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Foraging destinations of breeding Laysan *Phoebastria immutabilis* and Black-footed *P. nigripes* Albatrosses in relation to longline fishery activity

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Significant bycatch of Laysan *Phoebastria immutabilis* and Black-footed Albatrosses *P. nigripes* in longline fishing operations has been documented for years in the Pacific, with potential effects on population dynamics. In 1998 and 1999, satellite telemetry studies were initiated to determine the spatial distribution of 54 breeding albatrosses nesting at Tern Island, French Frigate Shoals, in the North-western Hawaiian Islands and Kilauea Point National Wildlife Refuge, Kauai, in the main Hawaiian Islands. Birds were tracked for 4–182 days (mean 57 days). Both species mixed short foraging trips near the nesting island with much longer trips, typically terminating over the western North American continental shelf. Laysan Albatrosses travelled primarily to the north on long trips, frequently reaching the Aleutian Islands and Gulf of Alaska. Long trips of Black-footed Albatrosses typically ended on the California, Oregon, and Washington State coasts. A comparison of these tracking data with concurrent distributions of longline fishing effort will be attempted in order to evaluate the degree of spatial overlap.

International albatross bycatch mitigation: policy prospects and problems

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Longline fishing is now well recognized as a major threat to the long-term survival of several species of seabirds due to their unintended capture on hooks baited for target fish species. It is now nearly a decade since the issue of albatross longline bycatch first received policy attention in Australia, resulting in the creation of a Threat Abatement Plan to mitigate the fisheries' impacts. More recently the international

community has also recognized and made efforts to address the impact of seabird bycatch: witness the FAO International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries. Although a laudable step, this measure is voluntary and falls short of an international legal commitment. Meanwhile, ongoing concern about seabird bycatch led to the 1997 listing of eleven species of albatross under the Convention on the Conservation of Migratory Species of Wild Animal (the CMS or Bonn Convention). Over the last year this listing has been translated into a draft text for an agreement between southern hemisphere range countries. Led by the Valdivia group of nations, the eventual intention is for the creation of a binding Plan of Action to be formed under the auspice of the CMS. This paper focuses on international efforts to reduce seabird bycatch in commercial fisheries operations. It outlines the current status of the CMS agreement, and discusses the potential oversights that may occur as well as the strengths of such an arrangement. Finally, this paper considers elements that have been of substantial utility in other international bycatch mitigation arrangements, and their potential application to ongoing albatross discussions.

How do parental provisioning patterns in Wedge-tailed Shearwaters *Puffinus pacificus* compare to other procellariiform seabirds?

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Procellariiform seabirds exhibit exceptional life-history traits with extended periods of parental care (often 100 days). In many cases, provisioning for chicks is constrained by long foraging trips (2–17 days) to distant and unpredictable feeding areas. The objectives of this study were to determine the provisioning patterns of a northern hemisphere, subtropical procellariiform, the Wedge-tailed Shearwater *Puffinus pacificus*, and to determine how parents partition food resources between themselves and offspring. Foraging trip length, meal size, and change in adult and chick body mass between foraging trips were measured during 1996 and 1997. Wedge-tailed Shearwaters had a unimodal foraging strategy with 1.5- to 2-day foraging trips. The rate of food delivery (g of food per day spent foraging) decreased with increasing trip duration. Chicks in superior body condition were fed smaller meals than chicks in poor body condition in both years. Parents returning to the colony in better body condition fed their young larger meals. Trip length was generally greater for adults returning with squid and fish combined than for adults returning with

squid only. Adults also returned with relatively larger prey items after longer foraging trips. Although foraging strategies may differ, rates of food delivery to chicks (40–60 g/day) were similar to those of other subpolar and temperate shearwater species that feed in highly productive areas and undergo bimodal length foraging trips. Distribution and abundance of prey resources in the foraging environment may influence foraging strategies and decisions made by parents about the timing and amount to feed offspring and the duration of parental care.

Incidental capture of seabirds in New Zealand tuna longline fisheries

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The incidental catch of seabirds during tuna longline fishing in New Zealand waters by Japanese vessels and domestic-owned and -operated vessels has been monitored since 1987/88. The number of hooks observed has increased over the years, with 100% coverage of the one million hooks set annually by Japanese vessels in recent years. Coverage of the domestic-owned and -operated vessels, which in 1998/99 set at least five million hooks, has been low in comparison. Furthermore, fishing practices and observer coverage vary from year to year, which results in inconsistency of temporal and spatial coverage. Higher seabird bycatch rates are found in areas off the eastern coasts of New Zealand despite the introduction of the use of tori lines and the voluntary setting of lines at night. Fourteen species of albatross and eight species of petrel have been positively identified from observed captures since 1989. Over 90% of seabirds observed caught on Japanese longlines each year were landed dead until 1998/99, when less than 50% were landed dead. About 80% of those observed caught on domestic longlines were released alive. The spatial distribution of the seabird species observed caught can be localized or can be spread throughout the waters fished. A description of the tuna fisheries in New Zealand waters and the associated seabird bycatch, based on the observer coverage, is given for 1987/88 to 1998/99.

Can albatross populations be reliably monitored from aerial photography?

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Evidence is presented to indicate that it is possible to monitor accurately albatross population trends and also measure breeding success from aerial photography. In some situations, this census method can have a considerable advantage over conventional on-ground evaluations, being potentially less disruptive to the birds, more time and cost effective and facilitating access to nesting habitat that is otherwise inaccessible for surveying. However, the accuracy of population monitoring from aerial photography may be inadequate to detect change of less than about 10% in the short term, which in long-lived species such as albatrosses, may be potentially problematic. Species for which it has been determined that annual

chick production can be correlated with population size are ideally suited to aerial population monitoring.

Australian policy and actions relating to albatross conservation

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The threatened status of albatrosses worldwide, and their vulnerability to longline-related mortality, has concerned seabird biologists for the last decade. Since 1995 Australia has been very active in the issue of albatross conservation, and has taken a three-pronged approach to the problem:

- 1) assessment of the conservation status of albatrosses, and subsequent preparation of recovery plans;
- 2) identification of key threatening processes affecting the conservation of seabirds, and the subsequent development of a threat abatement plan for oceanic longline fishing; and
- 3) facilitation and implementation of cooperative international action to complement domestic conservation actions.

With action on the first two of these items substantially complete, Australia is now actively encouraging the development of a Regional Agreement concerning southern hemisphere albatrosses under the Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention). A preliminary meeting involving a number of key southern hemisphere range states was held in June 1999. This meeting identified key elements for a framework of regional cooperation to ensure effective conservation of albatrosses, and also agreed to explore an exchange programme of experts to promote developing and implementing different techniques for mitigating fishing impacts on seabirds. The format of other regional agreements prepared under the CMS will be discussed to highlight the types of issues which a regional agreement could address. A further meeting is proposed in 2000 with all relevant range states to continue the development of this important initiative. Only the implementation of parallel domestic and international actions of the type discussed can assure the conservation of albatrosses.

Some aspects of energy assimilation and use in four southern albatrosses

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As part of a nutritional ecology study of non-breeding albatrosses in coastal New South Wales, we measured basal metabolic rate (BMR), specific dynamic action (SDA), and apparent energy assimilation efficiency (AEAE) of four species. The BMR value for adult Wandering Albatrosses *Diomedea exulans* averaged 176 kJ/kg/day, 18% above the value predicted by the allometric equation of Aschoff & Pohl (A&P) but comparable to a value previously reported during breeding; for adult Gibson's Albatrosses *D. gibsoni* it averaged 186 kJ/kg/day, 35% above the predicted value (A&P); for juvenile Gibson's Albatrosses it averaged 181 kJ/kg/day, 8% less than the predicted value (A&P); for White-capped Albatrosses *Thalassarche steadi* it averaged 207 kJ/kg/day;

and 232 kJ/kg/day in Campbell Albatrosses *T. impavida*. These values are comparable to those reported for other *Thalassarche* albatrosses during the breeding season. Aggregated mean SDA for Wandering and Gibson's Albatrosses was 13.8% of metabolisable energy and it averaged 16.6% for Campbell Albatrosses. Mean AEAE of Wandering and Gibson's Albatrosses on a diet of cuttlefish *Sepia apama* averaged 83.6%.

**Breeding biology and conservation of the Black Petrel
Procellaria parkinsoni on Great Barrier Island,
New Zealand**

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Aspects of the breeding biology of the Black Petrel *Procellaria parkinsoni* were studied between 1996–2000 in 250 study burrows and nine census grids on Great Barrier Island (36°8.5'S, 175°24.75'E), New Zealand. Adult and chick masses, breeding success and mortality factors are documented. Population estimates were calculated annually. Rat index lines were completed during the 1998, 1999 and 2000 breeding seasons and feral domestic cat *Felis catus* sign was monitored annually. Little cat predation was noted, but rat *Rattus* sp. predation varied from 1.4% to 8% over the study period. Other mortality factors are listed. Breeding success for each season was determined and ranged from 75% to 97%. This study is part of ongoing research on this species.

**The link between pair bond duration, parental coordination,
and reproductive success in Leach's Storm Petrels
*Oceanodroma leucorhoa***

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Mechanisms leading to long-term pair bond-associated increases in reproductive success are poorly understood. It is widely suggested that a primary benefit of long-term pair bonds is increased familiarity between partners, resulting in optimal coordination and improved reproductive success. However, very few studies have specifically addressed the hypothesis that long-term pair bond-associated increases in reproductive success are due to a fine-tuning of behavioural coordination between partners, and the causal link between increased pair bond duration and increased reproductive success therefore remains to be established. I tested the hypothesis that long-term pair bond-associated increases in reproductive success result from improved parental coordination by observing whether (1) parental coordination improves as the duration of the pair bond increases, and (2) reproductive success is positively related to parental coordination, using Leach's Storm Petrels *Oceanodroma leucorhoa* nesting at Kent Island, New Brunswick, Canada, as a model species. No significant increase in parental coordination (measured as the proportion of days in which no adult was present with the egg) with pair bond duration was found (simple regression, $P = 0.8405$, $n = 48$); the proportion of egg neglect was

approximately equal across all pair bond durations observed. Reproductive success was significantly negatively correlated with egg neglect (logistic regression, $P = 0.0034$, $n = 48$), whereby pairs who were more coordinated during incubation (i.e. low egg neglect) had higher hatching success than pairs who showed low coordination (i.e. high egg neglect). Contrary to numerous published findings on long-lived seabirds and previous results obtained for the study population of Leach's Storm Petrels, in this study hatching success did not increase significantly with pair bond duration when strictly controlling for the effects of breeding age on reproductive success.

**Dietary segregation of zooplankton-eating petrels at
Kerguelen Islands**

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Five species of small petrels (Common *Pelecanoides urinatrix* and South Georgian *P. georgicus* Diving Petrels, Thin-billed *Pachyptila belcheri* and Antarctic *P. desolata* Prions and Blue Petrel *Halobaena caerulea*) number millions of breeding pairs at the Kerguelen Islands, southern Indian Ocean. Their food and feeding ecology were studied during the chick-rearing period in three consecutive years (1995–1997). For four species, crustaceans were the main food by mass (88%–100%), whereas Blue Petrels took both crustaceans (52%) and mesopelagic fish (45%). Key crustacean species in the nutrition of small petrels were the amphipod *Themisto gaudichaudii*, the euphausiids *Thysanoessa* spp. and *Euphausia vallentini*, and the copepods *Calanoides acutus* and *Paraeuchaeta antarctica*. South Georgian Diving Petrels fed mainly on *Thysanoessa* spp. (50% by number) whereas the other four petrels preyed upon *T. gaudichaudii* (42–90%), indicating that this amphipod had an importance in the local trophic web similar to that of Antarctic Krill *Euphausia superba* at more southern latitudes. The size-frequency distribution of *T. gaudichaudii* found in stomach contents, when compared to that of individuals collected in net samplings, indicates that petrels fed both on coastal and more offshore populations. A strict spatial dietary segregation was found between the Common Diving Petrel, which foraged on hyperiids in coastal waters, and the South Georgian Diving Petrel, which fed on euphausiids in offshore waters. The presence of Antarctic Krill in some oily stomach contents of prions and Blue Petrels indicated that these small seabirds commonly foraged far away from the colonies (more than 1000 km) during the chick-rearing period.

**Use of olfaction by Blue Petrels *Halobaena caerulea* to
locate nesting burrows**

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Most petrels return to their nest burrows at night. The senses used by these birds to locate the colony and then their own burrow remain unknown, although several hypotheses have

been suggested over the past decades, including olfaction, visual cues, echolocation, and calls from burrows. Olfaction makes intuitive sense, since in Procellariiformes the anatomy of the olfactory system is well developed. However, the evidence for olfactory burrow location in Procellariiformes is not very compelling. We carried out an experiment to test whether Blue Petrels *Halobaena caerulea*, which are strictly nocturnal in their activity on land, use olfaction to locate individual nest burrows. Subjects were incubating birds from a colony on the Kerguelen Islands (southern Indian Ocean). Experimental birds were injected intranasally with a zinc sulphate heptahydrate solution (4%), which produces a reversible impairment of the olfactory mucosa; control birds were treated with physiological saline solution. After the treatment, in the early morning, the birds were returned to their burrows. During the following night they were captured again and released toward the sea in front of the colony, in the flow of other birds that were commuting between the sea and the colony. The burrows were then checked in the morning after the release and in the subsequent days. None of the birds treated with zinc sulphate solution returned to their burrows, whereas all of the birds treated with the saline solution returned. Our results clearly indicate that in Blue Petrels lack of olfactory cues prevent birds from finding their burrows. These findings suggest that procellariiforms with nocturnal activity on land may use the sense of smell to orientate themselves to locate their burrows, at least when neither the partner nor the chick are present.

Comparative population structure of Black-browed *Thalassarche melanophrys* and Grey-headed *T. chrysostoma* Albatrosses using genetic analyses

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Population structure of Black-browed *Thalassarche melanophrys* and Grey-headed *T. chrysostoma* Albatrosses was examined using both mitochondrial DNA (mtDNA) and microsatellite analyses. MtDNA sequences from 73 Black-browed Albatrosses from five island groups and 51 Grey-headed Albatrosses from five island groups were obtained. High levels of sequence divergence were found in both species (0.55–7.2% in Black-browed and 2.1–3.9% in Grey-headed Albatrosses). Results show Black-browed Albatrosses form three distinct groups: Falklands, Diego Ramirez/South Georgia/Kerguelen, and Campbell Island (*T. impavida*). Interestingly, *T. melanophrys* from Campbell Island comprised birds from each of the three groups, indicating high levels of mixture. In contrast, Grey-headed Albatrosses formed one large, panmictic population, despite having samples from a wide geographic distribution (Diego Ramirez, South Georgia, Marion, Kerguelen and Campbell Islands). Microsatellite

analyses using seven highly variable microsatellite markers found similar population structure to the mtDNA analyses. The differences in population structure between two closely-related species could be the result of differences in foraging and dispersal patterns. Breeding Black-browed Albatrosses forage mainly over continental shelves and migrate to (or remain in) similar areas when not breeding. Grey-headed Albatrosses forage mainly at frontal systems, travelling widely across oceanic habitats. Genetic analyses would support the current classification of *T. impavida* as distinct from *T. melanophrys*, but would also suggest splitting *T. melanophrys* into two groups: Falkland Islands and Diego Ramirez/South Georgia/Kerguelen. The appropriate rank (species or subspecies) for these taxa is complicated by the hybrids at Campbell Island.

Status and threats of the Ashy Storm Petrel *Oceanodroma homochroa* in the Southern California Bight, USA

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In the Southern California Bight, we estimated a population of about 2000 breeding pairs of Ashy Storm Petrels *Oceanodroma homochroa* (50–65% of the world breeding population), with relatively large colonies at San Miguel, Santa Barbara, and Santa Cruz Islands. During the breeding season (April–December), foraging occurred widely over the adjacent continental shelf. Mean breeding success at Santa Cruz Island from 1995–1997 was 14–23% lower than reported for the South Farallon Islands off Central California in three periods between 1971 and 1995. Relatively high levels of DDT and PCB contamination and eggshell thinning likely contribute to low hatching success. Human disturbance from recreational activities and numbers of avian predators appear to be increasing at certain colonies. Colony illumination at night by bright lights from squid-fishing boats is an emerging problem at many colonies. Oil and plastic pollution, military weapons testing, and light attraction likely impact smaller numbers. Planned eradication of rats at Anacapa Island may allow an increase in colony size. This California-endemic storm petrel may warrant evaluation for potential listing under the California and U.S. Endangered Species Acts.

Matrix population models for albatrosses: balancing simplicity and complexity

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I explore the balance between complexity of the albatross life cycle and simplicity of albatross population models. Matrix population models are ideally suited for demographic analy-

sis of complex life cycles. Albatross life cycles are complex by any standards, yet most demographic analyses have relied on traditional age-classified methods that cannot reflect this complexity. The lone exception (Croxall *et al.* 1990, *J. Anim. Ecol.* 59: 775–796) was presented in a difference equation framework that makes analysis difficult. I show how to translate this model into a matrix model, and examine some additional quantities that can be calculated from such a model. Although the complexity of the Croxall model is biologically satisfying, it may limit its applicability to populations for which adequate data are available. I present the results of a series of simplifications of the model that attempt to capture the essential structure of the life cycle with a minimum number of parameters. Sensitivity analysis applied to these models can provide valuable insights into the effects of incidental mortality.

Hormonal correlates of provisioning effort in petrels and albatrosses

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Several oceanic procellariiforms have evolved a peculiar chick-provisioning strategy where adults either alternate or mix long foraging trips over pelagic waters with short foraging trips over coastal waters. Adults store energy during the long trips and use this energy to deliver food to chicks during the short trips. This strategy may represent an effective compromise between the need of the chick to be fed regularly and that of the adult to forage at low risk of losing body condition. Thus, in these pelagic seabirds, body condition appears to be the major factor regulating provisioning decisions. However, such decisions are likely to be proximately controlled by hormones. We present data on Blue Petrels *Halobaena caerulea*, Short-tailed Shearwaters *Puffinus tenuirostris* and Wandering Albatrosses *Diomedea exulans*, showing that there is a positive relationship between adult condition and plasma levels of prolactin. This hormone rises during the incubation and chick-rearing periods and has been considered as the 'parental care' hormone. In the Blue Petrel, adults returning from long trips show significantly higher prolactin titres than birds returning from short trips. Furthermore there is a positive relationship between mass gain at sea and plasma levels of prolactin. To conclude, we will discuss possible mechanisms relating adult body condition, hormones and provisioning effort in oceanic Procellariiformes.

Managing pelagic longline-albatross interactions in the North Pacific Ocean

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The Short-tailed *Phoebastria albatrus*, Black-footed *P. nigripes* and Laysan *P. immutabilis* Albatrosses, all native to the North Pacific, interact with demersal and pelagic longline vessels and may on occasion be caught by a baited hook and

drown. This problem has been studied in detail for 105–115 pelagic longline vessels home-ported in Hawaii, which take between 1000–2000 each of both Black-footed and Laysan Albatrosses each year. No takes of Short-tailed Albatrosses have been reported for the Hawaii longline fishery, but between 1993 and 1997, five birds were incidentally caught in the Alaska longline fisheries. The Black-footed and Laysan Albatrosses are most vulnerable to longline fishing for Broad-billed Swordfish *Xiphias gladius*, where longlines are set near the surface, providing ample opportunity for albatrosses to intercept baited hooks. Studies of the rarer Black-footed Albatross population revealed fishery-induced mortality to be a chronic rather than a catastrophic source of mortality. Some simple mitigation methods implemented in the fishery should reduce the incidental catch of albatross by an order of magnitude and eventually lead to negligible take levels. However, the Hawaii-based longline vessels targeting swordfish represent only a small fraction of pelagic longline effort in the North Pacific and albatrosses will continue to be taken by Japanese, Taiwanese and Korean longliners operating in the same vicinity. These Asian vessels fish primarily for tuna *Thunnus* spp. and are likely to have much lower albatross take rates than the Hawaii-based fleet, but collectively these 3000+ vessels still represent a significant threat to North Pacific albatrosses. Although several multilateral agreements identify cost-effective methods to reduce significantly the incidental catch of seabirds in longline fisheries, very few international or national fishery management organizations require longline fishers to employ these mitigation measures. There is a need to strengthen international efforts to reduce seabird mortality on longlines, and for effective monitoring of albatross populations to gauge the success of mitigation measures.

Population change and foraging ecology of White-chinned Petrels *Procellaria aequinoctialis* at South Georgia

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The distribution and density of occupied burrows of White-chinned Petrels *Procellaria aequinoctialis* at Bird Island, South Georgia, were surveyed in 1998, using identical techniques and areas to a survey conducted in 1981. An overall decrease of 28% was estimated. Habitat modification due to activities of Antarctic Fur Seals *Arctocephalus gazella* accounted for only a small proportion of this change. Given that breeding frequency and breeding success remained similar between survey years, causal factors are likely to be operating at sea, possibly involving mortality in longline fisheries, to which this species is particularly vulnerable. Satellite-tracking and diet sampling of incubating birds (trips of 12–15 days, travelling 3000–8000 km) revealed foraging areas to the north-east of the Falkland Islands (taking *Illex* squid) and coastal waters of northern and southern Argentina (eating mainly fish and offal). During chick-rearing (trips of 2–11 days, travelling 1100–5900 km) intense foraging activity occurred over the South Georgia Shelf (targeting krill), along the northern shelf break off the South Shetland and South Orkney Islands (taking mainly *Brachioteuthis* and *Galiteuthis* squid), and along the edge of the Patagonian Shelf from southern Brazil south to the Falkland Islands (consuming mainly *Illex*). This study confirms the White-chinned Petrel as amongst the widest-ranging of seabirds when breeding, with versatile foraging and diverse diet according to location

and prey availability. However, its range and versatility promotes substantial risk of high mortality associated with longline fisheries in coastal, shelf-break and pelagic areas of the South Atlantic.

Decline of Newell's Shearwaters *Puffinus auricularis newelli* on Kauai, Hawaii

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We compared trends in the number of Newell's Shearwaters *Puffinus auricularis newelli* seen visiting Kauai, Hawaii, using ornithological radar in June 1993 and 1999 and trends in the number of young Newell's Shearwaters recovered in the 'Save Our Shearwaters' (SOS) Program on Kauai between 1979 and 1999. After pairing sampling dates at each site to remove temporal effects, the radar data indicated that the number of Newell's Shearwaters visiting Kauai decreased significantly between 1993 and 1999. The mean change across 13 sites was $-60.0 \pm 7.2\%$, with a range of $+1.4\%$ to -92.6% . All sites except one showed decreases of $37.5 - 92.6\%$. The SOS fallout data exhibited two trends, with a pattern of fairly stable numbers (but no overall trend) between 1979 and 1991 and a 45% decrease from 1993 to 1999. Both data sets indicated that a decrease had occurred, with annual rates of -14% for the radar and -9.5% for the SOS fallout data. Hence, we conclude that there has been a significant decrease in the numbers of Newell's Shearwaters visiting Kauai to breed since 1993. Exact causes of the decrease are unknown at present, but we suggest the most probable causes.

Can genetics determine the provenance of Shy Albatrosses *Thalassarche cauta* caught at sea?

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Australia's Shy Albatross *Thalassarche cauta* and New Zealand's White-Capped Albatross *T. steadi* are closely related and difficult to distinguish even in the hand. It is estimated that over the last decade more than 5000 'Shy-type' albatrosses have been killed on longlines within the Australian Fishing Zone alone. Unless banded, it is currently impossible to determine the species and provenance of Shy-type specimens collected from longlining vessels. Such data would be invaluable when attempting to quantify the impact of fisheries on specific albatross populations. Like most seabirds, albatrosses return to their natal colonies to breed. Such extreme philopatry prevents gene flow between island populations and will eventually lead to genetic differentiation. By quantifying the genetic variability within and between albatross colonies it may be possible to identify markers specific to particular colonies and use these markers to identify the provenance of albatross caught at sea. We have used mitochondrial DNA sequencing

and microsatellite genotyping to quantify the genetic variation within and between populations of Shy and White-capped Albatrosses. We report on the applicability of using genetic techniques to identify the sex, species and provenance of Shy-type albatrosses caught at sea. We also discuss how these genetic studies can also be used to investigate the evolutionary history of albatross colonies.

Seabird bycatch and longline fishing – aligning roles and responsibilities

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Seabird bycatch is both a nature conservation and fisheries management problem. Solutions therefore require action within both sectors if mitigation efforts are to be successful. Because albatrosses and petrels range widely and are impacted by longliners wherever they are found, nations must cooperate in their efforts to mitigate bycatch. Moreover, the growth in distant-water fishing requires cooperative national actions to be extended beyond jurisdictional boundaries and into the high seas. A capacity exists within fishing instruments to facilitate bycatch mitigation efforts on a regional basis. Future policy efforts should emphasize this capacity, both where it exists and as new regional fishery instruments are developed. An additional attraction of utilizing fisheries instruments to address bycatch is that it encourages the fishing sector to be responsible for mitigating the threats posed by longlining. It is also likely that measures adopted by fisheries bodies will be more actively promoted than those imposed through other mechanisms.

Endangered. The threatened albatrosses of Macquarie Island: conservation and threats

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The population sizes of three of the four species of albatrosses breeding on Macquarie Island are amongst the smallest across the range of each species. Consequently they are extremely vulnerable to any influences which impact on their survival rates. Annual population monitoring started in 1994 has shown that for the biennial Wandering Albatrosses *Diomedea exulans* on average 11 eggs are laid each year, and for Grey-headed Albatrosses *Thalassarche chrysostoma* c. 73 eggs are laid each year. For the annually breeding Black-browed Albatrosses *T. melanophrys* 40 eggs are laid each year. Black-browed Albatrosses had the lowest mean breeding success of the three species over the five-year period with an average of $50\% (\pm 8.5\%)$, whereas Grey-headed Albatrosses had the highest ($58\% \pm 11.1\%$) and Wandering Albatrosses the most variable ($56\% \pm 16.4\%$). Observations of trawling operations in the region show that individuals of all three species attend fishing activities. Initial results from satellite tracking the *Thalassarche* species show that foraging tracks during the brood period may also be extensive, with long-distance trips (to areas >1200 km from the island) ranging both east and south of the island. Attempts to assess the oceanic distribution of Wandering Albatrosses via miniature archival recorders have thus far failed due to equipment malfunction. The likely recent occur-

rence of illegal longline fishing operations in the region, as indicated by the examination of longline fishing equipment accumulating on the island coast, is cause for serious concern. Urgently required data for confident assessment of rates of adult survivorship and juvenile recruitment, and thus population status for all three species, are being compiled.

Shy Albatrosses *Thalassarche cauta* and longline fishing: an integrated study

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The endemic Shy Albatross *Thalassarche cauta* is the only species of albatross breeding in continental Australia. Following their exploitation in the 1800s, currently 12 250 pairs breed on three islands off Tasmania. Little attention was paid to the species until the 1980s when we initiated integrated studies of their ecology and the impacts of longline fishing. The at-sea distribution of breeding birds was examined by satellite telemetry whereas fishing effort and bycatch rates were both observed directly and derived from observer data. Breeding Shy Albatrosses consistently foraged over the shelf; however, the foraging grounds of the three populations were mutually exclusive. Dispersal of juveniles also showed population specificity. The consistent and exclusive distributions of adults, coupled with regional differences in bycatch rates, strongly indicate that the southern populations could be more seriously impacted by longline fishing. Foraging activity information from archival loggers and diet analyses showed that Shy Albatrosses take three main prey species from the upper 8 m of the water column, largely during the day. Birds do, however, significantly increase their activity at night during the full moon, a pattern consistent with when birds are killed on longlines. Such integrated observations have been critical for the development and the monitoring of mitigation measures. Although through the 1990s hundreds of 'Shy-type' albatrosses were killed annually in the Japanese and domestic tuna longline fisheries in Australian waters, similarities between Shy and New Zealand's White-capped *T. steadi* Albatrosses make it impossible to partition the catch rate between these two species. Current demographic and genetic studies will assist in completing the conservation profile of the Australian species, but accurate population assessments of White-capped Albatrosses are urgently required. This case-study outlines how simultaneously examining population and foraging ecology and the nature of mortality in longline fisheries can provide effective initiatives for more seabird-friendly fishing practices, such innovations being critically required for the conservation of albatrosses.

Sexual dimorphism and sexual selection in foraging strategies of Northern Giant Petrels *Macronectes halli* during the incubation period

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Giant petrels *Macronectes* spp. are the most sexually dimorphic of all seabirds. We used satellite-tracking and mass

change during incubation to investigate the influence of sexual size dimorphism, in terms of the inter-sexual food competition hypothesis, on foraging and fasting strategies of Northern Giant Petrels at South Georgia. Females foraged at sea, whereas males foraged mainly on the South Georgia coast, scavenging on seal and penguin carcasses. Foraging effort (flight speed, distance covered, duration of foraging trips) was significantly greater for males than for females. Females could not compensate for the mass loss during the incubation fast while foraging, suggesting greater incubation costs for females than for males. Both sexes regulated the duration and food intake of foraging trips, depending on the depletion of body reserves. The importance of fasting endurance, competition over food and flight metabolic rates are likely to differ between sexes owing to differences in foraging strategies, thus maintaining sexual size dimorphism. We suggest that sexual segregation of foraging strategies arose from size-related dominance at carcasses, promoting sexual size dimorphism.

Investigating methods to reduce the incidental catch of albatrosses in the Hawaii longline fishery

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The purpose of the study was to provide scientific evidence supporting the use of mitigation devices to diminish the incidental catch of Laysan *Phoebastria immutabilis* and Black-footed *P. nigripes* Albatrosses in the Hawaii longline fishing industry. To achieve this goal we measured the particular effectiveness of various methods at reducing seabird mortality and recorded the behaviours that lead to mortality on commercial longline fishing vessels. Methods tested while the longline was being set were: using blue-dyed bait; towing a bird-scaring (tori) line or buoy; and, strategically discarding offal. Methods tested while the longline was being hauled were the same with the exception that 'no offal discards' replaced strategic offal discards. In addition, the effect of darkness at mitigating against mortality was also tested. Seabird behaviours were partitioned into two categories: 'attempts,' which included seabird dives, landings and chases; and 'interactions,' which included seabird contacts or entanglements with fishing gear and hooking. Seabird abundance was also recorded during all observation periods. All behavioural and mortality observations were made by the same observer during five separate longline fishing trips. Behaviour and mortality data for each device were compared to a general linear model (S-Plus software from StatSci), assuming a Poisson distribution. The number of mortalities per seabird per 1000 hooks were: 0.12 blue-dyed bait, 0.26 towed buoy, 0.32 strategic offal discards, 0.47 tori line, 0.60 for night setting and 2.23 for the control. If we express the effectiveness of the mitigation methods in relative terms, blue-dyed bait, the towed buoy, strategic offal discards, tori line and night setting each reduce mortality by a minimum of 73%. Blue-dyed bait reduced the albatross mortality by 95%. It is clear from this study that the employment of mitigation methods on swordfish longline fishing vessels could greatly reduce the level of albatross mortality now experienced in this fishery. This research demonstrates the various mitigation methods tested are highly effective on swordfish longline fishing vessels at miti-

gating the incidental catch of albatrosses and the behaviours that lead to the incidental catch.

Seabird bycatch by small-scale longline fisheries in northern Peru: a first approach

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Longlining has been encouraged in Peru as an alternative to small-scale fishing and for reducing cetacean mortality in gill nets. Very little is known about seabird bycatch in these longline fisheries. In January 1999, we surveyed five fishing villages in northern Peru to estimate seabird bycatch. Most fishers were reluctant to provide any information. Of the 62 fishers interviewed, 29 were longliners and 33 were gill-netters. All 29 longliners interviewed had witnessed seabirds scavenging baited hooks. Eighty percent used frozen bait, which floats and attracts seabirds to the longline, thus increasing the probability of seabird mortality. Ninety percent of fishers confirmed that birds are hooked while setting the gear. Additionally, we observed that over 40% of hooked seabirds were albatrosses. Descriptions did not allow us to determine species; however the most common albatross off northern Peru is the Waved Albatross *Diomedea irrorata*. Seabird bycatch in the Peruvian small-scale longline fishery should be of concern; pooled estimates of bycatch based on interviews with fishermen were 0.74 to 1.75 birds/1000 hooks. These estimates are higher than those reported by other countries. We strongly encourage researchers and NGOs to investigate seabird bycatch in Peru. Further research that includes onboard seabird bycatch surveys, as well as a larger sample of interviews with fishers are needed. Public awareness that encourages the combined use of bird-scaring lines, night setting of hooks, and the use of fresh or defrosted bait will reduce bycatch and bait loss, thus both promoting species conservation and benefiting fishers.

International cooperation for the conservation of seabirds

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This paper charts the development of international political efforts to mitigate the incidental catch of seabirds that have taken place since the First International Conference on the Biology and Conservation of Albatrosses, held in Hobart, Australia, in 1995. During this period, concern about the bycatch of ecologically-related species has increased to become a major issue in international fisheries management. Seabird bycatch, in particular, is now an important item on the agendas of regional fisheries management organizations (RFMOs). These developments, plus initiatives such as the International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries (formulated and endorsed by

the Food and Agriculture Organization of the United Nations), and attempts to reach agreements under the Convention on Migratory Species are outlined in the first part of the paper. In the second part, difficulties, limitations and barriers that have thwarted these international efforts are identified and examined. Some possible paths to circumvent these problems – drawn from experiences in other areas of concern relating to international wildlife conservation – are surveyed and their utility assessed in the third and final part. The paper thus provides a framework that will form the basis for discussion in one of the workshops (on international legislation and agreements) that follow the scientific presentations of the Conference.

Current status of the endangered Hawaiian Dark-rumped Petrel *Pterodroma phaeopygia sandwichensis* at Haleakalā and Hawaii Volcanoes National Parks

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The Hawaiian Dark-rumped Petrel *Pterodroma phaeopygia sandwichensis* is Hawaii's only endangered seabird species. Once found throughout the Hawaiian Islands, the species is now confined to high elevations. Habitat loss and predation by introduced predators caused the decline of this species. Currently, known nesting populations are located only on Haleakalā, Maui and Mauna Loa, Hawaii. Observations have been made of Hawaiian Dark-rumped Petrels flying to mountains on Kauai. However, nests have not been found. We present the status of the Haleakalā and Mauna Loa populations, population trends, current threats, and management activities.

Reproductive energetics of Antarctic fulmarine petrels

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We employed the doubly labelled water (DLW) technique to determine field metabolic rates (FMR) of four species of Antarctic fulmarine petrels breeding on Hop Island, Prydz Bay, Antarctica and used the FMR data, together with information on prey selection, to calculate population food requirements. We measured FMR of nestlings (seven age classes) and breeding adults of Antarctic Petrels *Thalassoica antarctica*, Pintado or Cape Petrels *Daption capense*, and Snow Petrels *Pagodroma nivea*, and nestling FMR (eight age classes) of Antarctic Fulmars *Fulmarus glacialisoides*. Nestling FMR ($\text{kJ}\cdot\text{d}^{-1}$), calculated from CO_2 production, increased linearly with mass in all four species. Nestling mass-specific FMR ($\text{kJ}\cdot\text{g}^{-1}\cdot\text{d}^{-1}$) decreased with increasing mass in Snow and Antarctic Petrels but not in Pintado Petrels and Antarctic Fulmars. Incubating adult petrels had lower FMRs than did birds provisioning nestlings for both Snow and Pintado Petrels. Neither mass-specific incubation FMR nor chick-provisioning FMR differed between the two species. Parental effort, expressed as the ratio of FMR/BMR, ranged from 1.23 in incubating Pintado Petrels to 4.56 in Snow Petrels provisioning nestlings. The average daily metabolizable energy of nestlings ranged from $375\text{ kJ}\cdot\text{d}^{-1}$ in Snow Petrels to $975\text{ kJ}\cdot\text{d}^{-1}$ in Antarctic Fulmars. On average, individual Antarctic Fulmar, Antarctic Petrel, Pintado

Petrel and Snow Petrel nestlings consumed 71 g, 57 g, 142 g, and 19 g of krill and 148 g, 95 g, 45 g, and 62 g of fish per day, respectively. Nestling fulmarine petrels on Hop Island consumed an average of 282 kg of krill and 522 kg of fish on a daily basis. Cumulatively, the Hop Island fulmarine petrel community removed 14 246 kg of krill and 26 503 kg of fish from the surrounding marine system to provision nestlings.

Muttonbird selectivity of Sooty Shearwater or Titi *Puffinus griseus* chicks harvested in New Zealand

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Chicks of Sooty Shearwaters *Puffinus griseus* harvested by Rakiura Maori on Putauhinu Island, south-west of Stewart Island, in the 1997, 1998 and 1999 muttonbirding seasons were a markedly non-random selection of the chicks available. Many very small chicks die of starvation in the late chick phase, but small live chicks averaging 531 g (ranging from 265 to 697 g) are also rejected by most muttonbirders. Up to 16% of the chicks fall at or below this reject size. Larger and more developed chicks are more vulnerable to harvest during the early part of the season when muttonbirders extract chicks from breeding burrows during the day. Presumably this selection results from concentration of harvesting on areas of the colony with larger than average chicks and/or where hatching was earlier and wing growth more advanced. Chicks are collected after they emerge from breeding burrows at night during the last half of the season. At first only relatively few and generally lighter chicks with more developed feathers emerge and selection by muttonbirders is relatively weak. By the middle and end of the season a more representative sample of the chicks remaining to fledge are out of burrows. By then chicks are super-abundant so the muttonbirders can be more selective. They strongly select heavier, less downy chicks and ones with longer wings from amongst the emerged chicks, presumably partly by gauging the chick's quality before deciding whether to pursue it. Harvest for most of the season is therefore concentrated on the bigger and better developed chicks, the very ones with an improved chance of survival and recruitment back into the breeding population. Demographic models will therefore have to incorporate chick quality as an important added dimension to avoid under-estimating harvest impacts and so protect the long-term sustainability of a culturally important traditional bird harvest for Rakiura Maori.

Extra-pair copulations in Waved Albatrosses *Phoebastria irrorata*

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Many socially monogamous birds participate in extra-pair copulations (EPCs) that may result in extra-pair fertilizations (EPFs), suggesting that EPC could be an effective alternative mating strategy for birds of both sexes. However, theoretical and empirical evidence predicts low levels of EPC in long-

lived, non-passerine taxa, including several procellariiform species. Waved Albatrosses *Phoebastria irrorata* are long-lived, colonial nesters thought to be socially and genetically monogamous. At their primary breeding site on Isla Española, Galápagos, Ecuador, individual males defend small areas within the colony during the days preceding egg-laying and attack other birds passing by these areas. These attacks typically end with what appears to be a copulation attempt. Anecdotal observations in the field by our group match this report: aggressive copulation attempts between apparently unpaired individuals occur. In an initial study, we collected blood from 16 chicks and their social parents to estimate the rate of extra-pair fertilizations in Waved Albatrosses. Our genetic analyses using multilocus minisatellite DNA fingerprinting revealed evidence of EPFs in four families and males were the excluded parent in all cases. These data suggest that Waved Albatrosses have an atypically high rate of EPF relative to taxa with similar life histories, including other procellariiforms. Here we report the results of our initial effort and outline an extensive behavioural and genetic study of EPC in Waved Albatrosses geared toward better understanding the context and fitness consequences of individuals' participation in EPCs.

Albatross response to survey vessels: implications for studies of distribution, abundance and prey consumption

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The study of albatross ecology at sea is complicated by their tendency to follow and attend vessels. Ship-following behaviour likely biases abundance estimates, blurs the correlation between distributions and habitat features over small scales, and inhibits the statistical analysis of dispersion patterns. These biases have important implications when estimating the size of rare and endangered populations, and prey consumption by abundant species. This paper illustrates how observations of recognizable ship-following individuals can be used to mitigate the biases of vessel-attendance. I surveyed albatross distributions off southern California between August 1996 and April 1999 using CalCOFI cruises as platforms of opportunity. I quantified the degree of albatross attraction to survey vessels, and estimated that standard 300-m strip transects overestimated their abundance by at least a factor of 3.57. Additionally, I modelled albatross ship-following behaviour and determined that 95% of recognizable Black-footed *Phoebastria nigripes* and Laysan *P. immutabilis* Albatrosses ceased to follow the survey vessel after 60 and 38 minutes, respectively. Using these models, I calculated that standard survey methods overestimated Black-footed Albatross abundance by an additional factor of 1.17 due to their ship-following behaviour. When these two biases were combined, standard survey techniques overestimated albatross abundance and squid consumption by a factor of four. Determining the degree of vessel-attraction and the temporal scale of ship-following will enhance our ability to monitor the distribution, abundance and consumption of albatross populations. Additionally, the accurate determination of at-sea dispersion patterns provides valuable information about foraging areas important for albatross conservation.

Overlap between satellite-tracked female Black-footed Albatross *Phoebastria nigripes* and longline fisheries in the eastern Pacific Ocean

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Fisheries bycatch impacts albatross populations globally. In the central north Pacific, Black-footed Albatrosses *Phoebastria nigripes* sustain substantial bycatch in the Hawaiian longline fishery, where an estimated 1–2% of the world population (58 500 breeding pairs) is taken yearly. Pelagic longline fleets not currently monitored by observer programmes are likely the source of additional mortality in the central and eastern north Pacific. Determining the overlap between longline fishing effort and albatross foraging zones is an important first step to identify potential sources of additional bycatch. I tracked four female albatross for a total of 109 days during their summer (July–September 1997–1999) dispersal and compared their movements to seasonal summaries of fishing effort from the Japanese eastern Pacific longline fishery. The tracked birds ranged across international boundaries and spent 22%, 26% and 52% of the time in U.S., Mexican and international waters, respectively. Determining the overlap between fisheries and albatross distributions was hindered by the inherent spatial and temporal variability of fishing effort. Whereas the analysis of summertime longline effort between 1981–1987 revealed potential overlap with albatross distributions, the pattern was not as clear when data from 1991–1997 were analyzed. At present, this research cannot directly evaluate whether Black-footed Albatross bycatch occurs in the Japanese eastern Pacific longline fishery. However, the available data do suggest that there is potential for albatross interactions with this fishery. These results underscore the need for ‘exploratory’ observer coverage in fisheries that overlap the ranges of albatross populations susceptible to bycatch and the importance of international cooperation in pelagic conservation.

Pelagic habitats of two sympatric north Pacific albatrosses nesting on Tern Island, Hawaii

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In the open ocean, areas of high production and biomass concentration often occur at topographic (i.e. shelf break) and hydrographic (i.e. front) features. Regions of sustained production and the predictable aggregation of prey are of great importance to predators foraging in patchy pelagic environments. We determined the habitats exploited by Black-footed *Phoebastria nigripes* and Laysan *P. immutabilis* Albatrosses during the brooding (within 18 days after chick hatched) and chick-rearing (18–140 days post-hatching) periods. Analyses of satellite telemetry data in conjunction with remotely-sensed sea surface temperature and chlorophyll concentrations from satellites revealed substantial differences in habitat preferences across genders and species. During the brooding period, for instance, Black-footed Albatrosses restricted their move-

ments to tropical waters (>20°C), whereas Laysan Albatrosses ventured into the cooler waters of the Transition Domain (15–12°C) and the Subarctic Frontal Zone (12–10°C). This pelagic segregation became even more striking with the expansion of the foraging ranges later in the breeding season. During the chick-rearing period, Black-footed Albatrosses commuted to the highly productive waters of the California Current and Laysan Albatrosses ventured into subarctic waters (<10°C) of the north-western Pacific and the Bering Sea. This research underscores the significance of temperate and subarctic continental shelves and boundary currents to albatrosses breeding in subtropical latitudes. Additionally, our results suggest that there exist gender-based and species-specific differences in the way albatrosses exploit the marine environment. Understanding these differences is vital to assess the susceptibility of different genders and species to bycatch in fisheries.

Abundance of plastic debris and ingestion by albatross on Kure Atoll, North-western Hawaiian Islands

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A study to compare the abundance of disposable cigarette lighters and chemical glowsticks with the incidence of ingestion by albatrosses was conducted at Kure Atoll, North-western Hawaiian Islands. Totals of 837 disposable lighters and 200 chemical glowsticks were collected opportunistically between 25 May and 23 July 1999. To examine occurrence of plastics ingested by Black-footed Albatrosses *Phoebastria nigripes* and Laysan Albatrosses *P. immutabilis*, 43 stomach content samples were collected. Plastics occurred in 100% of samples, disposable cigarette lighters occurred in 23% of Laysan Albatross samples (n = 6), and no glowsticks were recovered in regurgitations or chick carcasses. Items found in Laysan Albatross samples included: squid beaks; plastic pieces of various sizes; plastic pellets; plastic caps, tubing, bags and toys; disposable lighters; a toothbrush; fishing floats; styrofoam; pumice stones; walnuts and neoprene material. The average Black-footed Albatross regurgitation consisted mainly of squid beaks and monofilament nylon line. A correlation may exist between availability of plastics in a region and seabirds in the community that ingest plastic. To quantify the abundance and turnover rates of plastics available to seabirds at Kure we recommend continued collection of disposable lighters and glowsticks. In terms of conservation, to investigate negative human and commercial fishery impacts on reproductive success rates of albatrosses, future collections of regurgitations and necropsies of deceased chicks are necessary.

Experiments for reducing the incidental take of seabirds in tuna longline fisheries

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Many kinds of mitigation measures to reduce incidental catches of seabirds in tuna longline fisheries have been

developed in Japan during the past 10 years. Current experiments and research for reducing seabird mortality are reviewed. Incidental take of seabirds in longline fisheries can be mitigated by restricting their access to baited hooks during line setting. Tori poles, bird-scaring lines and streamers deployed astern of fishing vessels were developed and tested by Japanese tuna fishing vessels operating in the Southern Ocean. This mitigation method is now widely used by large fishing vessels. Additional improvements, including development of a machine-operated trouble-free system, optimization for smaller fishing vessels and instruction of proper deployment for fishers, will enhance the effectiveness and the wider use of tori poles. Other deterrent devices using high-pressure water, light, sound and electricity are also being studied. Increased hook sink rate is expected to reduce potential availability of baits for seabirds, especially if it is coupled with other deterrent devices. Movements of baited hooks are being analyzed, and the effects of propeller currents and line weighting on hook behaviour are being studied. Other possible mitigation measures, e.g., line setting at night, offal control and the use of artificial baits, are also being investigated. At present, improvements to the tori pole system combined with supplementary use of other methods seems the most practical measure for mitigating incidental take of seabirds by longline fisheries.

General rules for the sensitivity of long-lived species to increases in mortality, with special reference to albatrosses

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Albatrosses are well known to be among the animals with the lowest reproductive rates and the highest longevity. Decreases in numbers have been shown in several species to result from increased mortality due to interaction with human activities, in particular to accidental by-catch by long line fisheries. The effect of changes in mortality (or equivalently survival) on the growth regime in such long-lived species has been traditionally linked to a general 'K-species' syndrome, implying a high sensitivity of the growth rate to changes in survival. However, the sensitivity of growth rate to changes in survival does not depend on longevity when expressed in relative terms. We show that the disastrous effect of additional mortality in albatrosses and other long-lived species is mostly the consequence of a low maximum population growth rate. Across a wide range of species, the maximum growth rate varies inversely with generation time, as a result of the near constancy of the maximum multiplication rate per generation. This result is linked to the concept of the evolutionary invariant. Approximations of the maximum growth rate as a function of generation time are given. General rules for predicting changes in growth rate and population size as a result of changes in fecundity and survival are then developed. These results are discussed in relation to the conservation and management of albatross populations, with special reference to the Black-footed Albatross *Diomedea nigripes*.

Occurrence and death rate of sea birds off the coast of Bahia from 1994 to 1999 and new findings in Bahia and Brazil

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During a 10-year period we studied the death rate of seabirds along the coast of Bahia, Brazil. We surveyed the species that we found and identified the major mortality factors, besides developing an efficient technology for recovering debilitated birds. We also gathered important data on migratory routes through bird-banding. During the period extending from April to September 1994–1999, we explored the coast of Bahia and several beaches in Salvador, collecting any specimens found and documenting our findings through photographs, film, tachometer and GPS. We collected 5984 birds of 42 species, many of which were new records for Bahia and/or Brazil. We captured 28 banded birds, 18 of which had been banded in Portugal and two in Spain. We recovered and banded 60 birds of 13 species. The causes of death identified in that period agree with previous studies and show that malnutrition is a major mortality factor for seabirds along the Brazilian coast. In January 1999, an increase in the number of deaths among Cory's Shearwaters *Calonectris diomedea borealis* was attributed to a huge storm that happened at that time. The birds in good condition were collected, stuffed and deposited in Cetrel's scientific collection. The constant monitoring of the coast in Bahia has contributed to improving the understanding of migratory routes of oceanic birds, as well as recording the occurrence of new species in the state of Bahia and in Brazil.

A comparison of recruitment among 11 age classes of Black-footed Albatross *Phoebastria nigripes* chicks from Midway Atoll, 1960–79: evidence for El Niño and fisheries impacts

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Between November 1992 and April 1995, $\geq 90\%$ of the banded nesting Black-footed Albatrosses *Phoebastria nigripes* at Sand Island and $\geq 80\%$ of those at Eastern Island were recaptured at Midway Atoll. During this multi-year effort, 774 birds banded as chicks (known-age) and 1019 birds banded as adults were recaptured. Among the known-age birds were 669 from 11 age classes banded either by C.S. Robbins (71.9% from 10 age classes 1960–1972), or J.L. Ludwig (28.1% from the 1979 age class), yielding age-class specific survivorship and recruitment estimates for a 20-year period. All data for year classes

banded with aluminum bands were corrected for band loss to allow comparison with birds banded with stainless steel. Mean recruitment into the population from all age classes was 6.86% per year with an 18-fold range of actual recruitment (range 0.66 to 12%). Years of lowest recruitment were 1960, 1963, 1968 and 1969; several of the weak year-classes coincide with strong ENSO phenomena. Years of highest recruitment were 1964, 1965, 1966 and 1972. Overall, the combined data for all age classes suggest a mean recruitment of 6.9% into the population to balance a model-predicted natural adult mortality of 6%. This would provide replacements, but very little excess for population growth or to offset human sources of mortality. Over the 20-year period when these recruits entered the nesting population (1966–1986) these data suggest that a maximum population growth of about 17.6% was possible at Midway, assuming no significant exchange with other atoll populations. These and other recapture data on Pearl and Hermes and Tern Island nesting birds confirm that several important population parameters remain to be measured, including: age-specific breeding frequency in birds >30 years old; the degree of exchange of recruits among the leeward Hawaiian Islands; and the relationship of fledging rates to recruitment rates.

Solutions to the bycatch of seabirds in the Alaska freezer-longline cod fishery

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All Alaska longline fisheries face closure or limitation due to the potential hooking mortality of Short-tailed Albatross *Phoebastria albatrus*, an internationally endangered species, and now operate under regulations borrowed from other nations. In order to develop Alaska-specific and fleet-specific solutions to seabird bycatch, we compared seabird and fish catch rates among three seabird deterrent strategies and a control of no deterrent in the Pacific Cod *Gadus macrocephalus* fishery in the Bering Sea during August 1999. Vessels in this fleet are larger than 38 m, have crews of 20 or more, use automated baiting technology, and process and freeze fish at sea in trips up to 30 days. Deterrents were selected in collaboration with fishers and included setting lines: with added weight (4.5 kg of lead every 90 m), slack with a line shooter, and subsurface with a lining tube. Seabird abundance and behaviour (bait attacks per minute) were also quantified during each set. General Linear Modelling (GLM) techniques were used to compare catch rates among treatments (ANOVA), and to explore linkages between catch rates, seabird presence and behaviour, and physical factors. Preliminary results indicate that compared to the control, the bycatch of seabirds (Northern Fulmars *Fulmarus glacialis* and Short-tailed Shearwaters *Puffinus tenuirostris*) was reduced by 76% using added weight, 81% using the lining tube and increased by 35% using the line shooter. All deterrent strategies had little effect on fish catch rates. Contrary to longline bycatch dogma, seabird bycatch rates in Alaskan waters were three times greater at night compared to day, and seabird behaviour and abundance were poor predictors of seabird bycatch rates.

Solutions to the bycatch of seabirds in the Alaska Sablefish longline fishery

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Seabird mortalities occur in longline fisheries as seabirds feed on sinking baits when the gear is deployed. All Alaska longline fisheries face closure or limitation due to the potential hooking mortality of Short-tailed Albatross *Phoebastria albatrus*, an internationally endangered species, and now operate under regulations borrowed from other nations. In order to develop Alaska-specific and fleet-specific solutions to seabird bycatch, we compared seabird and fish catch rates among two seabird deterrent strategies and a control of no deterrent in the IFQ sablefish fishery in the Gulf of Alaska and Aleutian Islands in May and June of 1999. Vessels in this fleet tend to be less than 25 m, have crews of six persons, hand-bait hooks, and deliver iced fish in trips lasting up to a week. Deterrents were selected in collaboration with fishers and included lines with added weight to increase sink rates (0.23 kg of lead every 10 m) and a surface deterrent, paired streamer lines (tori lines). Seabird abundance and behaviour (bait attacks per minute) were also quantified during each set. General Linear Modeling (GLM) techniques were used to compare catch rates among treatments (ANOVA), and to explore linkages between catch rates, seabird presence and activity, and physical factors. Preliminary results indicate that, compared to controls, paired streamer lines were more effective at reducing seabird bycatch (93%) than were weighted lines (51%). Seabird behaviour and abundance were poor predictors of seabird bycatch rates.

The aggregation of the Wandering Albatross *Diomedea exulans* complex at the south-west Tasman continental shelf-break: 1. Composition and banding data

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The annual aggregation of individuals of the Wandering Albatross species complex *Diomedea exulans* in the inshore waters of New South Wales, Australia has been studied continuously since 1956. We have recently initiated a study programme in the waters of the continental shelf break at two sites east of the New South Wales coast. Herein we present data from the first season of this study. Observation at sea, moult analysis and banding data reveal a high proportion of individuals in the first several years of life. Banding recoveries indicated that a significant proportion of individuals frequent these waters on a regular basis.

Observation of moult in Grey-faced Petrels *Pterodroma macroptera gouldi* captured at sea in the south-western Tasman Sea

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The Grey-faced Petrel *Pterodroma macroptera gouldi* is a post-breeding visitor from New Zealand to the pelagic waters of New South Wales in the south-eastern Tasman Sea. The primary occurrence is between October and April, and a high proportion are in active moult during this period. Capture of this species from fishing vessels has enabled us to initiate a study at sea. Preliminary observations of moult status are presented herein. These results are compared with data obtained from beach-washed specimens and field observations.

Kia mau te tītī mo ake tonu atu: goals, design and methods for a research project to assess the sustainability of a traditional harvest of Sooty Shearwaters *Puffinus griseus* by Rakiura Māori

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The harvest of Sooty Shearwaters or Tītī *Puffinus griseus* (muttonbirds) on islands adjacent to Rakiura (Stewart Island) is one of the few remaining wildlife harvests managed entirely by Māori. The harvest is of great social and cultural importance to Rakiura Māori. The muttonbirders have requested this study to examine the sustainability of the harvest to ensure that the birds remain plentiful. This study will test and refine population monitoring methods; measure whether current Tītī harvests are sustainable; estimate sustainable yield; determine what sets the limit of present Tītī harvest levels so impacts of any future changes to technologies or harvest practices can be predicted; evaluate potential impacts of climate change, fisheries bycatch and pollutants on Tītī populations; and record and compare the understanding of Tītī ecology, harvest impacts and management with that from ecological science. Under this programme adults and chicks will be banded on both harvested and unharvested islands, the harvest observed, and survival of chicks and adults monitored. Harvest impacts will be estimated by computer simulation models. Trends in population on unharvested areas will be compared with trends on harvested sites to test the model's predictions of population changes. Tītī density on harvested and unharvested colonies will be compared for further rapid check of large-scale harvest impacts. Traditional environmental knowledge (matauranga) will be recorded using oral histories of experienced muttonbirders and questionnaires. Māori and eurocentric conservation philosophies will be compared using records of discussions with Tītī harvesters, environmental managers and conservation stakeholders. The research will be conducted by the University of Otago, but is directed by the Rakiura Tītī Islands Committee.

Solutions to the incidental capture of seabirds in longline fishing – progress in New Zealand

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Over the last five years a number of projects aimed at providing New Zealand longline fishers with more options for reducing incidental capture of seabirds have been completed. These include customizing bird-scaring (tori) lines for different types of vessels, development of underwater setting devices for tuna longline vessels, and measuring the sink rate of various types of longline gear, including weighted lines. In addition, an advisory officer position has been established to provide tuna fishers with advice on ways to reduce the likelihood of capturing seabirds while fishing. This initiative has proven to be very successful in terms of disseminating information and building relationships between the government and fishers. The government has recovered the costs of carrying out this work through a conservation services levy on the fishing industry. Funding of the development of the underwater setting devices has also been provided by the Australian Fisheries Management Authority and the Australian Fisheries Research and Development Fund. Joint projects between countries such as this one between New Zealand and Australia have many benefits, including shared effort and costs, faster results, exposure of the project to a wider audience, involvement of individuals with different skills and experience, and a coordinated response to solving the problem.

Albatrosses and longline fishing in waters off the west coast of Canada: identification of areas of potential bycatch

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Worldwide it is recognized that the bycatch of albatrosses in longline fisheries is a major conservation concern. Between May and September, the Black-footed Albatross *Phoebastria nigripes* is a common and abundant member of the pelagic seabird community off the west coast of British Columbia. Estimates of the numbers of birds within these waters during summer ranges from 2500 to more than 4000 individuals. The Laysan Albatross *P. immutabilis*, which probably numbers no more than 200 birds in summer, becomes the dominant albatross from October through April. The third species of North Pacific albatross, the endangered Short-tailed Albatross *P. albatrus*, infrequently wanders into Canadian waters primarily between April and October. In terms of the FAO's International Plan of Action-Seabirds, Canada is in the process of assessing the status of bycatch within its territorial waters. In this presentation, we discuss the spatial and temporal overlap between albatross distribution and longline fishing effort. From this analysis, we identify areas and times of high bycatch risk. With limited funding availability for deploying observers, the results of this analysis will serve as a useful

tool to focus (in space and time) observer effort in order to assess better the level of albatross mortality in longline fisheries.

The Procellariiformes and the Birds of North America Project

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The Birds of North America (BNA) project began as a joint venture of the American Ornithologists' Union (AOU) and the Academy of Natural Sciences of Philadelphia. The 700+ species of birds that breed in North America or in the AOU check-list region are the subjects of the individual BNA publications. Authors are generally experts on their species, and each species account provides an up-to-date and comprehensive summary of standard topics, including diet, limiting factors, and recommendations for future management and research. Approximately 500 accounts have been published thus far. Of these, 11 are of procellariiforms: Laysan Albatross *Phoebastria immutabilis*, Black-footed Albatross *P. nigripes*, Northern Fulmar *Fulmarus glacialis*, Bonin Petrel *Pterodroma hypoleuca*, Dark-rumped Petrel *P. phaeopygia*, Bulwer's Petrel *Bulweria bulwerii*, Manx Shearwater *Puffinus puffinus*, Newell's and Townsend's Shearwater *P. auricularis*, Wedge-tailed Shearwater *P. pacificus*, Ashy Storm Petrel *Oceanodroma homochroa*, and Leach's Storm Petrel *O. leucorhoa*. For more information, visit www.birdsofna.org or email bnab@birdsofna.org.

Wildlife Services – partners in island restoration

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Wildlife Services, as a unit of the U.S. Department of Agriculture's Animal and Plant Health Inspection Service, assists in solving problems that are created when species of wildlife cause damage to agriculture, effect urban or natural resources, as well as threaten human health and safety. We are a Federal cooperative programme that responds to requests by persons and agencies needing help in managing wildlife damage. Field operations are conducted in accordance with all Federal and State guidelines and in cooperation with wildlife management professionals from Federal and/or State agencies. Eradication programmes initiated in cooperation with various agencies have successfully eradicated rats *Rattus rattus* and *R. exulans* from four islands in the Northwest Hawaiian Islands. Wildlife Services programmes involving introduced predators have been successfully implemented elsewhere. A number of projects are currently underway and we would like to do more.

Use of weather systems by non-breeding Wandering Albatrosses *Diomedea exulans*

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The flights of 14 non-breeding Wandering Albatrosses *Diomedea exulans exulans*, *D. e. gibsoni*, and *D. e. antipodensis* were followed around the Tasman Sea and across the Indian, Pacific and Southern Oceans. Most flight paths tracked across winds within an arc of 110°–160° to following winds with occasional short or long flight into the wind. By using winds between and around LOWs and HIGHs, flights in all directions were achieved. A feature of all was a series of long direct flights, each of several hundred kilometres with little scatter of locations along the axis of the flight. This behaviour enabled an analysis of how the birds used weather systems to achieve their long-distance flights. Westward flights repeatedly used the south-west winds behind the cold fronts associated with southerly LOWs. These winds enabled the bird to fly to the north-west and, if this brought the bird ahead of an easterly moving HIGH, the E-NE winds blowing to the north of the HIGH were used to achieve further westerly movement. Eastward movement used westerly winds to the north of southern LOWs to fly north-east or south-east. In north-west or south-west winds direct easterly movement was achieved. Where an extensive blocking HIGH develops over the southern Pacific Ocean, a belt of accelerating winds can develop at the southern interface with circulating southern LOWs. These winds enable rapid eastward transoceanic flight. Long flights tended to zig-zag between 30°S–50°S, thus crossing oceanic interfaces and enhancing the chances of finding ephemeral foods.

Spatial interactions of albatrosses breeding on Marion Island with longline fisheries in the southern Indian Ocean: species, gender and seasonal effects

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Wandering Albatrosses *Diomedea exulans* and Grey-headed Albatrosses *Thalassarche chrysostoma* breeding on sub-Antarctic Marion Island are threatened by two major and spatially disjunct longline fisheries. These are the Southern Bluefin Tuna *Thunnus maccoyii* fishery, which is concentrated around the Subtropical Front, and the Patagonian

Toothfish *Dissostichus eleginoides* fishery, which is concentrated on the shelf area surrounding the island and at sea mounts. Wandering Albatrosses are killed less frequently in toothfish operations, although they are recorded in large numbers around these vessels. We tracked breeding Wandering Albatrosses and Grey-headed Albatrosses from Marion Island throughout their breeding season in order to assess the level of spatial interaction with these fisheries. Both species interacted most strongly with the toothfish industry during the early chick-rearing stage, when the birds had a more constricted foraging range. During the late chick-rearing and incubation stages, birds foraged farther north from the island, interacting more strongly with the tuna fishery. Male albatrosses showed a higher affinity for toothfish fishing areas than did females, with the difference being strongest during the chick-rearing period. Females spent more time foraging in the more distant tuna fishing areas. Wandering Albatrosses spent more time in the main toothfish fishing area than did Grey-headed Albatrosses, despite the fact that far more Grey-headed Albatrosses are killed by the Marion Island toothfish industry. These species, gender and seasonal differences in degree of exposure to both the risk of incidental mortality and supplementary feeding on offal will have important effects of the population dynamics and breeding success of these populations.

Proportions of Tristan and Wandering Albatrosses in incidental captures off the Brazilian coast

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Wandering Albatross *Diomedea exulans* and Tristan Albatross *D. dabbenena* were considered as subspecies of *D. exulans* until recently. Captures of both of these albatrosses have been counted together as belonging to the same species, *D. exulans*. The impacts on the Wandering Albatross from fishing-related mortality off the Brazilian coast are well known. However, a banded Tristan Albatross captured by a Brazilian fishing boat demonstrated that these birds are impacted as well. A sample of 10 captured birds was used to distinguish between Wandering and Tristan Albatrosses by comparing published data to measurements of both species such as culmen, tarsus and middle toe, and by means of discriminant analysis. Eight measurements were used in the discriminant analysis, of which culmen, distance between nostrils and culmen end, depth and width of bill at base, length of tarsus, and middle toe length with claw were selected for the model. Five birds were identified as Tristan Albatrosses (four females and one male), and five as Wandering Albatrosses (two females, two males and one indeterminate). Both species were discriminated without overlapping between the two groups, which are even far from each other on the canonical root. Despite the small sample size, this result shows a considerable proportion of Tristan Albatrosses in the longline fishing captures off southern Brazil. This is even more worrying when the small Tristan Albatross population size is taken into account. Thus, urgent measures are required to reduce the mortality caused by the Brazilian longline fishing fleet.

A new model of olfactory foraging by procellariiform seabirds

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This presentation reviews our current knowledge of how procellariiform seabirds use odour cues to locate patchily-distributed food resources over vast expanses of open ocean. I synthesize results from a variety of controlled experiments performed in the Southern Ocean and in the Bering Sea investigating this behaviour. These studies demonstrate a species-specific attraction of procellariiform seabirds to a variety of scented compounds associated with primary prey. These scented compounds include krill-related odours (pyrazine and trimethylamine), and crude fish extracts (cod liver oil and herring oil), as well as odours more closely associated with primary productivity (dimethyl sulfide, DMS). I review data collected in the context of global climatic regulation that suggest that at least one of these odours (DMS) can be associated with predictable bathymetry, including upwelling zones and sea mounts. Such odour features are not ephemeral, but can be present for days or weeks. Finally, I present a new model for olfactory foraging. This model suggests that procellariiform seabirds foraging over vast distances use large-scale odour features to recognize areas of high primary productivity where foraging is likely to be successful. Once in a profitable foraging area, procellariiform seabirds may switch behavioural strategies to use a combination of olfactory and visual cues to locate prey patches on a smaller scale.

Time in Exclusive Economic Zones by non-breeding Wandering Albatrosses *Diomedea exulans*: conservation consequences

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Fourteen non-breeding Wandering Albatrosses of three taxa, *Diomedea exulans exulans*, *D. e. gibsoni* and *D. e. antipodensis*, were satellite-tracked between 1992 and 1996 in the Southern Ocean between 30°E–180°–70°W for a total of 1127 days, providing 3965 locations. Eight *D. e. exulans* which were tracked during August to November around Australian waters between 110° and 160°E spent 52–100% of their time in the Australian Exclusive Economic Zone (EEZ). Three subsequently moved into and two across the Indian Ocean. Three *D. e. gibsoni* were tracked in the Tasman Sea and the south-west Pacific Ocean. One tracked from September to November spent 52% of its time in the EEZs of Australia and New Zealand. Two others tracked in January and February spent 23% and 33% of their time in Australian and New Zealand EEZs in the Tasman Sea. Two of three *D. e. antipodensis* tracked in the southern Pacific Ocean were tracked from the

New Zealand EEZ to the Chilean EEZ. One which returned to New Zealand waters was tracked for 373 days. All of these birds spent more than 50% of their tracked time in EEZs. The considerable time spent by non-breeding Wandering Albatrosses in EEZs gives host nations an opportunity to establish measures to reduce greatly bycatch losses from longline fishing. The mobility of these albatrosses between the EEZs of different nations suggests that such measures could be further enhanced by nations participating in the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention).

**Flight characteristics of the Chatham Albatross
Thalassarche impavida from satellite tracking**

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In the annual cycle of the Chatham Albatross *Thalassarche eremita*, three flight patterns were recognized: foraging flights while the birds were breeding, migration across the Pacific Ocean, and localized foraging at low latitudes off the north-west coast of South America. We hypothesized that the three modes of flight indicate different biological activity. Associated speeds, distances flown per day and other indices of activity were developed. These provide the first measurements for this species of the sustained speed of flight point-to-point over varied time periods, and for short and long distances throughout the year. These data and the analytical techniques show what can be obtained from a small number of individuals, and the confounding variables that result from the satellites' orbits and the transmitting characteristics of long-duration PTT experiments. The interrupted reception of transmitters through the non-availability of satellites may bias speed and distance measurements. Difficulties interpreting the data are discussed. Point-to-point flight speeds ranged up to 85 km/h and were a function of the time interval for the measurement. Daily rate of change of latitude and longitude and the minimum daily distances travelled were calculated. The results provide a guide to the design of satellite transmitter techniques for long distance and duration studies for other oceanic species. They also contribute to an understanding of where this species obtains its food and to interpreting foraging theory.

**Northern Royal Albatross *Diomedea sanfordi* behaviour
deduced from prototype loggers**

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Prototype geolocation data loggers were designed by Embedded Pty. Ltd. and fabricated by Sirtrack Ltd. They recorded time, light level, and temperature at 23-s intervals into flash

memory, which is potentially retained for 10 years. Different loggers from the British Antarctic Survey recorded time and light level only. Loggers were deployed at fixed points ashore and on the legs of Northern Royal Albatrosses *Diomedea sanfordi* at the Taiaroa Head colony in New Zealand. Data were recovered from four loggers, giving continuous monitoring and over 100 000 records. Examples illustrate recordings from a fixed point in the albatross breeding colony and from albatrosses while incubating ashore and flying or resting at sea. Two loggers recorded activity from 4.7 to 9.5 months at sea, including a round-the-world migration. Daily patterns at a fixed point ashore are contrasted with those from a bird. Easily discerned was the shift of local midday due to longitudinal movement by the bird; likewise the combinations of light and temperature for different behaviours (e.g. incubating with local flights; trans-oceanic flights; 'rest and recreation' activity). Differences suggested alternate positions of the legs during flight for two individuals. The periods around full moon are illustrated. The proportion of time spent flying and not-flying for different behaviours illustrates the consequences of not-flying on the point-to-point daily speeds obtained from both satellite tracking and geolocation loggers.

Phylogenetic relationships of Pacific *Pterodroma* petrels

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We report a molecular phylogeny of the avian genus *Pterodroma* (Order Procellariiformes: Family Procellariidae). We develop a finer-and-finer dissection of *Pterodroma* diversity focused on the 'Dark-rumped Petrel' which faces complex conservation issues. Using genes encoded on opposite strands of the mitochondrial genome, our study supplied a framework for delimitation of distinct phylogenetic units of Pacific Ocean *Pterodroma*. Firstly, our single gene data indicated these birds evolved diverse but discrete radiations between oceanic systems. In the Pacific Ocean we found rapid and early divergence of four taxa of 'long-winged' *Pterodroma* at the Juan Fernandez, Kermadec, Galapagos, and Hawaiian archipelagoes. Secondly, our multiple gene data focused on the sister-taxon, *phaeopygia* and *sandwichensis*, regarded traditionally as the 'Dark-rumped Petrel' biological species, breeding on the Galapagos and Hawaiian archipelagoes. The taxa diverged a relatively long time period ago and should be considered distinct species. Our data endorsed a higher conservation status on behalf of each species. Other interesting facts emerged from the data. No genetic structure between islands of the Galapagos could be detected in *phaeopygia*, perhaps indicative of frequent gene-flow within the archipelago. We also found genetic variation, comparable to *phaeopygia* populations, present in the dwindling Maui *sandwichensis* population. The variation may be a 'signature' of enormous populations once present at the archipelago before Polynesian contact. Further studies of extant small populations at other Hawaiian islands and the inclusion of ancient DNA studies of lava-tube (pre-Polynesian) and midden-site (post-Polynesian) bones may prove interesting and help reveal the original diversity of *Pterodroma* in the region.

Microsatellite characterization from the Northern Royal Albatross *Diomedea sanfordi*

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We report the characterization of dimeric and interrupted multimeric DNA microsatellite loci from the Northern Royal Albatross *Diomedea sanfordi*. The loci were discovered by creating plasmid cloned libraries of genomic DNA from this species. The clones were enriched for the presence of potential dimeric repeat regions. Positive clones, those identified by hybridization to target dimeric repeat oligonucleotides, were sequenced to obtain the potential microsatellite locus. In numerous cases flanking regions surrounding the microsatellite region were identified. Characterization of these regions enabled the design of specific amplification primers for the isolation of each locus. Members of the albatross genus *Diomedea* – including *amsterdamensis*, *antipodensis*, *chionoptera*, *epomophora*, *exulans*, *gibsoni*, and *sanfordi* – were surveyed by PCR amplification of the selected microsatellite loci. Fluorescent-labelled PCR products were size-fractionated by capillary electrophoresis using a PE Biosystems 3700 DNA Analyzer. Microsatellite profiles were established for each island population of each taxon to create a library of searchable allelic information. Philopatric behaviour of albatrosses, the return of birds to their island of natal origin, reinforces genetic subdivision and the establishment of unique population allelic complements. Birds can be typed by differing allelic frequencies in populations as well as the presence of discrete alleles, i.e. those uniquely limited to a single population. By cross-referencing of birds of unknown origin to the library of allelic data, we can establish taxon identification and island provenance. Most importantly, this technique may be of use in the future to trace birds killed in fishery bycatch to their natal island.

The last rat-free petrel colony?

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Ta'u Island, American Samoa (14°S, 169°W), is often referred to as the cradle of Polynesian exploration. Yet even in the island's earliest human history, the summit of Mt. Lata, the highest point on Ta'u, remained remote and mysterious. Today little has changed, with the exception of the pristine summit area now coming under the protection of the U.S. National Park Service as part of a 50-year lease signed with local village chiefs. American Samoa is the only U.S. territory in the southern hemisphere, and contains the only example of insular paleotropical cloud forest under U.S. jurisdiction. Sizeable petrel populations are being discovered here as part of the National Park's current efforts to assess seabird populations

and breeding areas in the territory. In support of similar claims by previous summit research trips, our preliminary observations suggest an absence of feral mammals, namely rats, cats and pigs, from the upper elevations of Mt. Lata. If further trapping reveals this is indeed true, the summit of Mt. Lata represents crucially unique breeding habitat for at least one, if not several, petrel and shearwater species believed to be nesting there (*Pterodroma rostrata*, *P. heraldica*, *P. brevipes*, *Puffinus lherminieri*, *P. pacificus*). We are interested in knowing where similar predator-free breeding areas remain world-wide, if any, and what procellariid species are present in those areas.

Estimating seabird bycatch in Brazil

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About 20 pelagic seabird species interact with both demersal and pelagic longliners off Brazil, mostly in waters south of 20°S. Currently there are about 35 bottom long-liners in southern Brazil and this number seems to be decreasing. Two studies have found bird capture rates of 0.32 and 0.1 birds/1000 hooks for this fishing technique. Birds with greater diving abilities, such as Great Shearwaters *Puffinus gravis* and *Procellaria* spp., are the main species captured. From the total fishing effort we estimate the Brazilian demersal longlining fleet kills 2201–6226 (average: 4214) seabirds/year, including 1341–3794 (2568) Great Shearwaters, 378–1070 (724) White-chinned Petrels *Procellaria aequinoctialis*, 103–292 (197) Spectacled Petrels *P. conspicillata*, 206–584 (395) Atlantic Yellow-nosed Albatrosses *Thalassarche chlororhynchos*, and 172–489 (329) Black-browed Albatrosses *T. melanophrys*. Currently, pelagic longliners in Brazil target mostly Broad-billed Swordfish *Xiphias gladius*, resulting, since 1994, in the widespread replacement of the heavier Japanese-style fishing gear with lighter and more buoyant monofilament long-lines. The fleet based in Brazilian ports is increasing steadily, mostly in north-eastern Brazil, with 58 vessels in 1998 compared to 45 the previous year, but only 22 vessels operate from southern ports and are more likely to interact with seabirds. Pelagic long-liners in three studies captured 0.09, 0.73 and 1.35 birds/1000 hooks. This wide variation is probably due to the larger geographic and temporal scope of the first study. Estimated annual mortality by the southern pelagic longlining Brazilian fleet ranges from 2165–4004 (average 3084) White-chinned Petrels, 1139–2107 (1623) Black-browed Albatrosses 484–896 (690) Yellow-nosed Albatrosses, 399–738 (568) Spectacled Petrels, 171–316 (243) Wandering Albatrosses *Diomedea exulans* 86–158 (122) Great Shearwaters, 29–53 (41) Antarctic Fulmars *Fulmarus glacialisoides* and 29–53 (416) Tristan Albatrosses *D. dabbenena*. Actual figures are probably closer to the estimated averages. There is significant mortality of the endangered Spectacled Petrels and Tristan Albatrosses, and of the vulnerable Atlantic Yellow-nosed and Wandering Albatrosses in Brazil. Conservation efforts for these species should consider changing fishing practices by the Brazilian fleet.

**Spatio-temporal distribution of White-chinned
Procellaria aequinoctialis and Spectacled *P. conspicillata*
Petrels off Brazil**

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Both White-chinned *Procellaria aequinoctialis* and Spectacled *P. conspicillata* Petrels occur off the Brazilian coast. Spectacled Petrels have recently been found to be common in south and south-east Brazilian waters, contrasting with the few records in Uruguay and Argentina. Nevertheless, little is known about at-sea distribution and seasonality of both species in that area. Olmos counted pelagic seabird flocks (followers) attending bottom long-liners operating on the southern Brazilian coast between 23 and 27°S (hereafter northern sector) on five cruises between 1995 and 1997, and made complementary observations aboard a pelagic long-liner operating at 26–29°S, 42–45°W in August 1999. Neves conducted censuses of following seabirds and both continuous and instantaneous censuses off the southern Brazilian coast during four cruises made in July, December, March–April and August 1997–1999 between 26–36°S (southern sector). Spectacled Petrels were the most abundant (>50% all recorded birds) species attending the vessels on the coastal shelf of the northern sector in March, May–June, October and November but were virtually absent in July and August, during the austral winter. White-chinned Petrels made up 35% of the birds observed during July–August and 4% in May–June, but only ~1% during the other months. An additional cruise made aboard a pelagic long-liner operating off the shelf between 26°30' and 28°40'S in August found Spectacled Petrels to be the dominant species in attending flocks (over 50% of all birds) while White-chinned Petrels made up only 1–5%. Interestingly, only White-chinned Petrels were recorded over shelf waters during this cruise, corroborating the previous data. Spectacled Petrels made up less than 15% of seabird records during standardized censuses in the southern sector, although present year-round, while White-chinned Petrels were more dominant during the winter (20–25% of bird records). Multiple regression models found that in both sectors Spectacled Petrel numbers were positively correlated both to depth and water temperature, but not to White-chinned Petrel numbers, but the association was stronger in the northern sector. White-chinned Petrel numbers were correlated to lower temperatures and depths in both sectors. Apparently, Spectacled Petrels prefer the deeper and warmer waters associated with the Brazil Current, whereas White-chinned Petrels are associated with colder waters that flow closer to the coast during the winter. Spectacled and White-chinned Petrels apparently segregate themselves by selecting different water masses, suggesting different ecological habits, which reinforces the case for specific status for the former. It is interesting that more White-chinned Petrels were killed by the pelagic long-liner studied by Olmos, despite being rarer than Spectacled Petrels, suggesting they are more adept at night foraging and diving.

**Foraging movements of Southern Giant Petrels
Macronectes giganteus on the Antarctic Peninsula:
preliminary findings of a satellite-tracking study during
the breeding season**

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Satellite telemetry was used to determine the foraging movements of Southern Giant Petrels *Macronectes giganteus* nesting in the vicinity of Palmer Station, western Antarctic Peninsula. Telemetry studies were conducted during the late incubation and the chick-rearing phases of the 1998/99 and 1999/00 breeding seasons. Although foraging patterns during 1998/99 were gender-specific, with females undertaking significantly longer trips than males, the overall pattern between breeding seasons was consistent. Instrumented birds typically followed the western Antarctic Peninsula shelf break as they moved south into the Bellingshausen Sea. Upon reaching this region, they turned west, paralleling residual summer ice sea before turning north to return to their breeding sites using the predominant westerly winds. Average trip lengths for excursions in excess of 200 km were 2600 km for the 1998/99 and 3000 km for the 1999/00 breeding seasons. These observations suggest that Southern Giant Petrels nesting in the vicinity of Anvers Island are taking advantage of foraging opportunities presented by the shelf break and ice edges south of their breeding sites. This is important because this area is currently not fished commercially, hence entanglement is not a significant factor affecting the demography of this population. In contrast to other breeding populations of Southern Giant Petrels, this regional population is currently increasing.

**Nocturnal behaviour of the endangered Dark-rumped
Petrel *Pterodroma phaeopygia phaeopygia* on the
Galápagos Islands**

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Although the Procellariiformes are predominantly nocturnal, there is little information about their behaviour at nesting colonies. We report on the behaviour and nocturnal activity pattern of the endangered Dark-rumped Petrel *Pterodroma phaeopygia phaeopygia* at several colonies in the highlands of Santa Cruz Island, Galápagos. A total of 733.8 hours of observation was made on 78 days between 5 June and 30 September 1990 (corresponding to late egg-laying/incubation and well into chick-rearing), to yield a total of 63.3 hours of nocturnal activity. A total of 253 petrels was sighted between 19h00 and 06h00. Of the 13 different behaviours observed, walking/running was the most frequent (25.4% of total), and sitting/standing (13.2%), landing (11.5%), flying (9.3%), circling in air (8.3%), falling through vegetation (7.7%), entering burrows (7.0%), vocalizing (6.0%), climbing vegetation (4.4%), exiting burrows (3.8%), preening/allopreening (2.2%), collecting vegetation/digging (0.7%), and fighting (0.5%) were the next most frequent behaviours observed. Each of the thirteen behaviours exhibited seasonal patterns of frequency that appear to relate to the breeding cycle and to the age and

status of the population. The data and methodology reported here could be useful in monitoring and assessing the status of other petrel colonies.

**Decline and recovery of the endangered Gould's Petrel
*Pterodroma leucoptera leucoptera***

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Cabbage Tree Island, off the east coast of Australia, is the sole breeding site of the endangered Gould's Petrel *Pterodroma leucoptera leucoptera*. In the early 1990s the petrel population had decreased to 1500 birds, with fewer than 250 pairs breeding. Breeding success was poor (<20%) and adult mortality on land exceeded the total reproductive output of the species (<50 fledglings a year). Causes of mortality were entanglement in the sticky fruits of the indigenous Birdlime Tree *Pisonia umbellifera* and heavy predation by two species of indigenous birds – Pied Currawongs *Strepera graculina* and Australian Ravens *Corvus coronoides*. These threats had arisen because of the degradation caused to the petrel's nesting habitat by the European Rabbit *Oryctolagus cuniculus*, introduced to the island in 1906. Remedial management actions implemented since 1993, including the eradication of rabbits from Cabbage Tree Island, have seen the petrel undergo a dramatic recovery. The breeding population now exceeds 750 pairs, producing more than 300 fledglings a year. The recovery of the Gould's Petrel over the last decade may warrant a change in its conservation status from 'endangered' to 'vulnerable'.

**Establishment of a second breeding colony of Gould's Petrel
Pterodroma leucoptera leucoptera by translocation of fledglings**

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Limited to a single breeding colony on a small island close to a large industrial city, Gould's Petrel *Pterodroma leucoptera leucoptera* is vulnerable to extinction through localized catastrophe. As a safeguard to such an event, a programme has recently been undertaken to establish a second breeding colony of Gould's Petrel on another island. We first undertook a trial translocation of nestlings within their current breeding grounds on Cabbage Tree Island to investigate whether such translocations could be achieved without any discernible detriment to the individual birds involved. This experimental translocation, incorporating the use of artificial feeding, resulted in a small increase in fledging mass, but no reduction in fledging success or change to the time of departure of fledglings. Translocated fledglings that have since returned to Cabbage Tree Island have all returned to their adopted nest site. A total of 200 nestlings has since been translocated to nearby Boondelbah Island. This paper describes the procedures involved, and assesses the initial success of this conservation initiative.

Reproductive success and adult survival in decreasing populations of Black-footed *Phoebastria nigripes* and Laysan *P. immutabilis* Albatrosses on Midway Atoll, 1997–2000

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Breeding population counts of Black-footed *Phoebastria nigripes* and Laysan *P. immutabilis* Albatrosses in the North-western Hawaiian Islands indicate recent decreases for both species. For the Black-footed Albatross, adult mortality resulting from interaction with long-line fisheries in the Gulf of Alaska has been documented and may be a factor in declining populations. For the Laysan Albatross, recent decreases in reproductive success could result from several factors, including insufficient food resources, which may also be contributing to population declines. In 1997 the U.S. Fish and Wildlife Service, in cooperation with the Oceanic Society, established a long-term programme to monitor albatrosses and other seabirds breeding on Midway Atoll National Wildlife Refuge. Up to 33 plots were established to monitor the reproductive success of Black-footed and Laysan albatross breeding on Sand Island. In 12 of these ('known-individual' plots), all breeding adults were banded and returning birds were confirmed each year. Here we present data collected during 1997–2000 on breeding population size, reproductive success, and adult return rate for both albatross species. Estimates of adult survival, 'recapture probability' (which may indicate degree of movement in and out of plots), and 'proportion of residents' (which may indicate incidence of skipped breeding years) will be obtained for the known-individual plots from modified Cormack-Jolly-Seber mark-recapture analyses using the program SURVIV. Contrasts between the two species in success and survival may help explain or confirm reasons for the recent population declines in each species.

The Chatham Albatross *Thalassarche eremita*: at home and abroad

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The Chatham Albatross *Thalassarche eremita* is one of the least known of the world's albatross taxa. Breeding solely at The Pyramid, a small and precipitous rock in the Chatham Islands, there are few published records of its biology and distribution. From 1974–1999 there have been sporadic short research visits with overnight stays totalling 86 observation days. Three cohorts of chicks were banded from 1993–1995. First returns were at four years of age and no breeding had occurred by six years. Three breeding productivity estimates and one complete nest count have been made during 1995–1999. The potential breeding population is now estimated to

be 5300 pairs. Satellite tracking of 13 birds, band returns, fisheries bycatch and observations at sea have provided the first definitive picture of distribution at sea in the South Pacific. Breeding records suggest laying in August–September, incubation of 66–72 days, hatching October–December and probable chick fledging February–April. Mean annual productivity of chicks ranges from 50–65%, with parts of the island as low as 34% due to seasonally-adverse weather or degraded nesting habitat. Localized foraging is indicated within 300 km over the shelf edge, and slope from 1000–4500 m during the breeding season. Following breeding, birds migrate to Chile and Peru for 3–4 months ‘rest and recreation’ over similar depths, returning via a more northerly route in July–August. As an endangered species they remain vulnerable to habitat change at The Pyramid, sporadic harvesting of chicks by Chatham Islanders and fisheries bycatch in New Zealand, Chile and Peru.

**Around the world with the Northern Royal Albatross
*Diomedea sanfordi***

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Northern Royal Albatross *Diomedea sanfordi* have been tracked from Taiaroa Head and the Chatham Islands in New Zealand during parts of their biennial breeding cycle, using satellite PTTs and a prototype data logger. Records analysed total 2620 days (6000 records) and 500 days (75 000 records of time, temperature and light level), respectively. A PTT attached by harness was successfully deployed and transmitted for 564 days, using intermittent transmissions to conserve battery life. Distinctive patterns of behaviour away from the nesting colonies will be demonstrated; short-distance foraging over shelf and shelf break while nesting; express dispersal to non-breeding ‘holiday’ locations in South American waters; ‘rest and recreation’ over shelf and shelf break; express migratory return to the breeding location. When not at the nest site, birds are only in flight from 25–50% of the time, depending on the behaviour pattern selected. In spite of this, while on migration, point to point progression at the rate of 10 degrees longitude per day is common, indicating regular mean flight speeds over 90 km/h. When on migration most flying is in the daytime, but is more often at night while on ‘rest and recreation’. The full migratory route demonstrated by transmitters and logger is circumpolar and downwind. The Northern Royal Albatross spends the majority of its feeding life in the Exclusive Economic Zones of New Zealand, Chile, Argentina, Uruguay, with migratory transition through South African and Australian waters.

Effect of line tension and fleet length on longline sink rates

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Slow-sinking longlines tend to hook and drown more seabirds than do longlines that sink fast. Two factors that may affect longline sink rates are the tension of the line when deployed

from vessels and the length of the fleet (i.e. length of longline deployed between the anchors on either end of the line). Line tension occurs when longlines are pulled from the vessel by the drag of the line already deployed and by the anchor (this is the typical line-setting method used by autoline vessels). This tension could slow sink rates and allow seabirds more time to attack baited hooks. Similarly, short fleets of line might sink faster than long fleets due to the proportionally greater pull-down effect of the anchor. We examined the effect of line tension and fleet length on longline sink rates on an autoliner fishing in the Norwegian ling and tusk fishery. The vessel fished with 9-mm Fiskevegn swivel-line, set the line at about seven knots, used a Mustad autobaiter and a Mustad line shooter. The line shooter consisted of two hydraulically-driven opposing wheels which gripped the longline and expelled it from the vessel at about 0.5 knots faster than the vessel’s speed. This caused the line to fall in loose coils about 0.5 m behind the vessel. The line entered the water 2 m to one side of the propeller turbulence. To avoid spurious depth readings caused by wave action, we measured sink rates from 3–20 m depth with time–depth sensors attached to the longline at the join of each magazine of line (a magazine is 1780 m of line). The longline was deployed in fleets of two, three, four and five magazines. The sink rate of longline set tightly averaged 15.3 cm/s as against 16.2 cm/s for line set loosely; overall, the difference was not significant (ANOVA, $F_{1,53} = 2.65$, $P = 0.11$). However, there was a significant interaction between line tension and fleet length ($F_{3,53} = 4.82$, $P = 0.005$). In the three-magazine fleets loosely set lines sank, on average, 4.5 cm/s faster than tightly set lines (Tukey test, $q = 5.05$, $P < 0.05$). All other comparisons of line tension within fleet length were statistically indistinguishable. The result for the three-magazine fleets is counterintuitive and is not supported by results for fleets of other lengths. We have no logical explanation for this difference. The three-magazine fleets were set across the current and it is possible that the current may have accelerated the sink rate of the loosely set lines. It would be prudent to suggest that further data are required on line tension and fleet lengths under different sea conditions. The sections of line in five-magazine fleets all sank at similar rates (14.5–14.8 cm/s (ANOVA, $F_{3,29} = 0.06$, $P = 0.98$). We made no measurements of longline sink rates in surface waters, which is where most seabird attacks on bait occurs. It is possible that line tension might affect bird strike rate, if not line sink rate, in this part of the water. Since longline is fairly stiff, and since line set without tension falls in ‘open’ coils near-vertically into the water, loosely set line tends to penetrate the water column to about 30 cm or so immediately on deployment. The longline then tends to assume in cross section a ‘w’ shape, with about half the line deeper than the other. This nuance of a loosely set line may place some of the baits deeper than others and make some baits less available to seabirds. Although for most fleets line tension did not affect sink rates there may be benefit in setting lines loosely. Loose lines enter the water about 0.5 m astern whereas tensioned lines enter the water about 10 m astern. At seven knots setting speed this 9.5-m difference would be covered in less than four seconds, which seems a trivial amount of time. However, assuming loosely set lines commence sinking at maximum rates upon water entry, loose lines might reach about 50 cm deep (i.e. 4 s x 16 cm/s) by the time lines set under tension enter the water. Consequently, in potential contrast to the findings in the experiment, the significance of line tension to seabird conservation could be hidden in the subtleties of longline performance in the very upper reaches of the water column.

How fast do longlines sink?

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Seabird mortality in longline fisheries can be reduced if fishing vessels use lines that sink fast. The sinking rate of longlines is only one of the attributes for which longlines have been engineered, the others being high breaking strains, low water absorption, durability and wear resistance, elasticity, ease of coiling and cost effectiveness. These features vary with the materials used to make longlines, their construction (i.e. number of strands, tightness of weave), whether or not they are coated with tar (resists abrasion and water absorption) and their specific weight in water – factors that also affect sink rates and the likelihood of catching seabirds. Fiskevegn A.S (Norway) swivel-lines (longline fitted with metal swivels, stoppers, snoods and hooks) are used in all the major bottom fisheries in the world. Fiskevegn longlines are synthetic, being made of silver fibre, polyester or Danline (polysteel). Danline is a mix of polypropylene and polyethelene, has a breaking strain of 1.7 tonnes (for 10-mm diameter rope) and, with a specific weight of 0.91, floats in water unless lines contain leaded cores. Polyester lines are the heaviest Fiskevegn produce commercially: they have a specific weight of 1.38 and a breaking strain of 1.4 tonnes. Silver lines are made from a blend of Danline and polyester, have a specific weight of 1.1 and a breaking strain of 1.7 tonnes. Longlines made from silver fibre are the commonest lines sold by Fiskevegn. Silver lines and polyester lines are the only longlines made commercially by Fiskevegn. We compared the sink rates in seawater of eight Fiskevegn swivel-lines: 5.5-mm, 7-mm, 9-mm and 11.5-mm Silver (all tarred), 9-mm polyester (tarred) and 6-mm, 8-mm and 10-mm Danline lead-rope (centres contained a strand of lead). Each line was sunk 14 times, as indicated by a power analysis of a subsample of estimates. To simulate their use on fishing vessels, we soaked the lines in seawater for 24 hours before the trial. We measured sink rates using a diver on the seabed, an intercom to the surface and a stopwatch. Each line was 10 m in length and swivels were spaced 1.4 m apart. Hooks and snoods were the same for each line. At the end of the trial we attached mackerel bait (5-cm lengths) to hooks on the 9-mm polyester line to determine the effect of added bait on sink rates. We included in the comparison the sink rates (as measured by time–depth sensors between 3 m and 20 m depth) of 9-mm silver rope longlines deployed from a typical Norwegian longliner after correcting the results for the effect of bait. We analysed differences in sink rates with analysis of variance and Tukey pairwise multiple comparison test. Danline lead-rope sank (45–52 cm/s) about twice as fast as silver (18–21 cm/s) and polyester (23.3 cm/s) ropes. Sink rates of the three Danlines differed significantly (ANOVA, $F_{2,41} = 25.7$, $P < 0.001$); rates for both 8-mm and 10-mm lines were statistically indistinguishable but both sank significantly faster than the 6-mm line ($q = 6.8$ – 9.9 , $P < 0.001$ for both comparisons). Sink rates of the four silver lines, the 9-mm polyester line and the 9-mm polyester line with added bait differed significantly ($F_{6,97} = 80.2$, $P < 0.001$); rates for the 7-mm and 11.5-mm silver lines were statistically indistinguishable, but all other combinations, incl 1.7, $P < 0.001$ for all comparisons). The addition of bait slowed line sink rates by about 11%. Baited, 9-mm silver line sank significantly faster ($q = 6.9$, $P < 0.001$, 18 cm/s) in the trial than when deployed from a longline vessel (16.1

cm/s); the difference is presumably due to ship's propeller turbulence and wave action. Conclusions are 1) as expected, leaded Danline sank much faster than either the polyester line or the silver line; 2) polyester longline sank 5 cm/s (28%) faster than the equivalent silver line; and 3) sink rate differences of only few cm/s may seem insubstantial, but effects should be cumulative: lines with high specific weights deployed from vessels beneath the water's surface (via an underwater funnel) and away from propeller upwelling should greatly reduce the availability of baits to seabirds. Heavy lines have an important role to play in efforts to reduce seabird strike in longline fisheries.

Foraging ranges of *Islands Diego Ramirez* albatrosses and potential interactions with fisheries

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The waters surrounding the nations of South America contain four known breeding sites for albatrosses, three of which occur in Chilean territory. With an annual fish catch of six million tonnes, Chile has the largest fishery in South America. To determine the potential overlap between albatrosses and fisheries we satellite-tracked during incubation and early chick rearing 16 Black-browed *Thalassarche melanophrys* and 16 Grey-headed *T. chrysostoma* albatrosses at Isla Gonzalo, *Islands Diego Ramirez* (56.5°S), southern Chile. Black-browed Albatrosses ranged from 36°S to Antarctic waters at 67°S, but concentrated foraging over the narrow Chilean continental shelf. In contrast Grey-headed Albatrosses were more oceanic, rarely ventured over shelf waters, and ranged from 45–120°W and to 68°S. Distances covered per foraging trip ranged from 1000–7700 km for Black-browed Albatrosses and from 2500–12 000 km for Grey-headed Albatrosses. When foraging, Black-browed Albatrosses shared the same waters (continental shelf and shelf break) as hook fisheries for Patagonian Toothfish *Dissostichus eleginoides*, hake *Merluccius australis* and ling *Genypterus blacodes*. Overlap between these fisheries and Grey-headed Albatrosses on foraging flights appeared to be minimal.

Effect of line weights on sinking rate of longlines

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We conducted an experiment on an autoline vessel using a Fiskevegn 11.5-mm swivel-line (specific weight of 1.10) to derive a sinking rate that would minimise the capture of albatrosses. Sinking rates of lines deployed into propeller turbulence (which probably slowed sink rate) varied as a function of distance between line weights. Asymptotic sink rates (0.1–0.15 m/s) were achieved with 70 m between 6.5-kg weights. Sink rates to 4-m depth were greatest with 35 m (0.44 m/s) and 50 m (0.33 m/s) between weights. For vessels using bird-scaring lines, longline sink rates >0.3 m/s should greatly reduce the incidental capture of albatrosses.

The importance of mate retention and experience on breeding frequency and success in Southern Buller's Albatross *Thalassarche bulleri bulleri*

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We investigated whether breeding frequency and breeding success were correlated with the length of the pair bond and breeding experience in Southern Buller's Albatrosses *Thalassarche bulleri bulleri* at The Snares over the period 1992 to 1999. Overall, 91.4% of birds that retained their mate bred in successive years (yr_n and yr_{n+1}). The breeding frequency of pairs of first time breeders (84%) was similar in yr_{n+1} to that of pairs with at least one experienced bird (86%). The breeding frequency of newly established pairs with one or two experienced birds was similar. Overall breeding success was 71% and breeding outcome did not appear to affect breeding frequency. Lowest breeding success was associated with the attempts of first-time breeders (56%); performance of these pairs improved until the third attempt (79%). In pairs with at least one experienced bird, breeding success differed little between the first and subsequent attempts. Divorce was rare (1.1–6.3% annually). Generally, both first-time and former breeders mated with birds of similar status (85% and 58%, respectively). When breeders changed their partner as a result of divorce or death, the average interval before breeding again was 2.0 years for males and 2.3 years for females. Thus, the time taken to obtain a new partner has a lifetime reproductive cost.

Effects of a snow storm period on survival and growth of nestling Wilson's Storm Petrels *Oceanites oceanicus*

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The adaptive significance of lipid accumulation in nestling procellariiform seabirds is not yet fully understood. Most of the recent studies do not support the traditional view that nestling obesity is an insurance against food shortages affecting the population as a whole. Rather they suggest that chicks are chronically overfed, because food shortages on the level of individual pairs might be inevitable if feeding frequencies are relatively low and parents feed independently of one another. Wilson's Storm Petrels *Oceanites oceanicus* are abundant breeders on sub-Antarctic and Antarctic islands. Blocking of nest entrances by snow is reportedly a major reason for chick mortality in Wilson's Storm Petrels in the southern parts of the species' range. Frequently, adults are not able to dig up blocked entrances and are prevented from feeding their chicks. In this study, breeding burrows in a colony on King George Island (South Shetland Islands, Maritime Antarctic) were blocked by snow for up to four nights in a six-day-period of heavy snowstorms. The blocked entrances resulted in mass loss, decreased growth rates and starvation of a part of the chicks under investigation. Furthermore, chicks that were supplemented with cod-liver oil (pure lipids) suffered a significantly lower mortality than controls. The results therefore suggest that lipid accumulation in this species might serve as

an insurance against periods of limited food delivery (due to bad weather conditions) affecting the birds on a population level.

Declines in Sooty Shearwaters *Puffinus griseus* on their breeding grounds: the effects of bycatch or global warming?

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The population of Sooty Shearwaters *Puffinus griseus* on the Snares Islands, south of New Zealand, was estimated to be 2 750 000 breeding pairs between 1969 and 1971. Estimates made between 1997 and 1999 indicate that the population size on the Snares is considerably lower than the 1982 estimate. This apparent decline is concurrent with the species' virtual extinction on the New Zealand mainland. I discuss whether this apparent decline is real or simply a function of sampling techniques. Possible mechanisms for a decline are then discussed. Fisheries bycatch is postulated as the likely cause of the majority of the decrease. The effects of global warming on rainfall during critical periods in the species' life history can not be discounted. It is considered important to make full estimates of remaining Sooty Shearwater populations to establish a baseline to indicate future population trends.

Environmental conditions affecting the foraging energetics of Wandering Albatrosses *Diomedea exulans*: inter-annual differences

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Wandering Albatrosses *Diomedea exulans* maintain a remarkably constant annual reproductive success (c. 72%). Their success may be related to their ability to buffer the impact of low food availability by relying on body reserves and by adjusting foraging effort in order to match environmental conditions. We examined this by measuring the changes in body mass and costs of foraging in relation to activity and flight behaviour of adult Wandering Albatrosses breeding in the south-western Indian Ocean during the austral summers of 1998 and 1999. A total of 40 birds was injected with doubly-labelled water, and equipped with satellite transmitters and leg-mounted wet-dry loggers. In 1999, birds spent on average 2.5 days more at sea, travelled 30% farther and increased the frequency of landings and takeoffs by 37% when compared to 1998. The frequency of landings was significantly correlated to time at sea and thus, likely explained the increase in energy expenditure of foraging trips between years (4.52 ± 0.5 vs. 5.31 ± 0.9 Watts kg^{-1} , for 1998 and 1999, respectively). Although the total mass gain was 36% higher in 1999, the daily rate of mass gain was identical in both years. The results of the present study suggest that Wandering Albatrosses moderate their foraging effort to match the environmental conditions by increasing the frequency of landings and takeoffs. Also, the fact that body condition of birds in 1999 was lower than compared to 1998 (i.e. significantly higher total body water), suggests that adults rely upon body reserves when environmental conditions are less than optimal.

**Do different nesting habitats influence
St. Lazaria storm petrels?**

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We evaluated productivity and population changes of Fork-tailed *Oceanodroma furcata* and Leach's *O. leucorhoa* Storm Petrels among different habitats at St. Lazaria Island, Alaska, yearly from 1994 to 1999. Storm petrels nest across the island among three habitats dominated by grass *Elymus arenarius*, Salmonberry *Rubus spectabilis*, and mature Sitka Spruce *Picea sitchensis* forest. We examined hatching success and timing as part of the productivity analyses, and burrow entrance density and occupancy rates for population analyses. Whereas each habitat type provides a different microhabitat which may result in differential productivity, preliminary analyses showed similar productivity rates among them. Initial analyses show that burrow densities across all habitat types did not change appreciably from year to year, while productivity and burrow occupancy rates did fluctuate among years.

The aggregation of the Wandering Albatross *Diomedea exulans* species complex at the south-western Tasman Sea continental shelf-break: the occurrence of dark pigmentation in the tomtia and unguis

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In the austral winter of 1999, several albatross of the *Diomedea exulans* species complex exhibiting extensive dark bill pigmentation were observed during voyages into the pelagic waters of New South Wales, Australia. These individuals bore a striking resemblance to the Amsterdam Albatross *Diomedea amsterdamensis*. This led us to examine the tomtia and unguis of various *Diomedea* albatrosses both at sea and in the hand. Our preliminary results are presented herein and indicate that dark pigmentation in the tomtia and unguis is not restricted to the Amsterdam Albatross but is apparent in other members of the *exulans* group to varying degrees.

**The relationship between age and primary moult of
Indian Ocean Yellow-nosed Albatross *Thalassarche carteri* captured in the South-west Tasman Sea**

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Indian Ocean Yellow-nosed Albatross *Thalassarche carteri* are seasonal visitors to the coastal and pelagic waters of New South Wales in the south-eastern Tasman Sea. The primary occurrence is between May and August, corresponding to the season in which the breeding islands are vacated. This species regularly attends fishing vessels, allowing the opportunity for capture and study at sea. During the period 1994 to 1999 a

large number of individuals was banded and their age and primary moult status recorded. The sample includes individuals of known age and provenance. The regime of primary moult and its progression with increasing age has been deduced. This is discussed in comparison to moult data from Black-browed Albatross *T. melanophrys*, Grey-headed Albatross *T. chrysostoma* and Wandering Albatross *Diomedea exulans* from Bird Island, South Georgia.

Seabird bycatch reduction in longline fisheries: an industry perspective

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In 1995 the North Pacific Longline Association was unexpectedly notified by the National Marine Fisheries Service that freezer-longliners had taken two Short-tailed Albatrosses *Phoebastria albatrus* – a highly endangered species. The Association immediately developed a set of seabird bycatch reduction regulations through a private notice-and-comment rulemaking procedure. The regulations were adopted by the North Pacific Fishery Management Council. The Association then undertook a variety of outreach measures to inform longliners in the North Pacific and around the world of seabird bycatch problems. This presentation examines the life history of the Short-tailed Albatross in some detail, including recovery efforts by Hiroshi Hasegawa. It identifies albatrosses and other seabird species taken by longliners off Alaska, examines specific methods of seabird avoidance, describes generally the joint research efforts by the longline industry and the University of Washington Sea Grant Program. Finally it describes efforts to communicate with longliners worldwide.

Telemetry reduces colony attendance by Sooty Shearwaters *Puffinus griseus*

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Twenty-four imitation satellite transmitters (ISTs) were attached to breeding Sooty Shearwater *Puffinus griseus* adults late in the 1998/99 breeding season at Taiaroa Head, Otago Peninsula, New Zealand. There was no evidence of a difference in mass, mass change, size of adults or breeding success for individuals carrying ISTs compared to non-treatment birds. However, colony attendance was reduced by 39% from early March to mid-April 1999 in IST-carrying birds, but not at all amongst non-IST or non-handled birds. No difference in ensuing mass, size and emergence date of chicks was detected between treatment and control groups. The maximum attachment duration for an IST using glue was 21 days, but one bird lost its transmitter sometime between 3 and 31 days. Harnesses may be needed to study prolonged foraging behaviour late in the breeding season. Satellite-tracking studies will overestimate foraging trip lengths and possibly underestimate food provided to chicks if the reduced colony attendance detected in this study is a widespread problem.

Protecting Alaska's islands from rodent introductions

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Introduced alien predators can devastate island bird populations. Rats and house mice will be introduced to additional Alaskan islands unless preventive measures are taken. The Alaska Maritime Refuge has a programme to deal with this threat: 1) Pribilof Islands Prevention – harbours at St. Paul and St. George are likely paths for rodent invasion. Defenses set up in 1993 have been expanded and improved. These consist of maintaining traps and poison stations, community education, local shipwreck response capabilities, expelling infested vessels, and development of regulations. To date, several rats have been killed in preventive stations at St. Paul, and there is no evidence of rats becoming established. The local communities are taking ownership in the programme. 2) Shipwreck Response – personnel have been trained and response kits have been developed. Rodenticides are the primary tool, but their use would be limited to bait stations. Due to the ruggedness of many islands, we plan to pursue permits for aerial poison dispersal. 3) Outreach – rodent-free ships pose no threat! Through direct contact with the shipping industry, newspaper advertisements, and distribution of free rodent prevention kits, efforts are being made to clean up vessels. These activities have centred around ships using the Pribilof Islands, and appear to be effective. This programme may be expanded to other areas of coastal Alaska.

Seabird mortality in the waters of the Atlantic Ocean off Uruguay

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The high productivity of the waters off the coast of Uruguay makes it host to 28 species of pelagic seabirds, including albatrosses. In the process of local studies, in order to identify the level of interaction and evaluate proposed international mitigation measures, Uruguay developed a project to address these questions, with the support of the Bonn Convention on Migratory Species. In Uruguay there are eight longline fishing boats operating in national and international waters, setting an average of 12 000 hooks every 10 days, that allowed us to survey 1 500 000 hooks during these investigations. The bycatch rate has not been greater than 1.7 birds/1000 hooks, which represents a marked improvement compared to previous years. Nevertheless, the lack of surveys of all the boats in the fleet, an increase in fishing effort, the possibility that demersal longliners may start operating in Uruguayan waters, and the exclusion of other fishing methods, as well as intentional mortality, could make this value an underestimation. In the present work the causes of seabird mortality are highlighted and examined. The mortality of seabirds in Uruguay is a new chapter in the history of environmental problems of a country with little conservation tradition. Controls in the application of mitigation measures are a challenge to public fisheries regulators presently out of funds. External aid in logistics and lobbying would play an important role. The international character of this problem necessitates and justifies external aid.

Body size effects and rates of cytochrome-*b* evolution in tube-nosed seabirds

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Variation in rates of molecular evolution now appears to be widespread. The demonstration that body size is correlated with rates of molecular evolution suggests that physiological and ecological factors may be involved in molecular rate variation, but large-scale comparative studies are still lacking. Here we use complete cytochrome-*b* sequences from 85 species of tube-nosed seabirds (order Procellariiformes) and five outgroup species of penguins (order Sphenisciformes) to test for an association between body mass and rates of molecular evolution within the Procellariiformes. Cladistic analysis of the 90 sequences estimates a phylogeny largely consistent with the traditional taxonomy of the Procellariiformes. The Diomedidae, Procellariidae, and Pelecanoididae are monophyletic, whereas the Hydrobatidae is basal and paraphyletic. However, the two subfamilies within the Hydrobatidae (Hydrobatinae and Oceanitinae) are monophyletic. Likelihood ratio and *F*-ratio tests detect significant deviation from clock-like evolution in our data. Using a sign test for an association between body mass and branch length in the seabird phylogeny we find that larger taxa tend to have shorter terminal branch lengths than smaller taxa. This observation suggests that rates of mitochondrial DNA evolution are lower in larger taxa. Rate calibrations based on the fossil record reveal concordant body size effects. Our results support previous findings of body size effects and show that this effect can be significant even within a single avian order. We interpret these results as evidence for a metabolic rate effect, as the species in this order exhibit large differences in metabolic rates which are known to be highly correlated with body mass in this group. From this, we suggest that even lineage-specific molecular clocks may not be tenable if calibrations involve taxa with different metabolic rates.

Incidental catch of seabirds by longline fisheries in Alaska

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The incidental catch of seabirds by longline fisheries is a conservation issue in Alaska. National Marine Fisheries Service (NMFS)-certified observers record seabirds and fish species caught by longline fisheries for Pacific Cod *Gadus macrocephalus* and other groundfish in the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA). Total estimated annual mortality of seabirds in the Alaskan longline groundfish fisheries was 14 000 birds between 1993 and 1997, rang-

ing from 9400 birds in 1993 to 20 200 birds in 1995. Approximately 83% of the take occurred in the BSAI region. The estimated annual bycatch rate was 0.090 birds/1000 hooks in the BSAI and 0.057 birds/1000 hooks in the GOA regions between 1993 and 1997. Northern Fulmars *Fulmarus glacialis* represented about 66% of the total estimated bycatch of all bird species, Glaucous *Larus hyperboreus* and Glaucous-winged *L. glaucescens* Gulls contributed 18%, whereas Laysan Albatrosses *Phoebastria immutabilis* accounted for 5% and Black-footed Albatrosses *P. nigripes* were about 4% of the total. During the period from 1993 to 1997, only one Short-tailed Albatross *P. albatrus* was recorded in the observer sample and the estimated annual take averaged one for this species. NMFS implemented regulations in May 1997 requiring longline groundfish vessels to use seabird avoidance measures, and in 1998, similar regulations were enacted for the Pacific Halibut *Hippoglossus stenolepis* fishery. Continued data collection by NMFS-certified observers and improved data analyses will allow the effectiveness of these bird avoidance measures to be monitored.

The spectacular spread of Northern Fulmars *Fulmarus glacialis* in the North Atlantic over the last 300 years: facts and fairy tales reviewed

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Northern Fulmars *Fulmarus glacialis* have progressively colonized many offshore islands and mainland coasts of the temperate North Atlantic. In the early 1950s, the late James Fisher summarized the first 250 years of this remarkable spread, but the Northern Fulmar is still colonizing new sites and coastal areas and is now abundant in sea areas where until recently hardly any fulmars were seen. Although many North Atlantic seabirds increased only after human persecution and exploitation came largely to a halt, early in the 20th century, the increase of the Northern Fulmar commenced sometime during the 18th century. Explanations to account for the success of this bird have varied, but most focus on the effect of additional supplies of food, first from the Arctic whaling industry and later from discarded fishery waste in commercial fisheries. In this presentation, an update of the spread of the Northern Fulmar is presented, together with new material that might help explain the observed trends.

The demographic profile of the endangered population of Wandering Albatrosses *Diomedea exulans* on Macquarie Island: work in progress

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The population of Wandering Albatrosses *Diomedea exulans* on Macquarie Island, diminished as a result of sealers and other mariners in the 1800s, has more recently been reduced to critical levels as a result of mortality associated with longline fishing. A long-term monitoring programme was

established in 1994 to assess the demographic parameters and survival prospects for the population. To date, Wandering Albatrosses have consistently shown a biennial breeding pattern with 95% of successful breeders returning to breed after two seasons. In 1998/99, 15 eggs were laid, more than has been recorded for the last two decades. Breeding success averages 56% but is highly variable, mainly attributable to variation in hatching success. Incubation averages 79–80 days, with shifts averaging almost nine days. Currently, the breeding population is estimated to be 20 pairs. In 1998/99, the age of the breeding birds of known age (26 of the 30 birds) ranged between 8 and 36 years (mean 16.5 years). The young age of recently recruited birds is suggestive of elevated mortality levels in the recent past. Determination of levels of survival over time are ongoing. The total population is estimated to be 65 birds.

Foraging strategies and foraging activity of breeding Southern Royal Albatross *Diomedea epomophora* on Campbell Island, New Zealand during incubation: preliminary findings

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The main breeding population of Southern Royal Albatross *Diomedea epomophora* (previously *D. epomophora epomophora*) is on Campbell Island (52°30'S, 169°E) in the New Zealand sub-Antarctic sector. The characteristics of foraging trips during the latter half of incubation (January to early February) were investigated in this study. Satellite tracks were obtained for 10 birds (seven females and three males) during foraging. These birds were also fitted with wet-dry data loggers to investigate their behaviour at sea. These data were integrated with environmental data using the purpose-built program 'Diomedea' (Centre d'Etudes Biologiques de Chizé). Total distance flown by tracked birds ranged from 2898 km to 6589 km (mean 4262 km). The mean duration of foraging trips during the study period was 10.37 days (n = 52, ±0.41 SE, range 5.5 to 16 days). There was no significant difference between male and female trip duration. Trip duration was shorter towards the end of incubation. Satellite tracks show that the birds commuted directly to one or several main foraging sites. The most used site was a shelf edge just south of the Snares Islands. More time was spent on the water with depths of 250 m than at any other depth.

A national plan of action for reducing the incidental catch of seabirds in longline fisheries

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Concerns about the incidental catch of seabirds in the world's longline fisheries led to the endorsement of the International Plan of Action for Reducing the Incidental Catch of Seabirds

in Longline Fisheries (IPOA–Seabirds) by the Food and Agriculture Organization of the United Nations' Committee on Fisheries in February 1999. The voluntary IPOA–Seabirds applies to States with longline fisheries and would be implemented through the development of National Plans of Action, no later than early 2001. The U.S. NPOA–Seabirds contains the following themes:

- 1) Regional assessments of seabird interactions with longline fisheries;
- 2) If a problem exists, then actions should be taken – data collection; prescription of mitigation measures; research and development; and outreach about seabird bycatch;
- 3) Annual regional reports on the status of NPOA–Seabirds implementation;
- 4) Cooperative efforts between NMFS and FWS on seabird bycatch issues and research; and
- 5) A national commitment to advocate the development of National Plans of Action within international fora.

By working cooperatively, fishermen, managers, regional fishery management councils, scientists, and the public will use this national framework to achieve a balanced solution to the seabird bycatch problem, promoting continuing sustainability of our national marine resources.

Nesting habitat selection by Grey-headed *Thalassarche chrysostoma* and Black-browed *T. melanophrys* Albatrosses at Gonzalo Island, Diego Ramirez, Chile

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There are only two countries in South America where albatrosses breed, Ecuador and Chile. Of three Chilean sites, Diego Ramirez is important because it holds 12% of the breeding population of Grey-headed Albatross *Thalassarche chrysostoma* and has unique mud flats habitats. Gonzalo is the second largest island of D. Ramirez Archipelago. It is 1.16 km long and 522 m at the widest section, 140 m maximum elevation and has irregular topography. The coast shows the erosive action of sea. Most of the island is covered by dense tussock *Paradichloa flabellata*. Using a topographic map we recorded the spatial distribution of all the albatross nesting areas and counted all active nests, in 1997 and 1999. We distinguished three categories of nesting habitats: Mud Flats, Tussock Cliffs and Coastal Terraces. We estimated nest density per unit area, on selected sites. Mud Flats are preferred by Black-browed Albatrosses *T. melanophrys* and Tussock Cliffs by Grey-headed Albatrosses. Total numbers of active nests during 1997 were: 3128 Grey headed and 4005 Black-browed Albatrosses. Grey-headed Albatross nest in low densities in the three categories of habitats. Mud flats are preferred by Black-browed Albatrosses, where they have the highest densities. Mud Flats occur along the drainage lines of topography and have a tendency to accumulate rainwater; this may cause problems to potential nesters. Grey-headed Albatrosses may nest in the periphery of mud flats and in low numbers. This habitat apparently does not exist in other

nesting localities in the sub-Antarctic. Its formation is in part consequence of nest construction using leaves of tussock grass.

Do worn flight feathers affect breeding frequency in the Black-footed Albatross *Phoebastria nigripes*?

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Breeding and moulting are temporally exclusive in albatrosses. The number of flight feathers replaced is influenced by a bird's previous breeding experience. A bird that breeds successfully in successive years could retain several two- and three-year-old primary feathers that may force it to skip a breeding season to replace all worn flight feathers. During the 1999 breeding season, we examined flight feather wear and studied reproductive success of 838 individually-marked, nesting Black-footed Albatrosses *Phoebastria nigripes* on Tern Island, French Frigate Shoals. The following breeding season we resighted all study birds to determine breeding status and to examine the number of feathers replaced. We predicted that birds with more worn flight feathers would be less likely to return to breed than birds with fewer worn flight feathers. In addition, we expected failed breeders to be more likely to return than successful breeders regardless of feather wear. We observed that successful breeders replaced fewer worn flight feathers than did failed breeders, supporting the theory of a time constraint between breeding and molting. However, this constraint does not appear to limit future breeding options. Logistic regression analysis indicates that reproductive success and flight feather wear were not significantly related to the probability of returning to breed the following season. Contrary to what we expected, individuals that failed and did not return to breed on average had the fewest worn flight feathers. Factors such as local climatic effects (rainstorms and high surf), oceanic conditions that affect foraging, and body condition should also be considered when investigating breeding frequency.

Population genetics of Black-footed Albatrosses *Phoebastria nigripes*: preliminary results regarding bycatch specimens and migration patterns

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We have recently begun an extensive multi-year, multi-gene survey of genetic variation among Black-footed *Phoebastria nigripes* and Laysan *P. immutabilis* Albatross colonies in the North Pacific Ocean. Our work is shaped by three questions. Can genetic markers serve as identifiers of the source colonies of bycatch birds? Is social philopatry reflected as genetic philopatry in Black-footed and Laysan Albatrosses? Does an association exist between individual genotype and choice of mate in these species? We propose a multilocus approach to allow effective resolution of the above questions. To date, we have developed a set of molecular markers, both mitochondrial and nuclear, for analysis of genetic variation within and among colonies of Black-footed and Laysan Albatrosses. This presentation will outline preliminary results which suggest that

some mitochondrial markers are geography-specific for Black-footed Albatrosses, and we present preliminary data on migration rates among colonies.

Population changes of albatrosses and petrels in the Indian Ocean: fisheries, global changes or what else?

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Populations of petrels and albatrosses have shown various trends in the Southern Ocean, with some species decreasing, others being stable with more or less fluctuations, and others increasing. Several factors are suspected to affect the dynamics of populations of pelagic seabirds. In this study we show that combining long-term population studies and satellite telemetry can help to determine the various reasons for population changes in southern procellariiform populations. Fisheries have impacted seabird populations but we show that it is often difficult to prove that fisheries are the only cause for the decline of a population because an extensive amount of data is often necessary, and in particular, data on fisheries are often lacking. The climatic anomalies that affect oceanographic features such as sea-surface temperature (SST) and sea-ice extent are likely to affect the biotic environment, and consequently top marine predators such as albatrosses and petrels. Here we show that warm SST anomalies had a negative effect on the breeding success of species foraging mainly south of the Antarctic Polar Front in Antarctic waters, but a positive effect on species foraging mainly north of the Antarctic Polar Front in sub-Antarctic waters. We also show that sea-ice extent affects the survival and breeding performances of petrels in Antarctica. For the same species, demographic parameters can vary extensively between sites and are mainly explained by the environment exploited by the population. We conclude that populations of seabirds from the same locality will be affected differently by global warming, depending on their foraging zones, and that the effects of fisheries may be obscured by this complexity.

Foraging behaviour in petrels and albatrosses and optimal use of wind by Wandering Albatrosses *Diomedea exulans*

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Since 1989 many studies have been carried out on the foraging behaviour of petrels and albatrosses that have demonstrated the ability of these birds to rely on distant resources. We show that a large variety of foraging strategies exists within Procellariiformes that allow populations to exploit more or less distant food resources. Yet many aspects of their foraging behaviour remain poorly known, such as the forag-

ing behaviour of non-breeding birds. We present here some recent results based on satellite telemetry and geo-location systems on movements of non-breeding Wandering Albatrosses *Diomedea exulans*. It is generally assumed that Wandering Albatrosses use the energy of the wind to soar at very low cost and increase flight speeds to maximize distance covered. We used heart rate measurements as instantaneous indices of energy expenditure in conjunction with measures of foraging behaviour and activity to determine the influence of wind patterns on flight speed and activity of male Wandering Albatrosses. We show that when flying with favourable tail or side winds, Wandering Albatrosses can achieve very high flight speeds while expending very little energy. On a larger scale, we show that in order for birds to have the highest probability of experiencing favourable winds, Wandering Albatrosses use predictable weather systems to engage in a stereotypical flight pattern of large looping tracks. When heading north, albatrosses soar in anti-clockwise loops, and to the south, movements are in a clockwise direction. Thus, the capacity to integrate instantaneous eco-physiological measures using remote sensing technologies with records of large-scale flight and wind patterns allows us to understand better the complex interplay between the evolution of morphological, physiological and behavioural adaptations of albatrosses.

The dispersion of albatross species in the waters of the Falkland Islands

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Systematic surveys of seabirds and marine mammals have been conducted from various vessels in the waters around the Falkland Islands since February 1998. During these surveys nine species of albatross have been recorded. The most numerous of these, the Black-browed Albatross *Thalassarche melanophrys*, breeds in internationally important numbers in the Falkland Islands. During the breeding season, Black-browed Albatrosses were most numerous in inshore waters. Outside the breeding season, the highest concentrations of birds were recorded farther offshore. At all times of year, Black-browed Albatrosses were commoner over the shallower waters of the Patagonian Shelf than over deeper, oceanic, waters. Of the other eight species recorded, the Southern Royal *Diomedea epomophora* and Northern Royal *D. sanfordi*, Wandering *D. exulans* and Grey-headed *T. chrysostoma* Albatrosses were recorded regularly, whereas Light-mantled *Phoebastria palpebrata*, Sooty *P. fusca*, and 'Shy' *T. cauta* species group Albatrosses were recorded as vagrants. Southern Royal Albatrosses were more common than Northern Royal Albatrosses by a factor of about eight to one. Royal Albatrosses were more common over Patagonian Shelf waters, whereas Wandering Albatrosses were recorded more often in deeper oceanic waters. Grey-headed Albatrosses were commonest in oceanic waters but were found in Patagonian Shelf waters in late summer and autumn. A sound knowledge of the at-sea dispersion patterns of albatrosses and other seabirds in Falkland Islands waters is important for assessing the potential effects on seabirds of human activities, such as fishing and hydrocarbon exploration and exploitation.

Seabird– and seal–fisheries interactions in an Australian trawl fishery

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From 1997 to 2000, contacts between seabirds and seals following vessels with fishing gear were recorded on two Australian trawlers catching Patagonian Toothfish *Dissostichus eleginoides* around Macquarie Island (MI, 54°30'S, 158°55'E) and Heard (53°05'S, 73°30'E) and McDonald Islands (HIMI, 53°03'S, 72°36'E). Totals of 47 042 and 148 593 bird and seal sightings were made at MI and at HIMI, respectively. Of 631 shots/hauls at MI, 263 shots and 344 hauls were observed, and 620 shots and 699 hauls of a total of 1324 shots/hauls were monitored at HIMI. Interactions occurred in 308 and 283 of observed shots and hauls, respectively, at HIMI; at MI contacts between wildlife and fishing gear was noted in 58 and 124 of shots and hauls observed. A total of 637 and 1696 contacts were observed at MI and HIMI, respectively, of which 98% (622 at MI, 1656 at HIMI) did not incur any injuries. At MI no deaths or serious injuries were reported during observation periods, but one Southern Elephant Seal *Mirounga leonina* may have died in the net outside observation times. During shots at HIMI, four Pintado or Cape Petrels *Daption capense* were reported to be injured seriously and one Pintado Petrel and one giant petrel *Macronectes* sp. were killed. Another three Pintado Petrels may have sustained serious injuries, two died and another two are likely to have died during hauls. The low number of serious incidences is mainly ascribed to the 'clean' and safe fishing practices by the vessels involved.

Long-term decreases in albatrosses and petrels in Prydz Bay, East Antarctica

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At-sea abundances of four Southern Ocean species, Light-mantled Albatross *Phoebastria palpebrata*, Wandering Alba-

tross *Diomedea exulans*, Northern Giant Petrel *Macronectes halli* and White-chinned Petrel *Procellaria aequinoctialis* decreased significantly in the Prydz Bay region, East Antarctica, between 1980/81 and 1997/98. Light-mantled Albatrosses decreased by 82%, Wandering Albatrosses by 83%, Northern Giant Petrels by 99% and White-chinned Petrels by 95%. Individuals of all four species are known to be caught on longlines in Southern Ocean longline fisheries. These decreases in at-sea abundance are substantially greater than those reported from breeding colonies. Whereas the decreases may reflect a contraction or change in their at-sea distributions, the time span of these decreases (18 years) suggests that at-sea abundance may be a more sensitive indicator of population trends than what is possible from colony census data.

Why monitor health of free-ranging seabirds?

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Free-ranging pelagic seabirds comprise a significant biomass of avian fauna in the Hawaiian Islands. In many islands, populations of birds are increasing due to effective management of nesting habitat such as predator control. However, increasing numbers of birds increases possibilities of disease outbreak, which could be particularly severe in pelagic seabirds which aggregate in large numbers and in high density. Like other demographic parameters in populations, such as reproductive success and population size, morbidity and mortality are important factors that are often overlooked by managers. However, baseline information on causes of morbidity and mortality in free-ranging seabirds can be important for managers. For example, data on baseline health of Laysan Albatross *Phoebastria immutabilis* allowed us to evaluate the extent and effects of lead poisoning on birds on Midway Atoll and provide management recommendations for its mitigation. An unusual mortality of Wedge-tailed Shearwaters *Puffinus pacificus* on Oahu was attributed to unusual weather patterns that year. Systematically evaluating relative importance of causes of morbidity and mortality in seabird populations can provide the manager with valuable insight into the potential impact of these mortality/morbidity causes on populations. This information thereby allows managers to focus limited resources on mitigating factors that impact populations most severely.