparently formerly bred on Wake, Marcus, and the Bonin islands (King 1967).

Information on population sizes is scant. Ashmole and Ashmole (1967) reported the Christmas Island population to be 7000 birds, making it the largest known colony. Harrison and Jehl (1988) estimated 2500 pairs nesting at Sala y Gomez, Chile. Fefer et al. (1984) reported a total of 2960 pairs nesting in the northwest Hawaiian Islands, and Amerson and Shelton (1976) estimated 30 individuals on Johnston Atoll. The Easter Island population consisted of 80–100 pairs in 1968 (Johnson et al. 1970). Comprehensive accurate data are lacking, but a world population on the order of a few tens of thousands seems likely.

Breeding is year-round on equatorial Christmas Island (Schreiber and Ashmole 1970), but seasonal in the more subtropical Hawaiian Islands, where adults return to colonies in March and fledge most of their young by late September (Richardson 1957; Fefer et al. 1984). Nesting usually occurs in fairly open areas, in rock crevices or under vegetation (Shallenberger 1984). Unlike most other species of *Puffinus*, Christmas Shearwaters do not nest in burrows.

Open ocean waters are preferred by this species, and it is uncommon but regular throughout the eastern and central tropical Pacific (King 1967; Pitman 1986). Although there is no published information to suggest that populations undergo any regular migrations within the tropics, moderate numbers are usually present off the coasts of central and southern Mexico and Central America (Pitman, unpubl. data), more than 4500 km from the nearest known nesting colony, suggesting regular movements to that area.

There appear to be no major threats to this species at sea. Breeding colonies in Hawaii were adversely affected by introduced rabbits, but seemed to recover when the rabbits were eliminated (Harrison et al. 1984). The Johnston Atoll population declined from 400 to 30 birds after the island was occupied by the military and a paved airstrip was installed (Amerson and Shelton 1976). There is concern for the small Midway Island population (25–50 pairs; Fefer et al. 1984), which is currently threatened by introduced black rats *Rattus rattus* (Woodby 1988).

2.9. *Puffinus opisthomelas* Black-vented Shearwater

The only documented breeding locales of this species are at Isla Guadalupe, Isla Natividad, and Islas San Benito, all off the west coast of Baja California, Mexico (Everett 1988a). On Isla Natividad, the shearwaters burrow in the sandy soil covering most of the southeast portion of the island. The only known active colonies at Isla Guadalupe are on two offshore islets, Isolote Negro and Isolote Afuera. Anthony (1900) reported breeding on the main island of Guadalupe, but exact locations have never been determined. The introduction of cats to the island may have resulted in abandonment of these breeding grounds. At Islas San Benito, nests have been found on all three islands, but nowhere in any large concentration. At both Guadalupe and the San Benitos, birds occupy natural holes in the lava or crevices, or they burrow under large boulders.

Based on the limited available information, breeding colonies are occupied by mid-January and the peak of laying is in early April. By June many burrows have a chick, and fledging occurs from late June through August (Everett 1988a).

Black-vented Shearwaters primarily inhabit coastal waters, up to 25 km offshore. During the breeding season they are uncommon in areas other than the Pacific coast of Baja California. When breeding is concluded many disperse to the north and south. Typically, birds that head north move into the Southern California Bight, from Point Conception to Islas Los Coronados. During some years they are found as far north as Monterey Bay. Stragglers have been recorded as far north as British Columbia (Campbell et al. 1990). South of Cabo San Lucas there are few data, and the situation is complicated because of the occurrence of mixed flocks of *P. opisthomelas/auricularis* (Jehl 1974, 1982).

The estimate of population size is speculative, based primarily on observations and counts of birds staging at dusk near the breeding islands. The number of pairs is likely in the following range: Isla Guadalupe 500–2500, Islas San Benito 250–500, Isla Natividad 2500–5000. Feral cats are established on most of the breeding islands, and all visitors to these colonies have reported widespread destruction. Huge flocks such as those reported at the turn of the century (Anthony 1896; Grinnell 1897) are no longer seen. Gillnet fisheries have expanded off the west coast of Baja California in recent years, but the impact of these operations (Atkins and Heneman 1987) on the Black-vented Shearwater population is completely unknown.

2.10. *Puffinus auricularis* Townsend's Shearwater

Isla Socorro and Isla Clarion in Las Islas Revillagigedo, off the west coast of Mexico, are the only known recent nesting locales for this species, which also formerly bred on Isla San Benedicto in the same group (Jehl 1982; Everett and Anderson 1991). Jehl (1982) most recently summarized the scant available information on the biology of this endangered species. The birds apparently return to the islands beginning in mid-November. Laying probably begins in January, as large young have been found in late April.

The pelagic range of this species is among the smallest of any seabird, extending in a narrow band of subtropical water between 11 and 23°N, from the Mexican mainland to about 400 nautical miles southwest of Isla Clarion (Pitman 1986).

There has been no census on either breeding island, but Jehl estimated 1000 pairs on Isla Socorro in 1981. The population on Isla Clarion in 1986 was thought to be at best slightly less (Everett, unpubl. data). A massive volcanic eruption in 1952 eliminated the colony on Isla San Benedicto, and the other breeding islands are suffering the effects of introduced predators and herbivores. Pigs and rabbits were introduced to Clarion in 1979 (Everett 1988b), and feral cats have long been observed on Socorro (which is much larger than Clarion) from sea level to the summit of this rugged volcanic island. All visitors (including Pitman in 1988) report mass destruction of shearwaters, feathers in scat, and similar signs of decline. A visit to Clarion in May 1990 (Santaella and Sada, in press) raised the disturbing possibility that the species has now been extirpated from the island.

There is a modest program under way to rid Socorro of cats, but this will be a difficult and perhaps impossible task given the large size of the island and the mostly hostile terrain (see Veitch 1985). Preserving the species on Clarion may be more feasible, if remedial steps are undertaken soon (see recommendations below). Based on observations in May 1990 of birds flying inland at dusk (Santaella and Sada, in press), it is possible the species may be recolonizing Isla San Benedicto.

2.11. *Puffinus newelli* Newell's Shearwater

Once common on several of the Hawaiian Islands, Newell's Shearwater is now known to breed only on the island of Kauai. Recent observations suggest that small colonies may still exist on other main Hawaiian Islands (Harrison 1990). Although the species was thought to be extinct for many years, a documented record was obtained in 1954 (Richardson 1955), and by 1967 the nesting grounds were rediscovered (Sincock and Swedberg 1969). King and Gould (1967) summarized historic information on the biology of the species. The breeding season extends from April to November (Harrison 1990), after which at least some of the population disperses to the north and southeast (Pitman 1986).

The most recent population estimate suggests that up to 6000 pairs inhabit Kauai (Harrison et al. 1984). The species' decline has been blamed on predation by pigs, cats, mongooses, rats, and Barn Owls *Tyto alba*. Fire has also destroyed some colonies. Another significant problem has been coastal street lights, which attract and disorient fledglings on their first flights to the ocean. The problem, most serious on moonless nights, has been somewhat mitigated by shielding upward radiation of light and by an intense salvage program to find and return stranded birds to the sea. Over 20 000 birds have been assisted in this manner (Reed et al. 1985; Tefler et al. 1987; Reed 1987; Harrison 1990).

In addition, cross-fostering with Wedge-tailed Shearwaters has been attempted in order to encourage establishment of new colonies on offshore islets free from terrestrial predation and light distraction (Byrd et al. 1984). Results of this experiment, in terms of birds returning to the foster colonies to breed, are as yet unavailable.

3. Hazards for shearwaters at sea

At present, the most serious threat to shearwaters at sea is undoubtedly incidental mortality in drift gillnet fisheries (King 1984; DeGange et al. 1985; Atkins and Heneman 1987). The species suffering the greatest losses is apparently the Short-tailed Shearwater, whose high-latitude migration places it in regions heavily fished (Jones and DeGange 1988). Its pursuit-diving habits also enhance its susceptibility to entanglement. Other diving species (e.g., Wedge-tailed and Christmas shearwaters) are not as gregarious or occur in areas of lower fishing effort. Although the Japanese high-seas salmon driftnet fishery has recently reduced its kill, concern is escalating regarding the incidental take in the North Pacific squid *Ommastrephes bartrami* fishery (King 1984). Preliminary results from a pilot observer program in this fishery are alarming, suggesting mortality in the hundreds of thousands for Sooty and Short-tailed shearwaters (Gjernes et al. 1990). At this writing, an expanded observer program is under way, and a call for a ban on all drift gillnet fishing has been made by the United Nations. The Japanese have agreed to cease their driftnet fisheries, but other nations such as Korea and Taiwan have yet to comply. Although the numbers of shearwaters killed in fishery operations have been massive, there is no current evidence of population declines for the species involved. However, shearwaters are notoriously difficult to census, so the situation heightens the need for monitoring breeding colonies.

Although competition with commercial fisheries may present problems for other groups of seabirds (Furness and Ainley 1984; Furness and Monaghan 1987), we know of no serious prey depletions adversely affecting shearwaters.

Oil spills also clearly present a threat to shearwaters, especially those inhabiting regions where shipping or extraction activities are high. After the *Exxon Valdez* spill in Alaskan waters in March 1989, many thousands of dead shearwaters were recovered, although the number of mortalities directly related to the spill is not clearly known (Piatt et al. 1990).

Ingestion of plastics at sea is a concern for many species of seabirds (Furness and Monaghan 1987), with both northern and southern hemisphere procellariiforms being heavily contaminated. The primary difficulty with plastics ingestion seems to be a reduction of gizzard and stomach capacity, with possible resultant malnutrition or starvation (Conners and Smith 1982; Ryan 1988). This has not, however, been demonstrated in shearwaters, which apparently have the ability to regurgitate undigestible items (e.g., squid beaks). At this time, plastic ingestion does not appear to be a significant problem for shearwaters.

4. Hazards for shearwaters on land

Many seabirds, including shearwaters, encounter problems resulting from habitat destruction and disturbance when they return to land to breed (Vermeer and Rankin 1984b). This can result directly from human activities or be a consequence of the introduction of alien animals. For species under consideration here, direct human disturbance has apparently been a factor in the declines of several tropical colonies. Occupation of remote islands by the military, especially where airstrips have been installed, has proven destructive to shearwaters (King 1973; Amerson and Shelton 1976; Ranzon 1985). Light attraction, discussed above, is a serious problem for Newell's Shearwater. Remedial action seems to be helping, and, fortunately, this problem is unlikely to affect most other shearwater species. The introduction of pigs and rabbits to Isla Clarion (Everett 1988b) has dramatically altered the island's landscape. The soil destabilization and erosion caused by their activities may destroy the breeding grounds of Townsend's Shearwater.

The most serious problem facing shearwaters on land is predation by introduced animals. The general impacts are well documented (Moors and Atkinson 1984), and need not be reiterated here. Species at the highest risk are those with small populations and few colonies. In addition, shearwaters breeding on high, thickly vegetated islands stand a more substantial likelihood of depredation because predators are more likely to become established in lush areas with alternative food sources available when shearwaters are absent. Many of the species discussed here suffer from predation, but Townsend's Shearwater, Newell's Shearwater, and possibly Black-vented Shearwater seem to be experiencing serious population declines as a result.

5. Recommendations

(1) Immediate action is required to rid Isla Clarion of pigs, then rabbits, in order to secure the island as a breeding locale for Townsend's Shearwater. Efforts are under way to remove feral cats from Isla Socorro, but that island is large and the terrain extremely difficult. Considering these problems it appears unlikely that the cat eradication program there will be successful in the near future.

(2) All drift gillnet fisheries should be banned or closely monitored and regulated. In cases where large numbers of shearwaters are being killed, fishing moratoriums should be implemented until it can be determined that serious seabird population declines are not resulting. This cannot be accomplished without careful censuses at breeding colonies over a period of several years at minimum.

(3) The population status and vulnerability of Black-vented Shearwater colonies should be determined, with implementation of appropriate remedial actions and policies if necessary.

(4) The multi-faceted program to protect and preserve Newell's Shearwater in Hawaii should be continued, including increased efforts to locate additional colonies.

(5) Predator removal programs currently in progress in New Zealand, Australia, and the central Pacific should be continued as long as required to achieve eradication.

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