Survey for Arctic-breeding Shorebirds in the Tuamotu Archipelago, French Polynesia, March 2003

Prepared by

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Executive Summary

In March 2003, biologists from the U.S. Fish and Wildlife Service and U.S. Geological Survey joined an international expedition headed by biologists from La Société d'Ornithologie de Polynésie and Wildland Consultants of New Zealand and traveled to remote atolls in the Tuamotu Archipelago, French Polynesia. The objectives of this collaborative venture were to (1) determine the presence and approximate numbers of resident and migratory birds and mammalian pests on several, mostly uninhabited, atolls in the central and southern Tuamotu Archipelago, (2) search for color-marked Bristle-thighed Curlews (*Numenius tahitiensis*), and where possible, capture and collect blood samples from individuals of this species, (3) conduct pelagic surveys for seabirds, and (4) promote cooperative bird research in the Central Pacific.

Between 4 and 26 March, we visited one island group and nine atolls spread across 1,400 km between Mangareva (23˚.12S 134˚.97W) and Fakarava (16˚.19S 145˚.75W). We conducted surveys for birds over a total of about 60 linear kilometers on atolls. Survey effort varied by atoll depending on logistics. We detected 30 species of birds and three species of introduced mammals (i.e., Pacific Rat [*Rattus exulans*], Ship Rat [*R. rattus*], and feral House Cat [*Felis catus*]) on the atolls and islands. The most numerous avian species were White Tern (*Gygis alba*), followed by Brown Noddy (*Anous stolidus*), Red-footed Booby (*Sula sula*), and Lesser Frigatebird (*Fregata ariel*). Four shorebird species were detected, including Bristle-thighed Curlew, Wandering Tattler (*Heteroscelus incanus*), Pacific Golden-Plover (*Pluvialis fulva*), and Tuamotu Sandpiper (*Prosobonia cancellatus*).

We counted a total of 268 Bristle-thighed Curlews but did not encounter any banded individuals. This prevented us from directly linking wintering sites in the Tuamotu Archipelago with breeding, staging, or other wintering sites where this species has been banded. Curlews were found on all atolls, regardless of if an atoll was dominated by native vegetation or altered habitats, or if it was rat-free or rat-infested. Most curlews were detected in coastal habitats either on the ocean (44% of detections) or lagoon (41%)

shores of atolls. Fewer were found in open shrub areas in the interiors of motu (9%) and on unvegetated flats (i.e., in oa) between motu (6%). We captured and collected blood samples from three curlews. These birds were slightly heavier than expected for birds in mid-March, but weights were well within the range for individuals at the conclusion of the pre-migratory fattening period. All captured birds had very bright breeding plumage with molt scores indicative of a recently completed wing, tail, and body molt. We tested several capture methods and provide recommendations on how to capture curlews more effectively in the future.

Thirty-eight of the 64 Pacific Golden-Plovers detected during surveys were at Haraiki. The remaining atolls had between one and nine birds each. Pacific Golden-Plovers were usually found in groups of two or three along the lagoon (71%) or ocean (23%) shores of atolls. Plovers did not appear to be territorial and some birds were beginning to molt into breeding plumage. We counted a total of 339 Wandering Tattlers spread across all atolls. Our observations are consistent with previous reports that wintering tattlers occur alone or in pairs, and that they frequently establish winter territories. We observed tattlers in natural habitats (e.g., reef flats and beaches) as well as man-made habitats (e.g., lawns, telephone poles, abandoned buildings in Rikitea, Mangareva). Most tattlers were detected in ocean (47%) and lagoon (42%) shores and reefs. Fewer were seen in unvegetated oa (7%) or the vegetated interiors of motu (4%). Some tattlers had begun molting into breeding plumage.

We conducted twelve pelagic bird surveys over a total of 502 km of open ocean while traveling between atolls. Nearly 1,500 individual birds (623 within pelagic survey area) belonging to 25 species were recorded. The most common birds observed were Brown Noddy, White Tern, and Red-footed Booby.

The information collected during this expedition will assist La Société d'Ornithologie de Polynésie, the local non-governmental organization in French Polynesia and the group that is at the forefront of bird conservation in the country, to move towards its primary goal of understanding bird and pest distributions in the Tuamotu Archipelago. This

information will help them to decide which atolls should (1) be designated as conservation sites, (2) undergo mammal eradication to protect endangered species and nesting seabirds and, (3) be used as reintroduction or relocation sites for endangered Tuamotu Sandpipers and Polynesian Ground-Doves. Understandably, biologists and conservationists in Polynesia and New Zealand are primarily tasked with conserving the threatened and endangered endemic species of the Central Pacific. Species that are relatively more abundant and not designated as directly threatened with extinction, like the migrant shorebirds, are not usually the focus of their research or conservation efforts. However, migrant shorebirds will likely benefit from future efforts aimed at conservation of terrestrial endemics because such endeavors work towards conserving and restoring the health of natural systems.

Background

At the South Pacific Regional Environment Program (SPREP) sponsored Central Pacific Flyway Bird Working Group meeting at Rarotonga, Cook Islands, in July 2002, scientists and conservation administrators from the governments of the Cook Islands, Kiribati, Republic of French Polynesia, and the U.S. agreed to a major multi-national conservation initiative. The goals of this initiative were to (1) provide an informal forum to facilitate, coordinate, enhance, and harmonize bird research, management, monitoring, and education activities within the Central Pacific Flyway (CPF; Fig. 1), and (2) provide a framework to link national bird programs in the CPF and promote bird conservation throughout the flyway.

A necessary first step in pursuing this goal is to ensure that information on bird diversity, distribution, and abundance is available for the CPF. Unfortunately, contemporary information on the status of avian species is lacking for many atolls and islands in this region. Such information is essential for the identification of priority areas for conservation and management. To help fill gaps in the CPF database, an international expedition was planned to visit remote atolls in the central and southern Tuamotu Archipelago. Scientists from La Société d'Ornithologie de Polynésie (SOP-Manu), Wildland Consultants of New Zealand, U.S. Fish and Wildlife Service (USFWS) in Alaska and Hawaii, and U.S. Geological Survey (USGS) in Alaska combined funds and personnel to conduct this expedition. This report summarizes the activities and results of this effort, with a focus on the shorebirds that breed in the Arctic and winter in the Central Pacific.

The specific objectives of this effort were to:

1. Determine the presence and approximate numbers of resident and migratory birds and the presence of mammalian pests on several, mostly uninhabited atolls, of the central and southern Tuamotu Archipelago. Biologists from French Polynesia, Cook Islands, and New Zealand focused on searching for endangered species,

particularly the Tuamotu Sandpiper and the Polynesian Ground-Dove, and documenting the presence of mammalian pests. We focused on assessing the abundance and habitat use of shorebird species that breed in the Arctic and winter in the Central Pacific, including the Bristle-thighed Curlew, a species of concern.

2. Search for color-marked Bristle-thighed Curlews, and where possible, capture and collect blood samples from individuals of this species. Samples will be used to conduct a genetic population study to determine if breeding populations segregate on the wintering grounds.

3. Conduct pelagic surveys for seabirds. This information will represent the first systematic pelagic data from this region of the world.

4. Discuss with colleagues in the CPF the next steps in promoting bird conservation research involving the United States and Central Pacific nations.

Arctic-breeding Shorebirds that Winter in the Central Pacific

There are three shorebird species that breed in the Arctic and have significant portions of their populations (i.e., >25%) spend the winter in the Central Pacific. These include the Bristle-thighed Curlew, Pacific Golden-Plover, and Wandering Tattler (see Appendix 1 for all scientific names).

The Bristle-thighed Curlew nests in two areas in western Alaska and winters exclusively on small islands and atolls in Oceania, particularly from the northwestern Hawaiian Islands southwest to the Marshall Islands, south to Fiji, and east to the Pitcairn Islands (Marks et al. 2002). The Bristle-thighed Curlew is listed as a Vulnerable species by the International Union for Conservation of Nature and Natural Resources (IUCN) and as a National Species of Conservation Concern by the U.S. Department of Interior (DOI). Several migratory bird conservation initiatives highlight the vulnerability of this species, including the U.S. Shorebird Conservation Plan (Brown et al. 2001) and the Bird

Conservation Priorities and a Draft Avifauna Conservation Strategy for the Pacific Islands Region (Sherley 2001). Concern stems from (1) the unknown status of the population that presently numbers about 7,000 breeding birds, and (2) direct and indirect threats to curlews on the wintering grounds from invasive species (Marks and Redmond 1994, Marks et al. 2002).

Our primary motivation to participate in this expedition was to take the opportunity to collect information that would help us evaluate the current status of the curlew population. By collecting blood samples from captured curlews across their winter range we would be able to conduct the genetic analysis necessary to determine if birds from the two breeding populations segregate on the wintering grounds. Such segregation would require management at a fine geographic scale. It was outside of the scope of this current venture to address the concern related to threats posed directly and indirectly by invasive species. However, other researchers have documented that curlews on the wintering grounds are particularly vulnerable to introduced mammals (Gill and Redmond 1992, Marks et al. 2002) because most individuals experience a flightless period during molt (Marks and Redmond 1994). Flightless molt is a characteristic evolved on predator-free atolls and is unique to Bristle-thighed Curlews among shorebirds. Future, more detailed, studies are needed to determine how curlews respond to introduced mammals to adequately assess the effect of predators on curlews. For example, do curlews move to predator-free atolls or motu to molt? Do rats reduce the vegetation on which molting birds depend for cover (Marks and Redmond 1994)? Do rat-induced changes in vegetation and invertebrate fauna reduce the availability of curlew foods?

The Pacific Golden-Plover breeds primarily in Siberia, although a relatively small breeding population occurs in western Alaska (Johnson and Connors 1996). The wintering range of this medium-sized shorebird is extensive and stretches from coastal California, across the insular Pacific Ocean, to Australia, southeast Asia, and northeast Africa. Over 50% of the global population is thought to winter in the insular Pacific. Birds from the Alaska breeding population occur on the main Hawaiian Islands and likely make up a significant portion of the birds that winter in Polynesia, Micronesia, and

Melanesia. The Pacific Golden-Plover is designated as a National Species of Conservation Concern by the DOI and some recent conservation initiatives (e.g., U.S. [Brown et al. 2001] and Alaska Shorebird Conservation plans [ASWG 2000]). This designation is based on (1) the small size of the North American breeding population, which currently numbers about 16,000 birds (Morrison et al. 2001) and (2) the lack of information about population trend.

The Wandering Tattler breeds in Alaska, the Russian Far East, and northwest Canada and winters throughout Oceania and along the Pacific coast of North and South America (Gill et al. 2002). The global population is thought to be 10,000–25,000 birds, with most (>90%) breeding in North America. The great majority of tattlers winter in Oceania, primarily in east and central Polynesia and in Micronesia. Few data exist on the status and trend of the population.

Surveys of Pelagic Birds

Pelagic bird surveys are an important tool to assess distribution and movement of seabird species, their feeding behavior at sea, and the status and trends of their populations (Gould and Forsell 1989). Due to the remote nature of the Tuamotu Archipelago, few systematic pelagic bird surveys have been conducted there. Given that much of this expedition would be spent traveling by boat from atoll to atoll, we decided to conduct pelagic surveys to gather quantitative data on pelagic seabird diversity, distribution, and abundance in this region.

Methods

The expedition relied on the *M/V* Bounty Bay, a 15-meter-long, 35-ton motor catamaran (Fig. 2), to provide a base of support while anchored at, and traveling between, atolls. This vessel, operated by Pacific Expeditions, Inc., provided all water, food, fuel, camping equipment, inflatable boats, and other necessary gear for conducting surveys. The vessel was equipped with navigation and safety gear including life rafts, VHF/SSB radios, GPS

and EPIRB to help ensure safe passage. The vessel was searched for pests (mammalian and plant) and, prior to landing on atolls, participants visually examined gear to help ensure that alien biota was not introduced. Biologists accessed atolls by inflatable boats powered by small outboard motors.

Surveys of Atolls

Atolls were selected based on their potential conservation importance (i.e., historic presence of Tuamotu Sandpipers and/or Polynesian Ground-Doves) and lack of current data. Duration of atoll visits varied depending upon atoll size, weather, presence of mammalian pest species, and logistical constraints. To conduct a survey, 3–9 observers lined up perpendicularly across an atoll spaced at about 50–200 m intervals from the ocean reef flats to the lagoon shore. Observers then proceeded to walk slowly along the length of the atoll within a designated habitat type (i.e., lagoon edge, inner vegetation edge of motu, forest interior, ocean beach, ocean reef flats, and oa). Individual motu (i.e., raised regions of the atoll that formed islets around the central lagoon) and oa (i.e., channels between the motu that were inundated with water from surf or during high tides) were used as start and stop points as well as a place for everyone to regroup (Fig. 3). All start and stop points were located with GPS to provide an estimate of linear distance surveyed. We recorded the number of individuals of each species and their associated habitat type. We minimized double-counting of individuals by comparing notes on location and behavior of birds in cases when individual birds flew around or were attracted to observers during surveys.

The presence of rodents was determined by setting out rat traps and/or lures. Traps were baited with roasted coconut and placed above the ground on trees to avoid harming birds and to decrease the incidences of bait removal by crabs. Lures consisted of wax baits that, when bitten, revealed an animal's dentition and allowed it to be identified. Rats caught in snap traps were identified to species and dissected to ascertain stomach contents and reproductive status. The presence of feral cats and dogs was determined by direct observation of animals and/or their sign (e.g., tracks, digging, scat). Special effort was

made to examine substrates most likely to preserve tracks, such as sandy beaches above the high tide mark.

Capture and Processing of Bristle-thighed Curlews

We attempted to capture curlews by nightlighting (netting curlews dazzled with lights at night), chasing after birds that were reluctant to fly, mist netting (erecting ground-level and elevated mist nets perpendicular to lagoon shorelines and along flight lines), and trapping (attracting birds to coconut bait located in spring traps). Captured birds were banded with a USFWS metal band and a unique combination of color bands. Birds were measured (culmen, tarsus, wing), weighed, and their feathers (primaries, secondaries, and rectrices) examined to determine stage of molt. Up to 100 µl of blood was collected from the basilic vessel of individual birds for subsequent use in a genetic population study.

Surveys of Pelagic Birds

Whenever sea and light conditions permitted, we conducted pelagic bird surveys while traveling between atoll destinations. Most pelagic surveys occurred near dawn and dusk. During surveys, the vessel traveled an average of 7 knots/hr and its position (latitude and longitude) was recorded at the beginning of successive 10-minute observation periods. One to three observers scanned for birds from the flying bridge of the *M/V* Bounty Bay with their naked eyes and binoculars. For each sighting of a bird, we recorded the genus and if possible, the species, behavior (i.e., flying, feeding, sitting on water), and general observation conditions. Sightings were separated into those inside and outside a 300-m-square transect (i.e., 150 m on each side and 300 m in front of the boat). Only birds seen on the sides and in front of the vessel were recorded (i.e., no observations were collected of birds behind the boat) to allow comparisons with pelagic bird surveys conducted in other regions of the Pacific.

Results and Discussion

Trip Summary

The SOP-Manu Expedition visited one island group and nine atolls in the Tuamotu Archipelago between 4 and 26 March 2003 (Fig. 4). During the 23-day voyage we traveled over 1,400 km within the archipelago, i.e., the linear distance between Mangareva (23˚.12S 13˚4.97W) and Fakarava (16˚.19S 145˚.75W). In addition, we conducted pelagic bird surveys on two days as the vessel traveled from Fakarava to Moorea (Fig. 4). A summary of locations visited and survey effort is presented in Table 1. An itinerary of daily activities is provided in Appendix 2. Detailed information about the status of endangered endemic species and the occurrence of introduced mammals is available in a trip report by Wildland Consultants and SOP-Manu (Pierce et al. 2003).

In general, marine charters appear to be an excellent means for surveying remote atolls in the Central Pacific. Expense and logistical constraints have often required contemporary ornithologists working in Oceania to fly to inhabited islands and atolls and subsequently rely on local fishing boats to transport them to a few nearby sites (e.g., Blanvillain et al. 2002, P. Raust and R. Pierce, pers. comm.). Such field trips can be cheaper and quicker than boat-based expeditions, but they limit studies to the particular areas that can be accessed in this manner. Dedicated vessels can allow for more rigorous study designs and expand access to remote sites with high conservation potential.

Pacific Expeditions, Inc. provided a reasonably priced vessel with a very knowledgeable crew. Graham Wragg and Ed Saul have worked in this region for several years and have extensive knowledge of the region's natural history, ocean navigation, and vessel management. Their experience made for a more efficient planning of survey effort. The crew skillfully transported biologists on and off atolls, maintained the vessel, prepared meals, set up camps, and assisted with data collection.

We were able to visit remote areas, be flexible with our trip plans, and not have to spend valuable time while on atolls attending to logistics. The vessel had recently been purchased and renovations were being planned. Graham Wragg indicated that he intends to upgrade the *M/V* Bounty Bay in several ways to better accommodate such trips, including acquiring higher horsepower outboard motors for use in reef landings and cross-lagoon trips, installing better refrigeration to keep food, and improving ventilation in the sleeping quarters.

Surveys of Atolls

Thirty species of birds and three species of mammals were detected on the atolls and islands (Table 2, Appendix 1). Six of the bird species and one of the mammal species (Ship Rat) were detected only on Mangareva, a high island in the Gambier Group. The number of bird species on each atoll ranged from 13 to 20, with the most species present on Tahanea and the fewest on Paraoa, Tekokota, and Haraiki (but note effort expended on each atoll, Table 1). The most numerous species was the White Tern (≥5445 individuals), followed by Brown Noddy (≥5061), Red-footed Booby (≥2139), and Lesser Frigatebird (≥1520). A total of four shorebird species was detected including, Bristle-thighed Curlew (≥268 individuals), Pacific Golden-Plover (≥ 64), Wandering Tattler (≥339), and Tuamotu Sandpiper (≥773).

These surveys represent a single snapshot of bird diversity and abundance for each site. We feel that they are reasonable assessments of the seasonal presence of bird species at these sites. Undoubtedly, additional species are present during other seasons, and for them, the importance of certain atolls as breeding locations went unnoticed in the surveys. Assessments in other seasons would provide a more complete picture of the avifauna of the region. These surveys provide reasonable but not rigorous estimates of seasonal abundance for many species, primarily because our short visits (0.5–2 days on each atoll) precluded the replicate surveys that would be needed to adjust count data. Also, logistical constraints necessitated many midday surveys, a situation that likely underestimated the number of breeding seabirds because most of them forage in the

ocean during the day. Further, the behavior of some species affected their detectability. Some species were quiet and difficult to detect (e.g., Polynesian Ground-Dove), others approached and followed observers (e.g., Tuamotu Sandpiper), and others flew from observers but then circled back (e.g., Bristle-thighed Curlew).

Arctic-breeding Shorebirds that Winter in the Central Pacific

Bristle-thighed Curlew

We counted a total of 268 Bristle-thighed Curlews on the nine atolls (Table 2). We did not observe leg bands on any of the about 50 individuals that we were able to inspect closely. Thus, we are unable to directly link wintering sites in the Tuamotu Archipelago with breeding, staging, or other wintering sites where individual curlews have been marked. The number of curlews counted on each atoll varied from 11 to 54, although not all atolls were completely surveyed (Table 1). The presence of curlews on all atolls suggests that they are resilient to the occurrence of Pacific Rats and to the alteration of native habitats. However, lack of data of their historic numbers at these sites makes it difficult to assess the full effect of altered conditions. Previous researchers have noted that curlews avoid atolls (or motu within atolls) with human settlements and/or feral cats (Marks and Redmond 1994). We had too few observations of curlews in such areas to evaluate their response to these potential disturbances.

Curlews were observed in all coastal habitats and some terrestrial ones (Fig. 5), but most detections on the surveys were of birds associated with ocean (44% of 223 detections on surveys) and lagoon (41%) shores and reefs. Fewer curlews were detected in open shrub areas in the interior of motu (9%) and in unvegetated oa (6%). Densely vegetated habitats (e.g., forest, *Pandanus* thickets) did not appear to be used by curlews. Evidence of curlew foraging (i.e., cracked open shells previously containing hermit crabs and periwinkles) was observed in oa and in clearings in the interiors of motu. In addition, curlews took refuge in the shade of vegetation, apparently within the vegetation/shore interface, during the hottest periods of the day.

Three curlews were captured on Reitoru on 17 and 18 March 2003 (Fig. 6). One was captured during the day by hand when Ray Pierce sprinted after a bird that was reluctant to fly. After chasing the bird for about 100 meters he was able to grab it. This bird appeared to be in good health and was later determined to be too fat to fly. Two curlews were captured with a small handheld net at night after being dazzled with a spotlight and flashlights. All three birds appeared to be females based on bill morphology, and weighed 600, 620, and 760 grams, which is about half again as heavy as an average breeding female ($\overline{X}$ ± SD = 427.7 ± 23.44, n = 35; Marks et al. 2002) and similar in weight to adults from Laysan Island during the pre-migratory fat accumulation period (early-mid April $\overline{X}$ ± SD = 583.9 ± 69.5, n = 14, late April/early May $\overline{X}$ ± SD = 656.3 ± 77.4, n = 70; Marks 1993). As with most long-distance migrants (up to 6,000 km one way in the case of the curlew), such mass accumulation is necessary for a successful migration and is especially important to an over-water migrant that has no place to stop and refuel. The fact that fat individuals could be caught by hand raised questions about the effect of rats and cats on birds during the pre-migratory period. For instance, are birds more vulnerable to predation by introduced mammals during this period? Captured birds had very bright and fresh breeding plumage, with molt scores indicative of a recently completed wing, tail, and body molt.

To meet our genetic sampling goal of 30 individuals, we will either need to revisit the Central Pacific to gather more samples, or attempt to use tissue samples from museum skins of curlews collected during earlier expeditions (e.g., Whitney South Seas Expedition in the 1920s, Pacific Ocean Biological Survey Program in the 1960s). We had been seeking to avoid using museum specimens as those prepared in the periods when most curlews were collected often contain substances that can interfere with DNA extraction and/or PCR amplification thus reducing the likelihood that they would provide useable genetic material.

Efforts to capture curlews with vertically erected mist nets were unsuccessful, although several birds flew over or under the outstretched nets and at least two birds walked under them. Birds seemed to easily see nets and were able to make evasive flight maneuvers

from several meters away. Based on our experience, it is probably not cost effective to try and capture curlews with mist nests at these latitudes because the necessary conditions (i.e., birds moving about while mist nets are not visible) was limited to about ½ hr at dawn and dusk. Mist netting might be warranted in situations with known roost sites or high densities of curlews. Efforts to capture curlews with baited spring traps were inconclusive as no birds came close enough to the traps to detect the bait. Given that traditional societies used bait to lure curlews into snares (Marks et al. 2002) it would be worthwhile to experiment further with the use of baited spring traps, especially on atolls with high densities of curlews.

The multiple objectives of this expedition restricted the amount of time available for capturing curlews. Some atolls were visited for only a few hours, precluding us from attempting to capture birds by mist netting or nightlighting. Atolls visited at the beginning of the trip had few curlews spread over a wide area (i.e., Morane, Ahunui), making it difficult to locate birds during nightlighting attempts. Atolls visited later had higher densities (i.e., Reitoru, Haraiki) but by then, the moon was waxing towards full and curlews could see us approach. Further, the nature of the trip (short visits to many sites) required us to continuously reevaluate and change capture plans, only to have to leave a site after one or two attempts. Future efforts to capture curlews in this region would benefit by (1) visiting atolls when birds are completely or semi-flightless, either during wing molt (September-November) or during pre-migratory fattening (March-April), (2) spending three to five consecutive nights on atolls/islands with high densities of curlews, (3) scheduling atoll visits to coincide with dark nights (i.e., as close to the new moon as possible), and (4) employing multiple teams of people over different motu so they can take advantage of any good nightlighting conditions. If some, or all, of these conditions were met, we believe that it would be possible to capture enough curlews to obtain an additional 20–30 blood samples within a reasonable time period (3–4 weeks).

Pacific Golden-Plover

Only 64 Pacific Golden-Plovers were detected during the surveys; 38 of these occurred at Haraiki and most of these were concentrated in an unusual shallow water area filled with thick mats of algae. The remaining atolls had between one and nine birds each. Pacific Golden-Plovers were usually seen in groups of two or three and were found primarily along inner lagoon shorelines (77% of 49 detections on surveys) and less often on ocean beaches (23%) or in the vegetation on motu (6%). A flock of three plovers was observed foraging in a soccer field on Mangareva and a single plover was observed in a grassy field near houses on Fakarava. Plovers did not appear to be territorial and would seldom return once flushed by observers. Some individuals were still in winter plumage while others were changing to breeding plumage.

Wandering Tattler

A total of 339 Wandering Tattlers was observed during the surveys (Table 2). The number per atoll ranged from 12 to 55 birds, although not all atolls were completely surveyed (Table 1). Our observations confirmed previous reports that tattlers occur alone or in pairs, and that they frequently establish winter territories. The latter observation is based on the even distribution of birds, rather than on direct observations of agonistic interactions. We did not attempt to capture Wandering Tattlers and did not observe any banded birds. Thus we could not evaluate whether birds remained on atolls during our visit, but their attachment to particular portions of the shoreline (i.e., once flushed they would return almost immediately) suggested high site tenacity. We observed tattlers in a variety of habitats including man-made ones on Mangareva (e.g., lawns, telephone poles, abandoned buildings), but most were either in ocean habitats (47% of 236 detections on surveys), particularly ocean reef flats, or in lagoon habitats (42%), primarily lagoon reef flats. Fewer were seen in oas (7%) or in vegetation on motu (4%). Visual examination of tattlers indicated some birds had begun molting into breeding plumage.

Surveys of Pelagic Birds

Twelve variable-length (7.6–81.1 km) pelagic routes were surveyed during the expedition. Total time spent surveying was 40 hr 20 min over a distance of 502 linear kilometers (Table 3). Nearly 1,500 individuals (623 within survey area) belonging to 25 species were recorded (Table 4). The most common species within the survey area was Brown Noddy (36.3% of observations), followed by White Tern (30.8%) and Red-footed Booby (19.1%). For nine species, only a single individual was observed (Table 4). In general, more individuals (birds/km) and species (species/km) were seen during periods when the *M/V* Bounty Bay passed through deeper water (> 4,000 m) on the western edge of the Tuamotu shelf, particularly on the passage to Moorea. Fewer species were detected on shorter surveys (spearman $r = 0.714$, $n = 7$, $P = 0.072$), suggesting the shorter surveys did not adequately sample the species diversity of an area.

Collaborative Bird Conservation and Research Efforts

The funds provided by the USFWS and USGS for this expedition extended the number of days the expedition could spend in the Tuamotu Archipelago. This allowed SOP-Manu to pursue its objective of obtaining a comprehensive picture of the distribution of birds and introduced pests in the region. This information will allow them to finalize many decisions about which atolls should (1) be designated as conservation sites, (2) undergo mammal eradication programs to protect threatened or endangered birds as well as nesting seabirds, and (3) be used as reintroduction or relocation sites for threatened or endangered birds. Given that many of these atolls had not been surveyed for flora and fauna in decades, this expedition provided important information on the current distribution of birds, mammals, and plants. Surveys of other Tuamotu atolls are still needed to fully document the current distribution of many species, and to evaluate where mammalian pests should be removed and endangered species reintroduced (Pierce et al. 2003). An important corollary action to the above would be to assess atolls under U.S. jurisdiction (e.g., Jarvis and Palmyra in the Line Islands) for their potential as translocation sites for the endangered Tuamotu Sandpiper (A. Engilis, Jr. and M.

Naughton, unpubl. data). The historical range of this species included Kiritimati in the Line Islands until it was extirpated there, probably in the late 1700s.

The funds, logistical support, and expertise of our colleagues from SOP-Manu, Wildland Consultants, and Pacific Expeditions, Inc. allowed us (U.S. biologists) to travel to these sites and to focus on our primary tasks of capturing curlews and observing shorebirds. We were able to gain perspective on migrant shorebirds in winter including a better understanding of the threats that they face, their habitat use, and the potential for future studies. We were also able to gain experience in conducting research and traveling in the region.

In general, biologists and conservationists in Polynesia and New Zealand are primarily tasked with studying and maintaining populations of endemic species in the Central Pacific. Species that winter in the Central Pacific and breed in the Arctic are usually not the primary focus of their efforts because, generally, these species are relatively more abundant and not known to be imminently in danger of extinction. Even so, any research or conservation efforts in the Central Pacific will likely benefit migrant shorebirds because such endeavors work towards conserving and restoring the health of natural systems. For example, SOP-Manu suggests that designating important atolls as World Heritage Sites will help raise the profile of these sites and thus encourage local communities to be involved in their welfare and upkeep (P. Raust, pers. comm.).

Conservation planning in the Central Pacific generally involves two methodologies: mammalian pest eradication and endangered species reintroduction or relocation (Blainvillian et al. 2001, Pierce et al. 2003, P. Raust, pers. comm.). Although eradications seem very feasible given the protocols and rat poisons developed in New Zealand, there are several challenges to conducting a successful eradication program on remote atolls in French Polynesia (G. Wragg, R. Pierce, and P. Raust, pers. comm.). First, funding is seldom adequate to fully implement a program, particulary one that involves repeat applications of poisons. Second, even after successful eradications have occurred, bio-security measures are rarely implemented to prevent pests from being

reintroduced (e.g., copra farmers still have access to atolls, no comprehensive education efforts have been undertaken). And third, the potential impact of rat poison applications on birds is not well studied and thus, eradication efforts must be conducted cautiously so as not to injure birds. This is especially important on atolls where small numbers of rare species still exist. The effectiveness of pest eradication as a conservation tool for migrant shorebirds is not known, but it is reasonable to assume that they would benefit directly and indirectly from removal of rats and feral cats and dogs. There is some discussion about restricting rat eradication programs to the months when most migrant shorebirds are absent (April-August) to reduce any danger of shorebirds eating poison bait. However, the potential problem would still exist because most of these species spend their entire early years (at least 3 years in the case of the curlew) in the Central Pacific.

Many bird conservation projects in French Polynesia have been funded by other countries, such as New Zealand and Australia, and have been carried out largely through volunteer efforts. SOP-Manu needs funding to hire full-time staff to write grant proposals to allow them to implement their plans for pest eradication and bird reintroductions (P. Raust, pers. comm.). Besides inadequate funding, perhaps the biggest obstacle to bird conservation in French Polynesia is convincing Polynesians that birds are an important resource and worthy of protecting (Pierce et al. 2003, P. Raust pers. comm.). SOP-Manu representatives believe that a good way to convince local people that pest eradication is possible and beneficial is to sponsor trips to visit islands in New Zealand where eradications have been successful. General awareness of the biodiversity value of the Tuamotu Archipelago could also be enhanced through public outreach and education, promoting eco-tourism, and consulting and discussing ecological issues with government leaders, traditional leaders, and landowners. Migrant shorebirds would benefit from such efforts because they would be part of a comprehensive program aimed at conserving natural habitats on atolls in the Tuamotu Archipelago.

Future collaborative efforts should focus on providing technical expertise, logistical support, and funding to evaluate the suitability of islands and atolls for restoration and to carry out restorative work. Suitability should be assessed through research on bird

abundance, distribution, and habitat use, and on the effects of introduced mammals on birds and their habitats. Such research is particularly important for islands and atolls with high conservation potential, including U.S. protected areas. The U.S. should continue to work cooperatively through SPREP with Central Pacific nations so that joint research expeditions are possible and so that birds, including migrant shorebirds, the shared resource, are included in the Central Pacific Working Group's research and conservation planning efforts.

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Table 1. Survey effort at one island group (Gambier Is.) and nine atolls in the Tuamotu Archipelago during the SOP-Manu Expedition, March 2003. Overlapping times of day indicate that groups of surveyors were evaluated different portions of the atoll.

Location	Date in March	Time of day / number of surveyors	Linear distance surveyed (km)	Percent of atoll length surveyed	Percent of vegetated motu visited
Gambier Is.	4–7	No surveys / 7	Several km^2 searched near roads of Rikitea. Outer islands viewed from boat.	N/A	N/A
Morane	8–10	0640–1100 / 9 1200–1655 / 7	14.5	100	100
Ahunui	13	0700–1124 / 4 0650–1200 / 3	7.0	35	80
Paraoa	15	0715–1000 / 4 0615–1010 / 4	3.8	25	80
Manuhangi	15	1600–1715 / 4 1615–1730 / 4	4.2	35	80
Reitoru	17	0726–0830 / 4 0726–1430 / 4	7.1	75	100
Haraiki	19–21	0930–1700 (19^{th}) / 4 0800–1730 (20^{th}) / 4 0810–1130 (21^{st}) / 4	18.9	95	100
Tekokota	19	1535–1745 / 5	3.3	100	100
Tahanea	22–24	0935–1648 (22^{nd}) / 5–6 0840–1630 (23^{rd}) / 5–6 1000–1530 (24^{th}) / 5–6	Not available	80	90
Fakarava	25–26	1530–1720 (25^{th}) / 5–6 0810–1230 (26^{th}) / 5–6	Not available	20	40

Table 2. Number of birds counted, mammalian presence, and apparent level of human occupation recorded during surveys in the Tuamotu Archipelago, March 2003. Numbers include those seen during regular surveys as well as rare species seen at other times; underline denotes evidence of breeding (i.e., nests, flightless young). Gambier Is. counts are incidental observations of animals from Mangareva, Manui, Kamaka, and Makaroa. See Appendix 1 for list of scientific names. Data on birds and mammals compiled by Ray Pierce.

Species	Location										
	Gambier Is.	**Morane**	**Ahunui**	**Paraoa**	**Manuhangi**	**Reitoru**	**Tekokota**	**Haraiki**	**Tahanea**	**Fakarava**	**Total**
Birds											
Tahiti Petrel	20+										20+
Murphy's Petrel						3+					3+
Kermadec Petrel	2	25									27
Juan Fernadez Petrel									1		1
Red-tailed Tropicbird		33+	13	18		78+	1				133
White-tailed Tropicbird	20+										20+
Masked Booby		190	1		2	2	2		3		200
Brown Booby	c. 20		1		2		3		55	146+	225+
Red-footed Booby		316	313	72	99	612	406	3	175+	143+	2139+
Lesser Frigatebird		3	1	1		1,200+		5	310+		1520+
Great Frigatebird	20+	173	9	40+	5	810	12		60+	135	1264+
Pacific Reef Heron	5	17	9	17	11	23	11	25	42	3	163
Spotless Crake									1		1
Pacific Golden-Plover	3	1		1	2	5	4	38	9	1	64
Bristle-thighed Curlew		22	34	54	28	42	13	31	53	11	268
Wandering Tattler	*c.*40	47	32	12	18	30	55	44	47	14	339
Tuamotu Sandpiper		530				57			185	1	773
Great Crested Tern	3+	11	42	24	5	27		7	84	15	198
Sooty Tern		3	2		2		754	2			763
Gray-backed Tern	2							2	2+	5+	11+
Black Noddy	20+	26+	288	88	23	44	11	100	540	141+	1281+
Brown Noddy	150+	900	837	233	19	660	1,068	333	860	91	5061+
Blue-gray Noddy	8										8
White Tern	600+	1,260	260	494	193	1,184	505	100	560	289	5445+
Laughing Gull	1										1
Polynesian Ground-Dove		10+									10+
Atoll Fruit-Dove			1						11		12
Rock Dove	12										12

Species	Location										
	Gambier Is.	**Morane**	**Ahunui**	**Paraoa**	**Manuhangi**	**Reitoru**	**Tekokota**	**Haraiki**	**Tahanea**	**Fakarava**	**Total**
Long-tailed Cuckoo	*c.*10	1				1			1	2	c.15
Tuamotu Reed-Warbler			22	46	12	40		43	55		218
Total bird species	17	18	16	13	14	17	13	13	20	14	
Human presence[1]	+	—	District	District	District	Other	Other	+	+	+	
Mammals											
Pacific Rat	XX[2]		XX	XX	XX	XX		XX	XX	XX	
Ship Rat	XX									??	
Feral Cat	XX							XX	??	XX	

[1]After Blanvillain et al. 2002: '+' indicates island/atoll is inhabited; '—' indicates island/atoll is uninhabited; 'District' means that island/atoll was uninhabited during our visit but more or less regularly exploited for copra by people from other Tuamotu islands; and, our term, 'Other' indicates that island/atoll was uninhabited during our visit but appears to have been visited periodically by people for other purposes (i.e., seasonal homes [Reitoru], seabird egg-collection [Tekokota]).

[2]An 'XX" indicates presence.

Table 3. Effort for pelagic bird surveys in the Tuamotu Archipelago, March 2003. Latitude and longitude data recorded by GPS in WGS84 datum (-9 hrs Greenwich time) and expressed here in decimal degrees. Observation conditions: 1= Optimum; 2 = Great; 3 = Good; and 4 = Fair; range of numbers indicate conditions varied throughout survey.

Details	**Mangareva-Morane**	**Morane-Ahunui**	**Paraoa-Manuhangi**	**Manuhangi-Reitoru**	**Haraiki-Tekokota**	**Haraiki-Tahanea**	**Fakarava-Moorea**
Date and timing of each survey	7 March 1610–1720; 8 March 0500–1050	11 March 0500–1000, 1410–1540; 1700–1740; 12 March 0510–1020	15 March 1200–1450	16 March 0530–1100	19 March 0900–1300	22 March 0530–0700	27 March 0540–1140, 1400–1640
Number of segments	2	4	1	1	1	1	2
Total observation time	5 h 40 min	12 h	2 h 50 min	5 h 30 min	4 h	1 h 30 min	8 h 40 min
Latitude (start-end)	23.09S-23.15S	22.12S-19.76S	19.13S-19.19S	18.56S- 18.16S	17.45S- 17.36S	16.89S- 16.86S	16.54S-16.956S
Longitude (start-end)	35.09W-137.08W	138.28W-140.30W	140.82W-141.16W	142.21W-142.69W	143.29W-142.82W	144.44W-144.58W	147.01W-148.31W
Total kilometers	63.5	142.7	38.8	70.1	53.3	16.6	116.5
Observation conditions	1–4	1–2	1	1–2	1	1	1–3

Table 4. Number of birds recorded inside survey area, or presence (X) of birds recorded outside of survey area (see text for methods) during pelagic surveys in the Tuamotu Archipelago, March 2003. See Appendix 1 for scientific names.

Species	Mangareva-Morane	Morane-Ahunui	Paraoa-Manuhangi	Manuhangi-Reitoru	Haraiki-Tekokota	Haraiki-Tahanea	Fakarava-Moorea	Total
Wedge-tailed Shearwater	X	3		2			6	11
Sooty Shearwater		3						3
Short-tailed Shearwater							7	7
Christmas Shearwater	X	2	9		3			14
Audubon's Shearwater	X	X						X
Little Shearwater						1		1
Black-winged Petrel							1	1
Tahiti Petrel	1		2		X		18	21
Phoenix Petrel		1		1		2		4
Murphy's Petrel		1						1
Kermadec Petrel		1						1
Herald Petrel	X						1	1
Juan Fernandez Petrel				1			X	1
Petrel species							2	2
Polynesian Storm-Petrel		X						X
Red-tailed Tropicbird	1		X	1				2
White-tailed Tropicbird							1	1
Masked Booby	X					X		X
Brown Booby		2				1	X	3
Red-footed Booby	11	22	2	5	51	5	23	119
Lesser Frigatebird						1		1
Great Frigatebird							X	X
Great Crested Tern				1				1
Black Noddy						9		9
Brown Noddy	5	14	6	76	66	20	39	226
White Tern	84	21	5	33	23	13	13	192
Total species/taxa (number)	10 (102)	12 (70)	6 (24)	8 (120)	5 (143)	9 (52)	13 (112)	26 (623)

Figure 1. Illustration of the approximate extent of the Central Pacific Flyway.

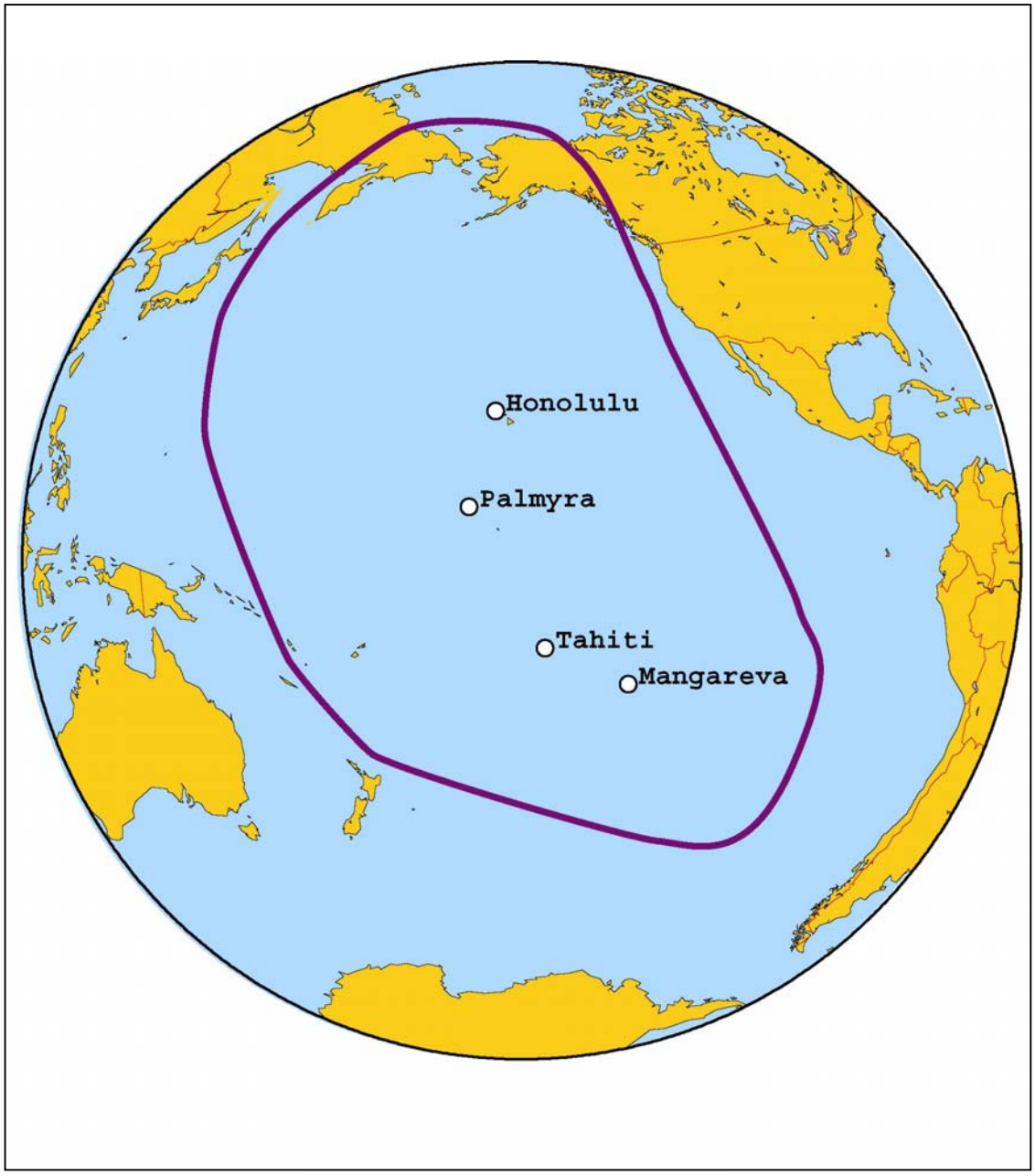

Figure 2. Photograph of the M/V Bounty Bay docked at Rikitea, Mangareva.

Figure 3. Photograph of a portion of an atoll illustrating the locations of a motu (elevated, vegetated areas) and an oa (spillways where water passes between ocean and lagoon).

Figure 4. Diagram of the route taken by the SOP-Manu Expedition, March 2003.

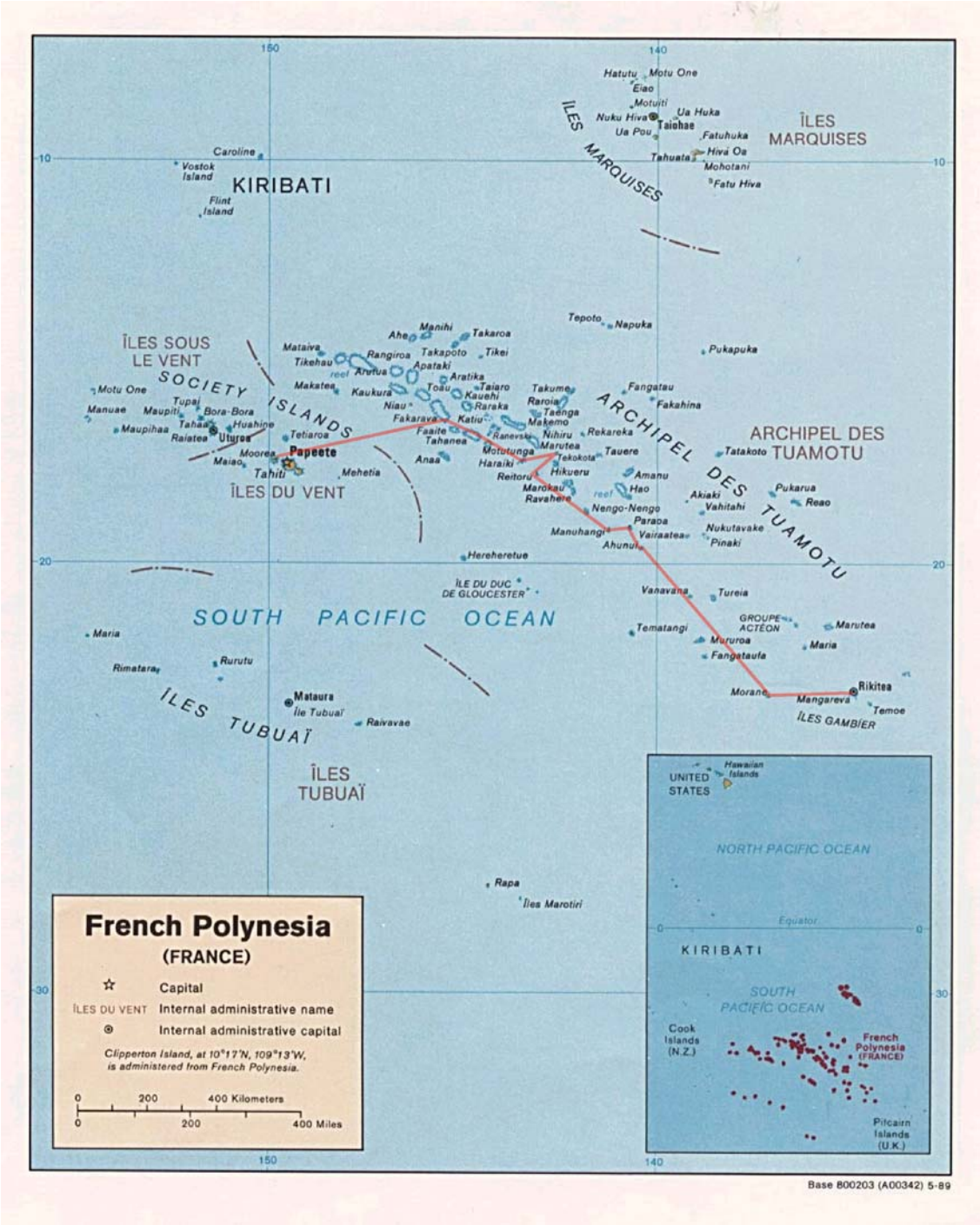

Figure 5. Examples of atoll habitats used by migrant shorebirds in the Tuamotu Archipelago.

a. From left to right: outer reef flats, ocean beach, edge of native vegetation on Morane.

b. From left to right: lagoon, lagoon shore, edge of coconut plantation on Ahunui. Mist nets are deployed across the lagoon shore in this paragraph.

Figure 5 continued.

c. View of an oa, or the spillway between the ocean and the lagoon, on Morane. From front to back: unvegetated oa, spillway, unvegetated oa, motu vegetated with native plants.

d. From front to back: edge of native vegetation on motu, lagoon beach, and lagoon on Reitoru.

Figure 6. Photograph of the first Bristle-thighed Curlew captured on Reitoru on 17 March 2003. This individual weighed 760 grams and appeared to be a female based on bill morphology.

Appendix 1. Common names, scientific names, and general locations of all birds and mammals detected during the SOP-Manu Expedition, March 2003.

Common English name[1]	Scientific name[1]	High island	Atoll	Pelagic
Birds				
Wedge-tailed Shearwater	*Puffinus pacificus*			XX
Sooty Shearwater	*Puffinus griseus*			XX
Short-tailed Shearwater	*Puffinus tenuirostris*			XX
Christmas Shearwater	*Puffinus nativitatis*			XX
Audubon's Shearwater	*Puffinus Iherminieri*			XX
Little Shearwater	*Puffinus assimilis*			XX
Tahiti Petrel	*Pseudobulweria rostrata*	XX		XX
Black-winged Petrel	*Pterodroma nigripennis*			XX
Phoenix Petrel	*Pterodroma alba*			XX
Murphy's Petrel	*Pterodroma ultima*		XX	XX
Kermadec Petrel	*Pterodroma neglecta*	XX	XX	XX
Juan Fernandez Petrel	*Pterodroma externa*		XX	XX
Herald Petrel	*Pterodroma arminjoniana*			XX
Polynesian Storm-Petrel	*Nesofregetta albigularis*			XX
Red-tailed Tropicbird	*Phaethon rubricauda*		XX	XX
White-tailed Tropicbird	*Phaethon lepturus*	XX		XX
Masked Booby	*Sula dactylatra*		XX	XX
Brown Booby	*Sula leucogaster*	XX	XX	XX
Red-footed Booby	*Sula sula*		XX	XX
Lesser Frigatebird	*Fregata ariel*		XX	XX
Great Frigatebird	*Fregata minor*	XX	XX	XX
Pacific Reef Heron	*Egretta sacra*	XX	XX	
Spotless Crake	*Porzana tabuensis*		XX	
Pacific Golden-Plover	*Pluvialis fulva*	XX	XX	
Bristle-thighed Curlew	*Numenius tahitiensis*		XX	
Wandering Tattler	*Heteroscelus incanus*	XX	XX	
Tuamotu Sandpiper	*Prosobonia cancellatus*		XX	
Great Crested Tern	*Sterna bergii*	XX	XX	XX
Sooty Tern	*Sterna fuscata*		XX	
Gray-backed Tern	*Sterna lunata*	XX	XX	
Black Noddy	*Anous minutus*	XX	XX	XX
Brown Noddy	*Anous stolidus*	XX	XX	XX
Blue-gray Noddy	*Procelsterna cerulea*	XX	XX	
White Tern	*Gygis alba*	XX	XX	XX
Laughing Gull	*Larus atricilla*	XX		
Polynesian Ground-Dove	*Gallicolumba erythroptera*		XX	
Atoll Fruit-Dove	*Ptilinopus coralensis*		XX	
Rock Dove	*Columba livia*	XX		
Long-tailed Cuckoo	*Eudynamys taitensis*	XX	XX	
Tuamotu Reed-Warbler	*Acrocephalus atyphus*		XX	

Common English name[1]	Scientific name[1]	High island	Atoll	Pelagic
Mammals				
Pacific Rat	*Rattus exulans*	XX	XX	
Ship Rat	*Rattus rattus*	XX	??	
House Cat	*Felis catus*	XX	XX	

[1]Bird names from Christidis and Boles (1994) and American Ornithologist's Union (1998); AOU nomenclature used in cases where a species occurred on both lists.

Appendix 2. Itinerary of daily activities while in the Republic of French Polynesia between 28 February and 30 March, 2003. Locations depicted in Figure 4.

28 February-3 March: Expedition scientists traveled to Papeete, Tahiti, via international air carriers from New Zealand (Ray), Australia (Jo), Hawaii, USA (Eric), Alaska, USA (Rick, Lee, Verena), and Rarotonga, Cook Islands (Ed).

4 March: Ray, Jo, Eric, Lee, Verena, Rick, Ed, and Jean-Marc flew via Air Tahiti to the town of Rikitea on Mangareva Island in the Gambier Group of the Tuamotu Archipelago. There they joined Graham and crew (Jen, Matt, Sheree, Liz, and Bert) aboard the *M/V* Bounty Bay.

4–7 March: The crew outfitted the *M/V* Bounty Bay for the expedition, obtaining fuel, water, and fresh food from the stores and townspeople of Rikitea. The biologists walked throughout Mangareva searching for birds and mammals and making notes on breeding status and abundance. No systematic surveys were conducted because the island had recently been surveyed by SOP-Manu, and few birds had been present. No efforts were made to capture curlews on Mangareva as none were encountered during daily walks.

7 March: We began the voyage to Morane at about 17:00 hrs. As we left the Gambier Group the *M/V* Bounty Bay passed near Manui, Kamaka, and Makaroa islands to allow Graham, Ed, Ray, and Jean-Marc to begin planning an upcoming rat eradication effort at these sites. We stopped briefly at Tarave to pick up fresh produce and to take a quick tour of the impressive Catholic church there. Verena, Eric, and Ray conducted a pelagic bird survey for about an hour prior to dusk. Rick, Lee, and others quickly succumbed to seasickness.

8 March: Pelagic bird surveys were conducted in the morning as the boat traveled to Morane. The *M/V* Bounty Bay arrived at Morane at 15:00 hrs and a field camp was established on a small motu on the west side of the atoll. Four motu on the west side of the atoll were searched for curlews but none was found. However, one curlew was heard

north of camp. Ray, Jo, and Ed set out a series of flavored wax lures to determine whether rodents were present. Eric made audio recordings of Tuamotu Sandpipers and Kermadec Petrels.

9 March: All biologists participated in a bird survey that covered most of Morane. This activity required most of the day. In the afternoon, Rick and Lee followed curlews back and forth between the ocean and lagoon sides of a large motu north of camp. Ed found mollusks (periwinkles) that appeared to have been eaten by curlews (broken in a manner consistent with flinging by curlews). Curlews appeared to be feeding in the oa between motu. However, we could not locate a site where curlews consistently returned to feed. In the evening, we made our first attempt to nightlight curlews on small motu south of camp. We used a night vision binocular to follow two birds as they walked along the vegetation edge at dusk, but could not relocate them once it became completely dark. We then resorted to traversing the vegetated areas of the motu, shining the nightlight ahead of us in hopes of encountering roosting curlews, however, none was detected.

10 March: We attempted to attract curlews to coconut bait placed in the middle of an oa where we had observed birds feeding the previous day. Two or three feeding curlews were displaced from this area just prior to putting out the bait, but they did not return over the next three hours. Rick and Lee made audio recordings of Tuamotu Sandpipers. We left Morane around 16:00 hrs and set course for Ahunui, some 44 hrs of boat travel away. Many of us succumbed to seasickness during this passage.

11 March: Continued traveling to Ahunui. Pelagic bird surveys were conducted in the morning and afternoon. Ray came down with a dramatic skin rash that was an apparent allergic reaction to *Pandanus* sap.

12 March: Arrived at Ahunui in the late afternoon and established a field camp on the west side in a shelter constructed by copra farmers. Most of the group stayed at Ahunui while Graham, Matt, Sheree, and Jean-Marc continued on to Hao. As planned previously, Philippe traveled to Hao from Tahiti to exchange places with Jean-Marc who

returned home. At Ahunui we attempted locating curlews with nightlights along the ocean beach in the evening, but none was detected. We did see many fresh tracks made by nesting sea turtles. Ray and Jo established an intensive rat trap line, which they maintained for two days (trapping in the late afternoon and night only).

13 March: We conducted surveys of about half of Ahunui; it was felt that a complete survey was not warranted because the atoll was infested with rats and the likelihood of encountering endangered species was very slim. In the late afternoon, we erected two mist nets about five meters above the ground along a lagoon beach across the motu from camp in the hopes of catching curlews flying along this shoreline. During the 1 ½ hrs of effective mist netting time (only the dusk and dawn periods were sufficiently dark to make the net difficult to see by curlews), several curlews were observed flying high and wide over the nets.

14 March: We attended mist nets in the early morning hours. Several curlews walked out of nearby vegetation where they had presumably been roosting or feeding. Two curlews walked, and later flew, directly under the mist nets. Later in the afternoon, we attempted to lure curlews into coconut-baited spring traps but few curlews were in the area and none came within 100 m of the traps during this time (the rats did however). The *M/V* Bounty Bay returned in the late morning and plans were made to depart in the evening after a final mist netting attempt. No curlews were observed in the evening near the mist nets and we left Ahunui around 19:30 hrs, and traveled to Paraoa. People (including Rick and Lee) were beginning to get their "sea legs."

15 March: Arrived at Paraoa in the early morning and spent three hours surveying a portion of the atoll for birds and rats. We encountered the most curlews yet, including a foraging flock of about 14 seen by Verena on the lagoon shore. Several turtle nests were seen. At 11:00 hrs, we boarded the *M/V* Bounty Bay and traveled to Manuhangi, arriving at 15:30 hrs. Pelagic surveys were conducted for nearly three hours during this inter-atoll trip. We surveyed a portion of Manuhangi between 16:00 and 18:00 hrs. One of the

skiffs ran out of fuel, forcing a long row across the lagoon and an exit from the atoll in the dark. By 21:00 hrs, the *M/V* Bounty Bay was traveling to Reitoru.

16 March: Pelagic surveys were conducted in the morning. We arrived at Reitoru about 16:00 hrs and, after an exciting reef landing (Sheree and Lee were knocked out of a skiff by waves), the group established a base camp on a motu on the southeast rim. Mist nets were erected on the lagoon shoreline of the camp motu at dusk but we did not detect any curlews in the area during the hour that mist nets were deployed. Rat traps were also set on the camp motu.

17 March: No attempt was made to mist net curlews in the morning because the wind was too strong. Ray checked the rat traps and then we all began a survey of the vegetated motu of Reitoru. We were unable to survey roughly 1/3 of the atoll (the south side) because it consisted of a narrow wave-swept reef. During the survey, biologists made three attempts to capture curlews that were walking slowly ahead of them and appeared to be reluctant to fly. Ray successfully captured such a curlew. He was able to contact Rick and Lee by radio and we boated across the lagoon to his location and banded the curlew there. In the evening, we abandoned mist netting efforts, and relied instead on nightlighting. After roughly an hour of searching, we captured the second curlew of the day at 22:00 hrs by locating a bird with a spotlight and flashlights and then running after it. The curlew ran about 10 m before it was captured with the small handheld net.

18 March: We nightlighted in the early morning (04:00–06:00 hrs) and located three curlews, only one of which was captured. This represented the third curlew captured during the trip. Rat traps were checked for the last time in the morning. Biologists spent most of morning and afternoon walking along the edges and vegetated interiors of motu in search of rare species and flightless curlews. Although numerous curlews were seen, all flew easily. We left the atoll at 17:00 hrs after some drenching skiff rides through the surf and the *M/V* Bounty Bay headed for Haraiki around 22:00 hrs. Highlights of Reitoru included a relatively high number of curlews of which three were captured, and the

opportunity to spend time observing foraging Bristle-thighed Curlews and Wandering Tattlers.

19 March: The *M/V* Bounty Bay arrived at Haraiki around 05:00 hrs and Ray, Jo, Eric, Liz, Bert, Jen, and Ed established a camp on the south side. Haraiki was almost entirely covered with coconut plantations, many of which appeared to be actively farmed. Several camps and a small village also appeared to have been visited recently. Several curlews were seen, but all flew when approached. Several small motu near camp were surveyed in the morning and rat traps were set on the largest southwestern motu. In the afternoon a skiff was used to access a medium-sized isolated motu in the south.

The remainder of the group remained on the *M/V* Bounty Bay and set out for Tekokota around 08:00 hrs. Pelagic surveys were conducted during this passage. The boat arrived at Tekokota around 15:00 hrs and a survey of this small atoll was conducted from 15:30 to 18:00 hrs. No effort was made to capture curlews as there was insufficient time. We had some difficulty exiting the reef through the waves but eventually were successful. Highlights of Tekokota included high densities of Wandering Tattlers, large breeding colonies of Sooty Terns and Brown Noddies, and no sign of rats. The *M/V* Bounty Bay left for Makemo at 21:00 hrs.

20 March: On Haraiki, biologists repeated surveys on the isolated motu in the morning to further ascertain whether rats were present. In the late morning and afternoon they surveyed portions of the largest motu and deployed rat traps there and around camp. No rats were captured on the large motu, but cat tracks were seen in the sand and later a cat was seen near the village. A freshly killed Red-footed Booby was found on the ground but cause of death was not apparent. Haraiki had few landbirds or seabirds, probably due to the presence of rats and/or cats on each motu. Highlights included the relatively high numbers of Pacific Golden-Plovers, Bristle-thighed Curlews, and Wandering Tattlers. Most of these shorebirds were concentrated in an unusual shallow water area covered with thick, spongy algae.

The *M/V* Bounty Bay arrived in Makemo around 08:00 hrs. After a pleasant (but very hot!) walk around the town, Lee, Philippe, and Rick traveled to Papeete at 14:25 hrs. They spent the evening relaxing at Philippe's home, eating dinner, and discussing bird conservation issues before leaving for Alaska at 01:30 hrs (on 21 March) via Air New Zealand. Back at Makemo, the crew replenished the boat with fresh water, bread, and vegetables, and then set out for Haraiki at 17:20 hrs. Two species of dolphins rode the bow wave out of Makemo.

21 March: The *M/V* Bounty Bay arrived at Haraiki at 06:30 hrs. Jo, Ray, and Ed conducted surveys on the middle portion of the main atoll and checked rat traps. To avoid a reef exit through the surf, all camp gear had to be transferred to the north side of the atoll. This required piling gear into the skiff and hand-carrying it across the large motu out to the ocean jetty. Everyone was onboard the vessel by 15:00 hrs and we then set out for Tahanea at 18:30 hrs. Jen celebrated her birthday this day.

22 March: The *M/V* Bounty Bay arrived at Tahanea at 07:00 hrs. Pelagic surveys were conducted for several hours prior to arriving at this relatively large atoll. Ed and Eric set out rat traps at 08:00 hrs and then two groups (Ray, Jo, Graham, and Sheree, and Ed, Eric, Matt, and Verena) set off in skiffs at 09:00 hrs to survey several motu. Observers recorded Atoll Fruit-Doves and Tuamotu Sandpipers; these species occurred on the more remote motu within this atoll. Some of the motu had recently occupied human camps, and cats and rats were likely present. The groups surveyed motu throughout the day, arriving at the *M/V* Bounty Bay at 18:45 hrs (after a one and a half hour skiff ride). No attempts were made to nightlight for curlews because the nearby motu had very few birds. The entire group slept on the *M/V* Bounty Bay, which was anchored inside the lagoon during their stay at Tahanea.

23 March: Beginning at about 08:00 hrs, Eric, Ray, Ed, and Verena revisited the motu where large numbers of Tuamotu Sandpipers had been seen the day before, they then continued to survey other remote motu of Tahanea. They used a skiff to travel between motu and surveyed until 16:00 hrs before heading back to the *M/V* Bounty Bay (a

difficult three hr skiff ride). Many of the remote motu appeared promising for capturing curlews but unfortunately they were too far from the vessel to access at night. Thus no attempts were made to capture curlews at Tahanea.

24 March: The mooring ring on one of the skiffs broke overnight, but luckily it drifted ashore within sight of the *M/V* Bounty Bay and was retrieved. Graham, Ray, and Eric surveyed the northern motu on Tahanea, enjoying yet another rough and lengthy skiff ride on the return. Ed, Joe, and Jen retrieved rat traps. Everyone met at the *M/V* Bounty Bay at 16:00 hrs and subsequently left Tahanea for the voyage to Fakarava.

25 March: *M/V* Bounty Bay arrived at Fakarava at 06:00 hrs and anchored at the village of Rotoava. Food and water were secured. Liz and Bert boarded an Air Tahiti flight for Papeete. Ray and Graham met with Claude Serra from the French Polynesian Delegation who was working on a Man in the Biosphere project for the Tahanea area. The *M/V* Bounty Bay left Rotoava at 14:00 hrs and traveled to a group of motu inside the lagoon of Fakarava where observers used skiffs to access these motu. Ed, Eric, and Jo surveyed two motu; and Ray, Verena, Jen, Sheree, Graham, and Matt surveyed two different motu. Some of the motu had evidence of recent human visitation. Surveys were completed around 18:00 hrs and the *M/V* Bounty Bay anchored in the lagoon.

26 March: Jen, Ray, Eric, and Matt set off on a skiff at 07:00 hrs to survey additional motu on the west side of Fakarava. A second group consisting of Sheree, Jo, Ed, Graham, and Verena left at 10:00 hrs to survey motu farther north. Both teams met at 12:30 hrs. The *M/V* Bounty Bay then returned to Rotoava and some of the group went scuba diving. Manta rays were observed in the lagoon. The *M/V* Bounty Bay left Fakarava for the Society Islands in the late afternoon.

27 March: Verena, Eric, and Ray conducted pelagic bird surveys in the morning and afternoon during the long voyage to Moorea, an island about 30 km northwest of Tahiti.

28 March: The *M/V* Bounty Bay arrived at Moorea in the early morning. Dolphins were seen as the vessel entered Cook's Bay. Ray, Graham, and Eric met with Orlo Steele, a friend of Eric's from the University of Hawaii who is helping construct an ethnobotanical garden for the University of California Gump Research Station on Moorea. Orlo helped identify various plant samples that Ray had collected during the surveys and answered other botanical questions. Sheree, Matt, Verena, Ray, and Graham then traveled to Papeete via the local ferry. Eric remained to help Orlo collect plants for the ethnobotanical garden and put them in pots. Ray, Graham, and Verena met up with Philippe and discussed the trip. Around 17:00 hrs, everyone but Verena returned to Moorea via the ferry. Verena left for Alaska later that night.

29 March: Eric traveled via ferry to Papeete, and flew back to Hawaii that night, arriving in Honolulu on 30 March. The remaining crew cleaned up the boat and themselves, hiked, snorkeled, and otherwise recovered from the long voyage.

30 March: Jo and Ray returned to New Zealand, and Bert and Liz returned to Alaska.

11–12 April: Graham, Ed, and crew traveled to Rarotonga, Cook Islands – the home port of the *M/V* Bounty Bay. Enroute they surveyed about 50% of the length of Maria, a 200 ha atoll in the Austral Group, where they encountered 14 species of birds (including 41 Bristle-thighed Curlews, three Pacific Golden-Plovers, five Wandering Tattlers, and one Sanderling) and, unfortunately more Pacific Rats.