

# *Biology and Conservation of the Juan Fernández Archipelago Seabird Community*

## 2003 Season Report

**Field season:** 22 December 2002 – 4 April 2003

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## INTRODUCTION

Six species of seabirds breed on the Juan Fernández Archipelago: the pink-footed shearwater (*Puffinus creatopus*), Juan Fernández petrel (*Pterodroma externa*), Stejneger's petrel (*Pterodroma longirostris*), Kermadec petrel (*Pterodroma neglecta*), white-bellied storm petrel (*Fregetta grallaria*), and DeFilippi's petrel (*Pterodroma defilippiana*). The first five breed during the austral summer, while the DeFilippi's petrel breeds during the austral winter. In December 2001, we began a research program focused on the first four species, the pink-footed shearwater, Juan Fernández petrel, Stejneger's petrel, and Kermadec petrel, investigating their basic ecology and factors potentially important for future conservation measures.

Our 2002 Season Report details our activities from our first season (December 2001-March 2002), and here we present a summary of our 2003 season (December 2002-April 2003). Because the majority of our efforts were a continuation of previous work, the structure of this document follows that of our previous report, and some basic information may be redundant. In addition, in order to complete this report for the Corporación Nacional Forestal (CONAF, Chilean Federal Park Service) in a timely manner, we present only preliminary analyses of our data. Further analyses will be published in the appropriate academic journals, and copies of these publications will be provided to CONAF when available.

## OBJECTIVES

### **Pink-footed shearwater (*Puffinus creatopus*), Juan Fernández petrel (*Pterodroma externa*), and Stejneger's petrel (*Pterodroma longirostris*)**

These three species breed in aggregations of burrows on Islas Robinson Crusoe and Santa Clara (*P. creatopus*) and Isla Alejandro Selkirk (*P. externa* and *P. longirostris*). The accessibility of colonies allows us to investigate various ecological parameters simultaneously:

- 1) breeding population biology
- 2) breeding biology and behavior
- 3) foraging ecology
- 4) migratory behavior (pink-footed shearwater only)
- 5) competition with, and predation by, introduced mammals

### **Kermadec petrel (*Pterodroma neglecta*)**

This species nests on small islets and rock outcrops offshore of Robinson Crusoe. Due to the difficulty of access for this species, we target the colony on a single outcrop, Morro Juanango, with the objective of monitoring the following:

- 1) basic breeding biology parameters (laying effort and breeding success)
- 2) size of breeding population
- 3) aspects of foraging ecology

## **Community involvement**

We place priority on interacting as much as possible with the local community in order to encourage involvement in conservation issues and enhance the sense of pride towards, and ownership of, the islands' valuable natural resources. In 2003, we made efforts to interact with a wide variety of audiences on the islands, introduce local youth to our research, and develop a proposed seabird reserve near the community on Isla Robinson Crusoe.

## **RESEARCH ON THE PINK-FOOTED SHEARWATER (*Puffinus creatopus*)**

The majority of work for this species was conducted on Isla Santa Clara, primarily because of the accessibility of nest cavities. Relative to burrows on Isla Robinson Crusoe, Santa Clara burrows were shorter, shallower, and less sinuous, thereby providing access to nest cavities via an infrared burrow camera. However, additional studies were conducted on Robinson Crusoe, and our combined research efforts on this species will be summarized in this section. All results are reported as mean  $\pm$  1 SD unless otherwise noted.

### **Breeding population estimates**

*Methods.* Isla Santa Clara covers 221 hectares (2.21 km<sup>2</sup>) and the majority of its terrain can be covered on foot. In 2002, the majority of the island was censused via systematic walking and direct counting, with some additional data collected via binocular and boat/binocular surveys (see 2002 Season Report). In the 2003 season, we accessed two critical areas (east side of Cerro Alto and Plan del Weste) that we had not reached previously and counted individual burrows, thereby improving our total burrow estimate for Santa Clara.

Burrow estimates provided the total number of burrows available for occupation, and direct burrow checks using infrared burrow cameras were employed to estimate the proportion of burrows actively used by shearwaters. Three colonies (also monitored in 2002) were chosen to evaluate burrow occupancy: Refugio, near base camp; Volcán Chico, a slope of a mid-sized peak; and Cerro Alto, a saddle on the summit of the island. At each of these colonies, 61, 60, and 60 nests, respectively, were probed to assess burrow occupancy. We checked burrows with infrared cameras during the egg stage, chick hatching stage, and late chick stage of the season to determine if each burrow was occupied by adult and/or chick, empty or unknown (burrow too long or sinuous to confidently categorize as empty). Improved burrow cameras this season dramatically increased our ability to determine burrow contents, resulting in very few burrows categorized as unknown (as compared to 2002). However, because an egg was not always visible underneath adults, the camera method could not always distinguish between breeding and prospecting birds during the egg stage. Burrow occupancy was therefore assessed several times throughout the breeding season, and we believe our data indicate the presence or absence of active breeding adults.

The European rabbit (*Oryctolagus cuniculus*) is an introduced inhabitant of Isla Santa Clara, and may share with shearwaters or solely occupy a significant number of available burrows. Eradication of this rabbit population from Santa Clara is currently an important objective for CONAF. As part of their eradication program, CONAF was

interested in identifying burrows utilized only by rabbits and asked for our assistance with checking burrow contents. We accompanied CONAF hunters to burrows of their choosing on Isla Santa Clara, and used the infrared burrow camera to determine if the burrow was occupied (shearwater, rabbit, or both), empty, or unknown. Below we provide additional data from these surveys which include sites outside of our study plots.

On Robinson Crusoe, we conducted studies at three additional colonies (also monitored in 2002): Vaquería, Piedra Agujereada and Puerto Francés. We censused the study plot at Vaquería in 2002; however, the entire colony extends well beyond our plot boundaries. In 2003, we completed the census of the entire Vaquería colony. In addition, we conducted censuses of the study plots (which include the core areas at each site, but not the entire colonies) at Piedra Agujereada and Puerto Francés by systematically walking the area and counting individual burrows. We were unable to collect burrow occupancy data similar to those collected on Isla Santa Clara due to the greater length and sinuosity of burrows on Robinson Crusoe. We use Isla Santa Clara burrow occupancy data to estimate colony sizes on Isla Robinson Crusoe.

*Results.* On Isla Santa Clara, 5,606 burrows have been counted individually, either directly or with binoculars. In addition, estimates remain for a few less accessible areas, which account for an additional 270 burrows. Thus, the total estimate of burrows on Santa Clara is 5,876. Because some areas are completely inaccessible, we consider this estimate to be a minimum.

Estimates of percent burrow occupancy on Isla Santa Clara based on the direct observations of burrows using the infrared burrow camera are presented in Table 1.

**Table 1. Burrow occupancy on Isla Santa Clara**

Colony	Occupancy Category (%)			
	Active	Empty	Unknown	Range of potentially active <sup>1</sup>
Refugio	59	39	2	59-61
Volcán Chico	38	62	0	38
Cerro Alto	32	68	0	32
Mean ± 1 SD of midpoint values of ranges				43.3 ± 14.7

<sup>1</sup> Range: Minimum = Active; Maximum = (Active + Unknown)

Combining our burrow counts and infrared probe data provides an estimate of  $5,876 \times 43.3\% = 2,544$  occupied burrows, or breeding pairs, on Isla Santa Clara in the 2003 breeding season.

The areas visited with CONAF hunters represent a variety of habitats distinct from our study colonies, including open, flat wheat meadow and dense thistle patches. Below are estimates of burrow occupancy in these areas on Isla Santa Clara based on the direct observations of burrows using the burrow camera (Table 2, see following page). Pink-footed shearwaters occupied 29% of burrows checked with hunters outside of our study plots.

On Robinson Crusoe, the Vaquería study plot included 487 burrows counted individually, and the extended colony had 3,005 individually counted burrows. At the Piedra Agujereada study plot, 1,630 burrows were counted, while at the Puerto Francés study plot a total of 942 burrows were recorded. Note that the entire colonies in these

areas extend beyond our study plot boundaries. We currently do not have estimates for these extended colonies at Puerto Francés and Piedra Agujereada.

**Table 2. Occupancy of Santa Clara burrows checked with CONAF hunters**

Contents of burrows	Number of burrows	Percent of total number of burrows probed
<i>P. creatopus</i> only	78	28%
<i>O. cuniculus</i> only	11	4%
<i>P. creatopus</i> and <i>O. cuniculus</i>	2	1%
Empty	186	66%
Unknown	4	1%
Totals	281	100%

The precise counts within study plots total 3,059 burrows on Robinson Crusoe. Direct counts outside of study plots total an additional 3,005 burrows, bringing the total of individually counted burrows to 6,064. Corrected for occupancy using the average from Isla Santa Clara (43.3%), this count provides a minimum of 1,325 and 2,626 active burrows (or breeding pairs) in study plots and censused areas, respectively, on Robinson Crusoe. Note that this should not be considered an estimate of shearwater population size on Robinson Crusoe as many pockets of burrows have not been visited; however, this provides an absolute minimum for regions of the island where we have concentrated our efforts.

*Discussion.* In 2000, Daniela Guicking and Wolfgang Fiedler provided an estimate of 1500-2000 breeding pairs of shearwaters on Isla Santa Clara. More refined burrow counts, as well as improved accuracy in determining burrow occupancy, support the conclusion that an even larger population is relying on Santa Clara for reproduction.

A comparison with 2002 occupancy data (not shown, see 2002 Season Report) reveals that our estimate of percent active nests in fact changed very little; the advanced 2003 camera technology primarily improved our ability to distinguish between empty and unknown, perhaps suggesting that longer or more sinuous burrows on Santa Clara (i.e. those difficult to probe in 2002) are less desirable burrows for shearwaters.

Shearwaters do not appear to be distributed evenly among sites on Santa Clara. Occupancy was markedly higher at the Refugio plot, which is located near the CONAF hut where rabbit hunters reside. This proximity may result in increased hunting pressure on rabbits, in turn decreasing competition for burrows between rabbits and shearwaters. Alternatively or additionally, a variety of physical characteristics may affect occupancy rates, such as burrow density, soil fragility, slope aspect, vegetation cover, etc. We cannot currently distinguish between these potential factors. The eradication of rabbits on Santa Clara would provide a partial test of these alternatives; however, because the absence of rabbits would also cause potentially variable changes in vegetation cover, distinguishing between these confounding factors would require additional experimental manipulations.

We found the lowest occupancy rate outside our study plots while probing to assist hunters with eradication efforts. The majority of these efforts took place in far smaller and/or less dense aggregations of burrows, suggesting that these are not ideal

nesting sites. We therefore expected that shearwater occupancy would be low. However, that occupancy was as high as 29% in these apparently sub-optimal areas was surprising, and may indicate that much of the island is being used, at least to some degree, as nesting habitat for shearwaters. Continued characterization of habitat and occupancy rates will allow a more accurate assessment of the size and distribution of the Santa Clara breeding shearwater population, as we eventually could report habitat-specific occupancy.

Due to the large size and rugged terrain of Robinson Crusoe, a direct burrow count may be unfeasible. We are currently researching alternative methods for assessing shearwater population size, while directly counting burrows in accessible, large colonies. Also, due to the nature of the burrows on Robinson Crusoe, a direct measure of burrow occupancy currently appears unavailable.

### **Breeding biology and behavior**

*Methods.* On Santa Clara, we monitored shearwater incubation, chick hatching and chick survival with infrared burrow cameras throughout the season to assess breeding phenology (timing) and success.

We studied adult nighttime colony attendance and surface behavior with night vision goggles, infrared beam, and red headlamps as weather and logistics permitted. Observations were conducted for 2-10 hours on 31 nights at Santa Clara, and from 2-9 hours on six nights at Vaquería (Robinson Crusoe). Every 30 minutes, we recorded the number of two types of vocalizations heard during a five minute sample, along with environmental characteristics (percent cloud cover, presence or absence of moon, and moonlight intensity). In addition, we opportunistically conducted behavioral observations as part of other night-time research, recording the time spent on the surface for birds seen landing or exiting a burrow within the colony.

We made audio recordings of shearwater vocalizations on both Islas Santa Clara and Robinson Crusoe, using a Sony stereo cassette recorder model # TC-D5PROII. Approximately 120 minutes of adult nighttime calls on the colony were recorded.

*Results.* We monitored 77 nests determined to have an egg and/or chick during the monitoring period (7 January–24 March). Of these, we collected hatching date data for 60 nests. The majority of chicks (93%, 56/60) hatched by 12 February. Chicks are typically left unattended 1-3 days after hatching, and adults are almost never found in the burrows during the day after this initial, brief brooding period.

For the remaining 17 nests, we recorded definite failures for seven nests (infertile, crushed or ejected egg) and possible failures for ten nests (unknown, eggs or egg shells but no chicks seen).

From these data, we estimated a hatching rate of 78% (60/77). For chicks hatched by 12 February, we calculated a chick survival rate to 21 March of 88% (49/56), and an overall breeding success rate to 21 March (including unhatched eggs) of 69% (53/77).

Nighttime observations provided preliminary data on various behavioral parameters, many of which will warrant further attention. We noted cycles of low and high activity (vocalizations and presence/activity on colony surface). Preliminary reviews of Santa Clara behavioral data suggest a partial correlation with lunar cycles; however, it is clear that other factors play a role.

Two different types of vocalizations were recognizable at each colony studied, categorized as Type I and Type II. Based on preliminary observations, the frequencies

and proportions of Type I and Type II calls appear to vary over the course of individual nights as well as over the season, and may also vary between Robinson Crusoe and Santa Clara. The reasons for these differences are unknown.

*Discussion.* Our efforts (2002-3 seasons) represent the most thorough study to date on breeding phenology (timing) and adult nocturnal behavior for the pink-footed shearwater. Future studies will require early season observations to determine laying dates, as well as late season observations to determine fledging dates and survival to fledging. Ultimately, a banding program would also allow us to address chick survival to adult stage, as well as adult mortality.

We continued to refine our observational methods to pursue the behavioral questions generated by the nocturnal observations conducted in both seasons (2002 and 2003). To determine and understand factors that regulate activity cycles, we will continue to monitor nighttime activity patterns, and examine data in concert with environmental and oceanographic parameters. We also remain interested in investigating potential differences in surface behavior due to the presence/absence of predators on the two islands, and will expand nocturnal observations in coming seasons.

The differences in vocalizations between Robinson Crusoe and Santa Clara still warrant further investigation. Recordings of these vocalizations will be analyzed spectrographically to see if characteristic patterns exist. Vocalization “dialects” have been demonstrated in a variety of other vertebrates, and may be related to the amount of interchange between populations on the two islands.

### **Foraging ecology**

*Methods.* We examined the foraging ecology of pink-footed shearwaters on Santa Clara both directly and indirectly. We deployed five solar powered satellite transmitters on seven breeding adults to directly monitor their foraging trip locations and durations. We tagged only one bird from a breeding pair, attaching the transmitters with Tesa brand tape to 5-10 contour feathers on the dorsal side of the bird, slightly above the base of the rectrices. Tags weigh 18 grams not including attachment materials. Tags remained adhered to the birds for 7 to 21 days (mean =  $12.5 \pm 5.3$ ), and ultimately all tags fell off and were lost. All satellite tagged birds were also equipped with two plastic Darvic leg bands.

Two birds were recaptured and their transmitters removed and re-deployed on different individuals. Three birds were recaptured after the transmitter had fallen off, and the remaining two birds were not recaptured.

We also collected a variety of samples for diet and stable isotope analyses. We collected diet samples either opportunistically when handled birds regurgitated or by stomach flushing. We obtained blood samples from the brachial vein using needle and syringe, and individual birds were only stomach flushed or bled (never both). All samples were stored in 98% ethanol.

*Results.* One satellite transmitter never initiated transmission, so our efforts yielded tracking data for six adult shearwaters. Estimates of minimum foraging trip duration range from 2-10 days, while estimates of maximum trip duration are as high as 18 days. Additional analyses of the quality of individual data points will be required to improve these estimates. These ranges are consistent with those observed for untagged birds, suggesting that tagging did not affect foraging trip duration.

Figure 1 (see following page) illustrates two examples of foraging tracks from two separate individuals. Our data indicate that tracked birds headed primarily east on their foraging trips, although one bird also spent part of a trip to the west of Santa Clara. Approximate maximum linear distances from the island ranged from 315 to 650 kilometers (mean =  $479 \pm 147$ ).

We collected seven stomach samples from breeding adult shearwaters captured on the colony surface to directly assess diet (prey identification and hard part analyses) and determine reference stable isotope profiles. We also collected 11 blood samples for stable isotope analyses of the trophic level at which adults are feeding. We will use egg membranes from 12 discarded eggs for stable isotope analyses of trophic levels of females during the egg provisioning period.

*Discussion.* Foraging trip durations, locations, and distances of breeding pink-footed shearwater adults in the 2003 season appear to be markedly different from those of the 2002 season. This season, several minimum trip durations were up to five times longer than those of birds monitored in 2002 (10 vs. 2 days); however, it is likely that shorter duration 2003 trips overlapped with the range of longer duration 2002 trips. The more directly eastern direction of foraging trips also departed from the pattern of 2002 trips, which were principally to the north- and southeast (see 2002 Season Report, Figure 1). Finally, 2003 maximum distances were significantly farther from Santa Clara than were 2002 values. The most distant maximum linear location in 2002 was approximately 258km, while the *nearest* maximum linear distance in 2003 was approximately 315km.

In 2002, we suggested that Isla Santa Clara shearwaters went on shorter duration trips than pink-footed shearwaters from Isla Mocha (where similar tagging studies have been conducted). In contrast, the trip duration of our 2003 birds more closely approached that of the Isla Mocha birds. More importantly, our data demonstrate that there are considerable interannual differences in foraging behavior, which must be considered to understand shearwater foraging ecology.

Additional analyses will allow us to investigate factors that relate to the observed changes in foraging behavior. We will examine satellite location data in concert with remotely sensed oceanographic parameters (e.g. sea surface temperature, chlorophyll *a* levels), which should indicate whether environmental factors play a role in determining foraging behavior. In addition, data from our diet and blood samples will add another dimension to our inquiry. This multi-perspective approach will provide a more comprehensive understanding of factors influencing foraging behavior in pink-footed shearwaters.

We have also contacted officials at the Servicio Nacional de Pesca and will be attempting to integrate our shearwater location data with industrial fishery location data. One of our primary objectives of investigating shearwater foraging is to identify whether overlap or interaction with commercial fishing efforts is a potential threat to the species.

As noted in the methods, all satellite transmitters were lost during the foraging trips. We were able to assess the majority of previously tagged returning adults for general health, and these birds did not appear negatively impacted, physically or behaviorally. Previously (2002) successful methods of satellite transmitter attachment clearly proved insufficient to secure the satellite transmitters for longer trips (2003), and we will be exploring modifications in our deployment techniques for future satellite tracking effort

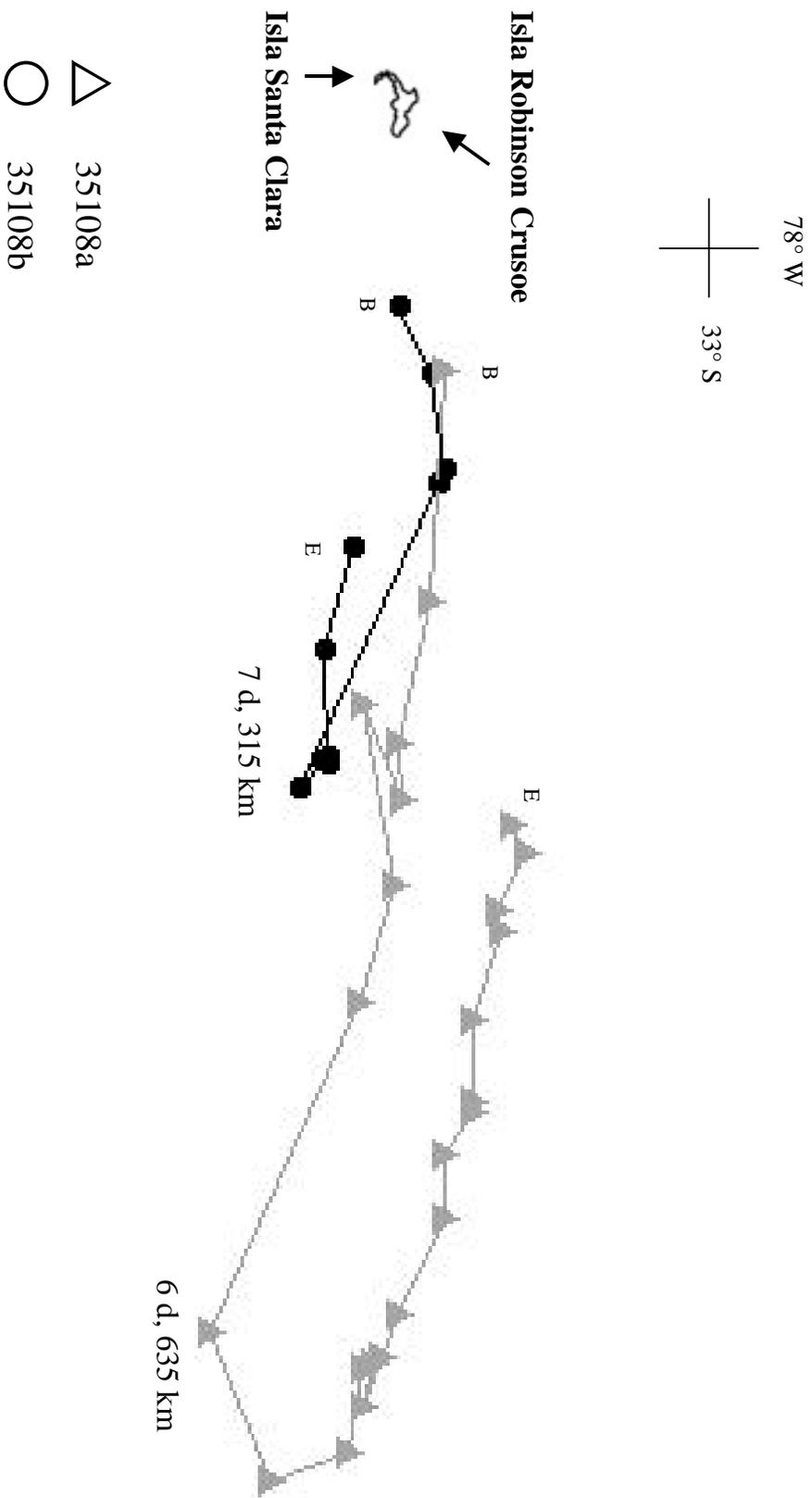


Figure 1. Preliminary 2003 satellite tracking data for two adult pink-footed shearwaters (*Puffinus creatopus*) breeding on Isla Santa Clara, Juan Fernández Archipelago, Chile. Trip notations represent duration of recorded portion of trip (d) and approximate maximum linear distance from colony (km). Partial trip coverage due to duty cycling of instruments. B = begin transmission; E = end transmission. Island size not to scale.

## **Migratory behavior**

*Methods.* Pink-footed shearwaters are known to migrate to waters off the west coast of North America after completing the breeding season on islands off the coast of Chile. Very little is known about migration routes and behavior, as the information collected thus far has been gathered from limited ship-based surveys. In collaboration with the program Tagging of Pacific Pelagics (TOPP), we are using geolocation tag technology to determine the migratory behavior of shearwaters leaving Isla Santa Clara and presumably traveling to the northeastern Pacific.

We successfully deployed seven dummy and five active Lotek geolocator tags on breeding adults. We attached tags, weighing approximately six grams, via a built-in loop to two Darvic plastic leg bands placed around the tarsus. Tags measure light level, temperature, and pressure, allowing an assessment of migratory patterns, as well as diving, surface, and flight behavior.

*Results.* The dummy and active Lotek tags will be removed next season (2004), at which time the relevant data recorded throughout the year (active tags only) will be downloaded and available for analysis. In addition to providing novel migratory information, these data will contribute to a larger, year-round foraging framework within which we can examine breeding season foraging.

## **Competition and predation**

*Methods.* We assessed competition between shearwaters and rabbits on Santa Clara by monitoring egg ejection from burrows at all three study colonies (Refugio, Volcán Chico and Cerro Alto). Every two weeks, we counted and removed all ejected eggs found within the plots. Although we cannot rule out ejection of eggs by other shearwaters, this is a very uncommon occurrence in related species. This conclusion is further supported by our observations of infertile and abandoned eggs remaining in burrows, even those that were no longer actively attended by adults. Also, during checks for ejected eggs, we simultaneously searched plots for dead pink-footed shearwater chicks and adults.

On Robinson Crusoe, we monitored egg ejection in a similar manner with semi-monthly checks at all three study colonies (Vaquería, Piedra Agujereada and Puerto Francés). In addition, we made preliminary attempts to assess predation threats by rats, cats, and coatis. While we censused study plots for ejected eggs, we also recorded adult and chick carcasses, assessed them for wounds/evidence of predation, and removed them from the plot.

We trapped for rats using Victor snap traps baited with peanut butter or tuna fish. We set traps within all three study plots at two different times within the season, late January and mid-March, totaling 265 trap-nights at Vaquería, 313 trap-nights at Piedra Agujereada, and 156 trap-nights at Puerto Francés. To determine diet of rats using stable isotope analyses, we collected muscle samples from each trapped individual and stored them in 98% ethanol.

*Results.* Study plots on Santa Clara revealed a mean egg ejection rate of  $18 \pm 6\%$  from burrows occupied by shearwaters. Study plots from Robinson Crusoe suggest an egg ejection rate of  $2 \pm 2\%$ .

No dead adults or chicks were found during checks in any of our study plots on Santa Clara. On Robinson Crusoe, carcass counts during these semi-monthly checks

varied considerably between sites. Estimates of predation on Isla Robinson Crusoe based on the direct counts of dead shearwaters in our three study plots are presented in Table 3.

**Table 3. Predation information from study plots on Robinson Crusoe**

	Colony			Mean $\pm$ 1 SD
	Vaquería	Piedra Agujereada	Puerto Francés	
# dead adults	1	35	0	-
# dead chicks	45	27	20	-
% adult predation (# dead adults/# breeding adults)	0.2%	2%	0%	1% $\pm$ 1
% chick predation (# dead chicks/# active burrows <sup>1</sup> )	22%	4%	5%	10% $\pm$ 10
% failed breeding adults <sup>2</sup>	22%	9%	5%	12% $\pm$ 9

<sup>1</sup>For information on estimates of numbers of active burrows and breeding adults on Robinson Crusoe, see above *Breeding population estimates: Results*

<sup>2</sup>% failed breeding adults = # failed breeding adults ((# adult carcasses + # dead chicks) x 2) / # breeding adults

Adult predation rates were highest at Piedra Agujereada, while chick predation rates were highest at Vaquería. The death of a chick represents a reproductive failure for both parents. Similarly, because the success of each nest requires the survival of both individuals in the mated pair, the death of an individual adult represents a reproductive failure for the mate as well. We therefore combined adult and chick deaths at each site to calculate the proportion of failed breeding adults potentially attributable to predation. The average rate of failed breeding adults due to chick and adult predation on Isla Robinson Crusoe was 12% ( $\pm$ 9) with Vaquería having the highest rate (22%). Because our index of breeding adult failures incorporates failed parents and mates, a 12% breeding adult failure rate represents a failure rate of 6% of shearwater nests. Note that these estimates of the impact of predation are maximum values, because we cannot conclusively determine cause of death for all carcasses (see Discussion below).

We collected 25, 11 and six rat muscle samples at Vaquería, Piedra Agujereada and Puerto Francés, respectively, for stable isotope and potential genetic analyses.

*Discussion.* Levels of both adult and chick mortality due at least in part to predation varied between sites, as did overall breeding adult failure rates. In addition, there were clear differences in the patterns of predation between years, including the large increase in chick predation from zero in 2002 (see 2002 Season Report). Future studies will attempt to better understand the effects of introduced mammals on shearwater population dynamics by continuing to monitor egg ejection, mortality and failure rates in our study plots. We also hope to develop methods to precisely determine the causes of death for chicks and adults. These refined methods will help identify agents driving shearwater mortality, and clarify differences in patterns of mortality (between chicks and adults, between sites, between years).

Understanding interactions with introduced mammals is critical for conservation of the entire seabird community. Our preliminary efforts have provided us with a sense of the importance of threats posed to seabirds from competition with rabbits and predation by other mammals, and of the need for further study of these interactions. In addition, we acquired samples for stable isotope analyses, allowing us to indirectly assess

the diet of rats in particular. Future efforts will focus on obtaining stable isotope samples from coati and feral cat populations on Robinson Crusoe. Investigating the impact of introduced mammals remains a high priority for our program. Cats and rats have devastated seabird populations world-wide, and the simple presence of these predators on the islands poses the same potential risk.

**RESEARCH ON THE JUAN FERNÁNDEZ (*Pterodroma externa*) and STEJNEGER’S PETREL (*Pterodroma longirostris*)**

We continued with the research program initiated in 2002 (see 2002 Season Report) on the ecology and conservation of the two endemic petrel species that breed on Isla Alejandro Selkirk, the Juan Fernández Petrel (*Pterodroma externa*) and Stejneger’s Petrel (*Pterodroma longirostris*). Peter Hodum and Samantha Hua conducted fieldwork in the Tres Torres and Cordon de los Inocentes Bajos sectors from 5 February through 17 March 2003. Michelle Wainstein accompanied Hodum and Hua in the field from 5-7 February.

Our research continued to focus on the following four general areas: population biology, breeding biology and behavior, impacts of predation, and foraging ecology. The objectives and methods are the same for both petrel species. In the following sections we will use these abbreviations for the two species: JFPE = Juan Fernández petrel and STPE = Stejneger’s petrel. All results are reported as mean ± 1 SD unless otherwise noted.

**POPULATION BIOLOGY**

**Burrow identification**

*Methods.* We measured the burrow entrance dimensions of additional Juan Fernández and Stejneger’s petrel nests to augment the measurements collected during 2002 (see 2002 Season Report). We measured maximum height, width, and diagonal (in mms) of the entrances of 46 and 34 JFPE and STPE nests, respectively.

*Results.* The average dimensions did not differ from those of nests measured during March 2002. The pooled data indicate that JFPE nest entrances are significantly larger in all three parameters (Table 4). Although there was some overlap in entrance height between burrows of the two species, there was no overlap in either entrance width or entrance diagonal. We did not find any Stejneger’s petrels nesting in burrows that had dimensions characteristic of JFPE burrows.

*Discussion.* These results indicate that burrow dimensions are useful criteria in identifying burrows of the two species nesting on Alejandro Selkirk.

**Table 4. Maximum dimensions of burrow entrances for Juan Fernández and Stejneger’s petrels (mean ± 1 SD; data from 2002 and 2003 combined)**

Species	Mean entrance height (mm)	Mean entrance width (mm)	Mean entrance diagonal (mm)
Juan Fernández petrel (n=46)	107 ± 25	148 ± 28	158 ± 25
Stejneger’s petrel (n=34)	79 ± 16	92 ± 14	95 ± 8

## Nest density plots

Although a thorough census of the colonies of both species would be highly desirable since this has never been done, the size and geographical extent of the colonies currently preclude such an effort. However, we have begun with smaller-scale censuses of nest densities in a variety of habitats in the colonies. We are ultimately hoping to combine these data with the digital map of Selkirk that CONAF is currently intending to develop. This would allow us to overlay our nest density data on a highly-detailed digital map on which we should be able to distinguish different habitat and vegetation types.

*Methods.* Combined with the data collected by Ronnie Reyes for his thesis in March 2002, we currently have nest density data from five different habitat types. During the 2003 season, we focused our efforts on determining nest densities in various types of tree fern habitat, both on the edge of the Tres Torres plain and on Cordón de los Inocentes Bajos. Canelo trees were irregularly interspersed through some of the Tres Torres tree fern habitat censused. On Cordón de los Inocentes Bajos we divided the plots into two categories: (1) “north side” refers to plots on the crest of the ridge and north-facing slopes and (2) “south side” refers to plots on south-facing slopes.

We measured burrow densities in 5 x 5m quadrats (16 quadrats in the Tres Torres sector and 36 quadrats on Cordón de los Inocentes Bajos) and used burrow entrance dimensions to distinguish between burrows of Juan Fernández and Stejneger’s petrels (see *Burrow identification* section above). We used qualitative measures to describe the density and height of the vegetation within each census plot. The vegetation density categories were 1 = very open, 2 = open, 3 = dense and 4 = very dense. Vegetation height categories were a = short (approximately 1m tree ferns or shorter), b = medium (1-2m tree ferns) and c = tall (>2m tree ferns).

*Results.* In the 16 Tres Torres tree fern plots all of the 198 burrows were of Juan Fernández petrels. Thirteen of the 16 plots had between 11-20 burrows while the remaining three plots had 3-6 burrows. The three plots with the considerably lower burrow densities were located beside light gaps with young, short ferns and fallen vegetation. Average density across all plots was  $12.4 \pm 4.9$  nests per plot (0.52 burrow entrances/m<sup>2</sup>). Excluding the three outlier plots, the average rose to  $14.3 \pm 2.9$  nests per plot (0.57 burrow entrances/m<sup>2</sup>).

All of the burrows ( $n=889$ ) in the 36 Cordón de los Inocentes Bajos plots were also of Juan Fernández petrels. Thirty-one of the plots were on the north side and five plots were on the south side. Nest densities did not vary between the north ( $25.1 \pm 5.7$  nests/plot) and south ( $22.2 \pm 3.3$  nests/plot) sides. Pooling the data for the north and south sides yielded an average density of  $24.7 \pm 0.5$  nests/plot (0.99 burrow entrances/m<sup>2</sup>) for the Cordón de los Inocentes Bajos plots.

In a comparison of the two major sites, burrow density was significantly higher on Cordón de los Inocentes Bajos than in the Tres Torres tree fern sector.

No STPE burrows were encountered within any of the tree fern plots at Tres Torres or Cordón de los Inocentes Bajos.

Average vegetation height was significantly lower in the Inocentes Bajos sector than in Tres Torres. The plant species composition is identical in the two areas, but the Tres Torres area is more sheltered from dominant winds that originate from the southern sectors. Thus, both tree ferns and canelo tend to be shorter along the ridge crest,

presumably due to wind shear effects. Tree fern (and canelo) height increases below the ridge crest on the north side of the ridge.

Vegetation density also differed between the areas, with vegetation being significantly denser on the south side of Inocentes Bajos than on the north side and in the Tres Torres tree ferns. Density did not differ between the north side of Inocentes Bajos and the Tres Torres tree fern forest.

*Discussion.* These results suggest that vegetation density in this general habitat type (tree fern forest) does not appear to affect the nesting density of Juan Fernández petrels. However, there is a negative relationship between JFPE burrow density and vegetation height. We do not currently understand if vegetation height actually affects nesting habitat selection by Juan Fernández petrels or if they are selecting nesting habitat because of other factors that are related to vegetation height.

Based on these results and other observations of nesting habitat of Stejneger's petrels, it appears that this species nests exclusively in open areas with low herbaceous vegetation rather than amongst the tree ferns. Clusters of STPE burrows appear to be concentrated on small rises along the ridge, among liverwort, an introduced species of berry, and other low vegetation. These concentrations of SPTPE burrows were interspersed within the larger continuous JFPE colony along the ridge.

### **Impacts of landslides**

A number of landslides occurred within the petrel colonies during the storm of 17-18 March 2002. We have not thoroughly surveyed the colony for landslides, but along the north aspect slopes of Inocentes Bajos there are at least four major landslides within prime breeding habitat. In many sections of the landslides all of the vegetation and soil have been removed, leaving bare bedrock. The largest of these four landslides exceeded 300m in length and 40m in width. Using values from burrow density plots along the edges of two of these landslides (1.0 burrow entrance/m<sup>2</sup>) and rough dimensions calculated from GPS points we conservatively estimate that these four landslides destroyed a minimum of 30,000 Juan Fernández petrel burrows. Based on our understanding of habitat preferences by Stejneger's petrels it appears that few if any burrows of this species were destroyed in the landslides that we examined.

We intend to continue with surveys of landslides so that we can derive a more complete estimate of the impact of these landslides on the petrel populations.

### **Adult mortality in the colonies**

Although most of the mortality we observed in the colonies was attributable to predation (see section below), we also encountered adults that died from other causes. All of the 10 adults in this category were Juan Fernández petrels. The major factor appeared to be collisions between petrels in flight over the colony at night. Such collisions between flying petrels can be heard every night in the colony. Of the 10 adults, three had a broken wing and four more had a broken neck. One was found entangled with another petrel that was still alive, while another bird apparently became trapped by its leg which was wedged into the base of fern fronds. The tenth bird died of undetermined causes.

## **BREEDING BIOLOGY AND BEHAVIOR**

In 2003, we followed the nest activity of all of the marked nests from our 2002 samples for both petrel species and incorporated additional nests into our study. For the Juan Fernández petrels, we monitored 32 marked nests in the Tres Torres plain study area and 15 marked nests in the tree fern-canelo forest adjacent to the Tres Torres plain (most accessible only with the burrow probe). We also monitored 16 nests in a new study area, called Point Break, in the westernmost clearing along the Cordón de los Inocentes Bajos and adjacent to our campsite. Finally, there is one marked nest amongst a cluster of Stejneger's petrel nests further east along the ridge. Thus, we currently have a total of 63 marked JFPE burrows, most of which have access holes to allow for nest status checks.

We also monitored a total of 32 marked Stejneger's petrel nests. There are four burrows in the Point Break study plot, 27 located in three clusters of burrows along the central Cordón de los Inocentes Bajos ridge, and one on the Tres Torres plain.

We used these marked nests to monitor breeding biology and nestling growth.

### **Breeding biology**

*Methods.* We used an infrared camera probe to determine the contents of burrows of both species and individually marked those in which we were able to determine status. For active nests (defined as having an adult and egg, unattended egg, adult and chick, or unattended chick) we excavated a hole that provided direct access to the nesting chamber. This allowed us to monitor hatching date as well as temporarily remove nestlings for nestling growth measurements. All of the marked nests for both species are currently accessible using the burrow scope and/or the excavated access holes.

After the initial determination of burrow status, we continued to monitor active burrows regularly throughout the field season. Nests that had an egg at the time of the initial check were rechecked every other day until hatching to determine hatching date or until egg failure. We periodically checked nests with chicks (every 6-15 days) to determine nestling survival.

Nest status for the JFPE burrows was initially checked between 5-9 Feb. for the Tres Torres study area and on 24 and 28 Feb. for the Point Break study area. We determined initial nest status for each of the 32 STPE nests from 5-11 Feb. 2003.

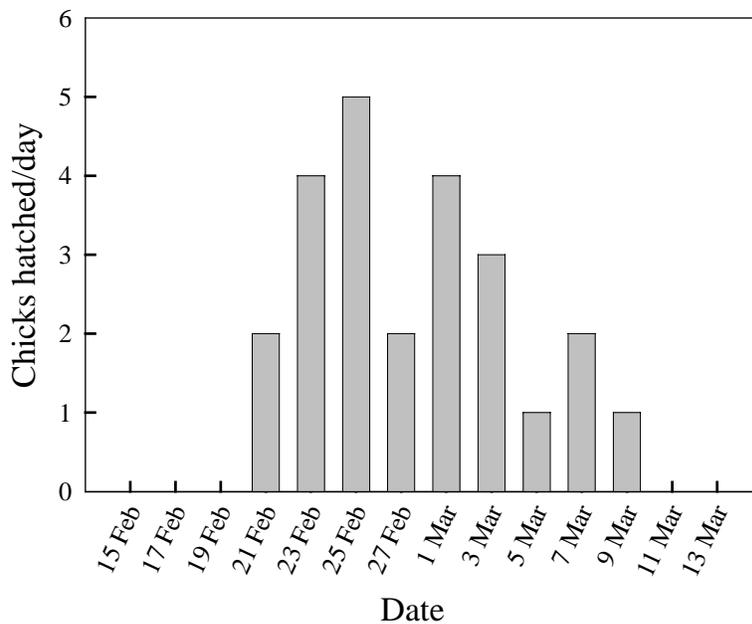
*Results: Juan Fernández petrels.* Of the 32 marked JFPE nests in the Tres Torres study area, 22 (69%) were active at the time of the initial check. Eighteen of the 22 eggs hatched (82% hatching success) with 13 of the 18 chicks surviving through 17 March (72% survival). Overall breeding success through that stage of the season was 59% (13 of 22). Note that our hatching success and overall breeding success estimates may be artificially high because they have been calculated based on information collected during the hatching period. Nests that failed early in the season may have been empty by the time of our initial status check. All of the chick mortality occurred within the first 5 days of life, with 3 of the 5 chicks dying on day 0-1.

Of the 16 marked JFPE burrows in the Point Break plot, 13 (81%) were active at the time of our initial check. Eleven of the 13 active burrows produced chicks (85% hatching success) with 9 of the 11 surviving through mid-March (82% survival). Overall breeding success through that stage of the season was 69% (9 of 13). One of the two chicks that died did so within the first five days after hatching while the second chick died during its second week of life.

When the data for the Tres Torres and Point Break study plots are combined, hatching success was 83%, chick survival through mid-March was 76%, and overall breeding success was 63%.

Unfortunately, the burrow probe broke at the end of February and, thus, we were unable to follow nest status in the tree fern-canelo forest. Based on the checks that we were able to conduct, 12 of the 15 burrows (80%) were active with at least 6 (40%) of the burrows producing chicks that survived until mid-March.

Our arrival in early February allowed us to follow the entire hatching period for all of our marked burrows in the Tres Torres plain and most of the burrows in the Point Break plot. Although four chicks had already hatched in the Point Break plot prior to our initial checks, we were able to obtain hatching dates for the remaining seven chicks. We determined hatching date for 24 chicks with the range of dates presented in Figure 2.



**Figure 2. Frequency distribution of hatching dates for 24 Juan Fernández petrel chicks in the Tres Torres plain and Point Break study areas.**

After hatching, JFPE chicks were typically brooded for no more than 2 days before being left unattended. Several chicks with down that was still damp, indicating that they had hatched that day, had already been left unattended. After the initial brief brooding period, adults were virtually never found in the burrow with their chick during the day.

*Results: Stejneger’s petrels.* Of the 32 marked STPE burrows, 27 (84%) were active at the time of the initial check. Twenty-four of the 27 active nests produced chicks (89% hatching success). The majority of the active STPE burrows already had chicks at the time of our initial checks (18 of 24 chick-producing nests). Twenty-one of the 24 chicks survived through mid-March (88% survival), at which point the oldest chicks would have been more than one-third of the way through the nestling period. Overall breeding success (also potentially artificially high, see above) was 78% (21/27).

Of the three eggs that did not hatch and were ultimately abandoned, two had mid-stage fetuses and one was infertile. In contrast with the pattern of JFPE chick mortality within the first few days following hatching, the 3 STPE chicks that died were all at least 14 days of age (two were approximately one month of age). There was no young nestling mortality evident in Stejneger's petrels.

We recorded hatching dates to the nearest second day for the six chicks that hatched after 5 February. Four of the six hatched between 5-11 Feb. while the remaining two hatched in late Feb. and early Mar. Two other chicks were attended by adults during our initial check on 5 Feb., suggesting that they had hatched on either 4 or 5 Feb. Chicks were brooded for no more than 2 days before being left unattended. Like the Juan Fernández petrels, STPE adults with chicks did not remain in the burrow during the day once brooding ceased.

*Discussion.* Hatching success appeared comparable for the two species, but chick survival (88% vs. 76%), and thus overall breeding success (78% vs. 63%), was higher for Stejneger's petrels. This pattern is consistent with the limited data that we have from the 2002 season in which chick survival appeared to be greater for Stejneger's petrels. However, because we were unable to follow nests from the date of egg laying, these results may be biased by possible egg loss early in the incubation period.

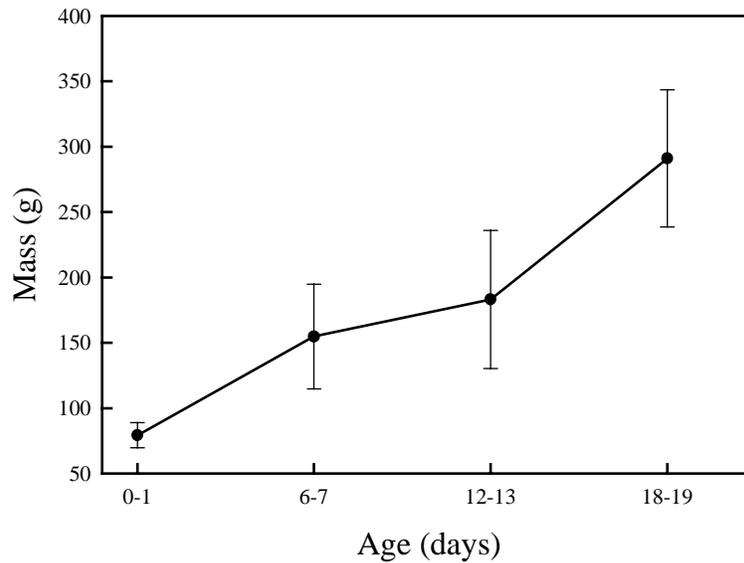
The peak hatching period of the two species appears to be offset by about three weeks. It appears that the peak of hatching for Stejneger's petrels occurs during the last week of January into the first week of February. This timing is similar to that of pink-footed shearwaters on Santa Clara and Robinson Crusoe and 2-3 weeks prior to peak hatching of Juan Fernández petrel chicks.

### **Nestling growth**

*Methods.* We collected nestling growth data from known-age nestlings of both species (20 JFPE and 6 STPE), measuring mass (g), wing chord length (mm), tarsus length (mm), and culmen length (mm) every 6 days from the day of hatching. We used excavated access holes to reach the chick in the burrow nest chamber. Chicks were returned to the nest chamber immediately after measurements were completed. We have measurements through 18-19 and 30-31 days of age for the oldest JFPE and STPE chicks, respectively.

We continued with the standard-date chick measurements that we began during March 2002. For these measurements, we measured all accessible chicks in our marked burrows on standard dates (15 Feb., 1 Mar. and 15 Mar.) whether or not they were known-age. These measures will allow for interannual comparisons of nestling growth and body condition even if we are unable to obtain hatching dates for all chicks. Most STPE nestlings had hatched by 15 Feb. but JFPE hatching had not yet begun. Thus, we only have JFPE chick measurements for 1 and 15 Mar.

*Results: Juan Fernández petrels.* We have growth curve data through day 18-19 for the parameters mentioned above, but will present only nestling mass growth for all 20 known-age JFPE chicks as an example (Figure 3, see following page).



**Figure 3. Nestling mass growth curve for 20 known-age Juan Fernández petrel chicks.**

A comparison of the 15 Mar. standard-date measurements for the 2002 and 2003 seasons is provided in Table 5.

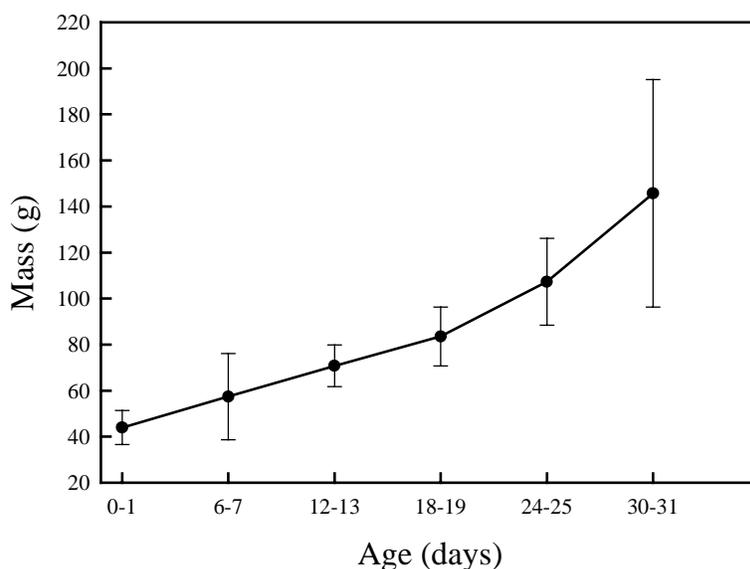
**Table 5. Standard-date JFPE nestling measurements for 15 March. Mean  $\pm$  1 SD**

Year	Mass (g)	Wing chord (mm)	Tarsus length (mm)	Culmen length (mm)
2002 ( $n=16$ )	195 $\pm$ 68	35 $\pm$ 7	27.3 $\pm$ 4.4	24.4 $\pm$ 2.1
2003 ( $n=18$ )	231 $\pm$ 68	35 $\pm$ 5	26.3 $\pm$ 3.1	24.5 $\pm$ 1.5

*Results: Stejneger's petrels.* We have measurements through 30-31 days of age for the two oldest chicks. At the time of our departure in mid-March, primary feathers on the oldest chicks were just beginning to emerge. Figure 4 (see following page) shows nestling mass growth for all six known-age STPE chicks.

For our standard-date STPE nestling measurements, we measured chicks on 15 Feb., 1 Mar., and 15 Mar. 2003 but present below only the data from 15 Mar. for both the 2002 and 2003 seasons (Table 6, see following page).

*Discussion.* Because we have very little growth data for known-age JFPE chicks from 2002, we cannot compare early chick stage growth rates between the two seasons. However, we can use the standard-date measurements to compare nestling growth between seasons. Based on these data and chick hatching data from both seasons that showed similar timing of hatching, chick growth appeared to be comparable between the two years at this stage of the season. Chicks in 2003 were slightly heavier, but were virtually identical in the three other measurements.



**Figure 4. Nestling mass growth curve for six known-age Stejneger's petrel chicks.**

**Table 6. Standard-date STPE nestling measurements for 15 March. Mean  $\pm$  1 SD**

Year	Mass (g)	Wing chord (mm)	Tarsus length (mm)	Culmen length (mm)
2002 ( $n=7$ )	155 $\pm$ 29	40 $\pm$ 5	26.8 $\pm$ 1.9	20.6 $\pm$ 1.2
2003 ( $n=19$ )	135 $\pm$ 35	34 $\pm$ 6	23.5 $\pm$ 2.8	19.5 $\pm$ 1.6

We lack growth data from known-age STPE chicks from 2002 which prevents us from comparing growth curves between seasons. However, as explained above, we can use the standard-date chick measurements to make interannual comparisons. Although the sample size for 2002 is small, the results suggest that STPE chicks from the 2002 season were slightly larger on the 15 March measurement date than 2003 chicks. Because we lack hatching dates for 2002, we cannot be certain that the hatching period was the same between the two years. However, based on observation of the developmental stages of chicks from both seasons, hatching periods appeared to be roughly comparable.

Like nestling survival, nestling growth can serve as an indicator of breeding season conditions. Thus, a multi-year set of nestling growth data, combined with dietary information and other breeding success parameters, can provide insights into possible long-term changes in the marine environment.

### **Egg measurements**

*Methods.* We measured length and width of eggs of both petrel species. Most measured eggs were found on the ground outside of burrows but three STPE eggs were collected from abandoned burrows. We examined the egg contents of the majority of the eggs, using the following categories: infertile, early embryo (evidence of early

development), embryo (more advanced embryonic development defined by presence of body), and fetus (more significant development characterized by the presence of down).

*Results.* Average egg length and width for Juan Fernández petrels were  $67.4 \pm 2.7$ mm and  $47.8 \pm 1.4$ mm, respectively ( $n=24$ ). Of the 18 eggs whose contents we examined, six were infertile, two had an early embryo, one had an embryo, and nine had a fetus. Thus, 50% of the eggs were successfully raised through at least the middle of the incubation period before failing.

Average egg length and width for Stejneger’s petrels were  $51.1 \pm 0.9$ mm and  $37.1 \pm 1.4$ mm, respectively ( $n=6$ ). Of the five eggs whose contents we examined, three were infertile, one had an embryo, and one had a fetus.

*Discussion.* With such a small sample size of STPE eggs, it is difficult to compare infertility rates between the two species, but this may be possible in the future with increased sample sizes. Because egg infertility obviously affects reproductive success, studies of its frequency add to our understanding of petrel breeding biology.

### Adult measurements

*Methods.* We measured adults of both petrel species, most of which were captured as part of the stable isotope diet study (see below). We were unable to determine the breeding status of these individuals, although most were probably either failed or non-breeders because they were captured while sitting on the surface of the colony and did not have well-developed incubation patches. We measured mass to the nearest 2g, wing chord length to the nearest mm, and tarsus and culmen length to the nearest 0.1mm. Birds were released at their capture location immediately after being measured.

*Results.* Table 7 below summarizes the average measurements of adults of both species.

**Table 7. Measurements of adult Juan Fernández and Stejneger’s petrels (breeding status unknown). Mean  $\pm$  1 SD**

Species	Sample size	Mass (g)	Wing length (mm)	Tarsus length (mm)	Culmen length (mm)
JFPE	17	$496 \pm 49$	$320 \pm 5$	$41.1 \pm 1.2$	$38.0 \pm 1.0$
STPE	11	$161 \pm 15$	$215 \pm 4$	$29.3 \pm 1.0$	$24.3 \pm 0.7$

*Discussion.* Although these data are basic, they are the most complete set of adult measurements available for both of these species. Such information has a number of fundamental applications including use in studies examining (1) classification and identification of seabirds, (2) condition of adult birds during the breeding season, and (3) nestling growth patterns. All of these applications can have conservation implications.

### Adult behavior and activity patterns in colonies

*Methods.* We have continued to study adult behavior in the colonies, focusing primarily on behavior of birds on the ground. This season we began to quantify behavior of individual birds of both species during night-time observations at marked nests of known status. We conducted observations on 16 nights, with observation periods ranging from 1 to 5 hours in duration. Inclement weather prevented us from conducting

observations on many other nights. The majority of our observations were made using the marked nests in the grassy clearing beside our camp area on Cordón de los Inocentes Bajos. JFPE nests comprised the majority of the burrows in this area, but there were at least 5 STPE burrows scattered throughout. In addition, we conducted 3 nights of observations at clusters of Stejneger's petrel nests.

We used night-vision goggles to observe a cluster of marked, known-status nests and opportunistically collected observations from nearby, unmarked nests as well. Burrow entries and exits were documented, and when possible focal-animal observations were initiated when a bird landed in the colony or exited a burrow. Observations of behaviors of individual birds were recorded every 30 seconds until the bird entered a burrow, took off, or was lost from view. Based on preliminary behavioral observations we developed 12 behavioral categories. These behaviors are as follows: sit on surface, sit and look (a behavior in which the bird sits and actively looks around), sleep, preen, walk, investigate burrow, vocalize, interact with other bird(s), "garden", short flight, dig/excavate burrow, and flap/stretch. "Gardening" is a term we ascribe to a behavior characterized by an adult bird steadily walking, uprooting small plants, and tossing them back over its wing. We also recorded arrival time and departure time to the nearest second. We noted the behavior of birds entering burrows because birds tended to either (1) enter a burrow directly with no hesitation or (2) sit at the burrow mouth and hesitate before entering. Departure behavior was also recorded (take off, enter burrow, or lost to view).

*Results.* We have not systematically analyzed these data yet, but we will present a brief overview of preliminary results. Time spent on the surface ranged from 12 seconds to 4+ hours for Juan Fernández petrels and from 5 seconds to >30 minutes for Stejneger's petrels. Individuals appeared to fall into two very general behavioral categories. The first includes birds that typically land within 1.5m of a burrow, walk directly to the burrow, and enter with no hesitation. They then take-off directly from the nest entrance. In contrast, there is a second category in which birds, after landing, typically wander around the colony for several minutes to hours, investigate a series of burrows, occasionally enter them, and generally spend considerably more time on the surface than birds in the first category.

*Discussion.* Our impression is that individuals from the first category are breeding birds, while those from the second category are non-breeding birds. These interpretations are consistent with published research on the behavioral patterns of other species of burrow-nesting petrels. However, in order to test these inferences for the species on Selkirk, we will need to conduct observations in the future on individually marked birds of known reproductive status.

## **FORAGING ECOLOGY**

*Methods.* We are continuing our study of the diet and trophic relationships of the Juan Fernández seabird community. We are using stomach content samples from adult petrels and stable isotope (carbon and nitrogen) analyses of blood samples collected from adult and nestling petrels. We collected stomach content samples from six adult Juan Fernández petrels that we found dead in the colonies as well as blood samples (100-300  $\mu$ L) from 11 adults and 9 nestlings of each species.

*Results/Discussion.* Although we have not yet analyzed the stomach samples, an initial examination suggests that they feed primarily on squid with fish making up the balance of the diet. Each stomach contained numerous squid beaks while several also contained remains of fish as well as fish otoliths (ear bones).

## **PREDATION**

We used a variety of methods to continue to investigate impacts of introduced mammalian predators on the breeding seabird population. These methods included attempts to determine if predation by hawks could be distinguished from predation by feral cats, the establishment of plots within the colonies in which we checked for predated petrels, direct observations in the colonies, and trapping for rats and mice.

### **Distinguishing between cat and red-backed hawk predation**

It appears that predation by cats can be distinguished from predation by red-backed hawks (*Buteo polyosoma exsul*). Cat predation, based on what we have observed on Robinson Crusoe (where there are no hawks) with pink-footed shearwaters, is characterized by wounds to the upper back and/or neck. Carcasses with these types of wounds may be uneaten or partially eaten, with the predator removing part or all of the pectoral (breast) muscles and leaving the rest of the carcass intact. Wings and head are typically not removed from the body of the seabird.

In contrast, hawks tend to remove most of the feathers on the breast and then disarticulate the carcass, removing the wings, legs and sometimes the head. Typically all that remains from a hawk predation event are feathers, sternum and wings. The remains are completely stripped of flesh and organs. On two occasions we observed hawks feeding on recently killed Juan Fernández petrels. After removing much of the plumage they appeared to disarticulate parts of the carcass.

### **Predation impacts plots**

*Methods.* We surveyed a series of plots in four habitat categories: 10 plots in tree fern forest adjacent to Tres Torres, one continuous plot in the Tres Torres grassy plain, and 27 and 5 plots in tree ferns on the north side and south side of Cordón de los Inocentes Bajos, respectively. We conducted surveys in 25 x 20m plots (Tres Torres) and 20 x 20m plots (Tres Torres and Inocentes Bajos), counting dead adult petrels, dead chicks, and eggs on the surface and noting evidence of predation, if present. The single plot comprising the Tres Torres grassy plain was surveyed daily from 5 Feb. through 17 Mar. in association with daily checks of marked JFPE nests. Each of the remaining plots were checked once during the season. We surveyed the Tres Torres tree fern plots between 10 Feb. and 7 Mar. Because of the nearly impenetrable density of tree ferns on the south side slopes we modified our survey technique to out-and-back transects 20m long (40m total length). We were able to see, on average, 3m to either side of our transect lines, thereby creating a total area surveyed of 240m<sup>2</sup> per out-and-back transect or 480m<sup>2</sup> for both people.

We recorded the same predation data in our nest density plots (5 x 5m dimensions) in Inocentes Bajos but not in Tres Torres.

*Results.* Survey results are presented in Table 8 (see following page). We encountered adult JFPE carcasses in all sectors surveyed except for the Tres Torres plain,

with the greatest density (1 carcass/514m<sup>2</sup>) found in the north side plots on Cordón de los Inocentes Bajos. This is also the only sector where we found the remains of adult Stejneger's petrels. In addition to the JFPE carcasses found in the Tres Torres tree fern forest plots, we also found five predated adult Juan Fernández petrels in the immediate area surrounding the plots, on either side of the small freshwater drainage from where drinking water is collected. All of the adult carcasses that showed evidence of predation appeared to have been killed by cats.

We found little evidence of chick predation, although some of the surveys were conducted before the peak JFPE hatching period. Both of the dead JFPE chicks found outside of burrows in our predation plots showed evidence of predation. During our daily nest checks along the Inocentes Bajos ridge we also found numerous dead JFPE chicks outside burrow entrances, but few of these showed evidence of predation. We did not find any dead STPE chicks on the surface in any of the study plots.

Of the 37 JFPE eggs found on the surface in these plots, four were intact, 11 showed evidence of predation (small holes with the egg contents removed) and the remainder were either crushed or appeared to have hatched. We found no STPE eggs on the surface in any of the plots. The lack of STPE eggs on the surface provides further evidence that this species does not nest in tree fern forest habitat.

**Table 8. Results of Selkirk predation impacts surveys**

Plot location and type	Total area surveyed (m <sup>2</sup> )	# of JFPE eggs on surface	# of nestling JFPE carcasses (% predated)	# of adult JFPE carcasses (% predated)	# of adult STPE carcasses (% predated)
Tres Torres: Plain	2,000	0	0	0	0
Tres Torres: Tree fern forest	4,700	10	0	2 (100%)	0
Inocentes Bajos: North side	11,525	22	2 (100%)	14 (79%)	9 (100%)
Inocentes Bajos: South side	2,525	5	0	4 (100%)	0
<b>TOTALS</b>	<b>20,750</b>	<b>37</b>	<b>2 (100%)</b>	<b>20 (85%)</b>	<b>9 (100%)</b>

*Discussion.* These surveys indicate that cat predation does occur within a broad area of the petrel colony and suggest an overall predation rate of approximately one predated Juan Fernández petrel per 561m<sup>2</sup> of colony. Excluding the Tres Torres plain habitat (in which we recorded no predation) yields a slightly higher predation rate within the tree fern habitat of one predated Juan Fernández petrel per 507m<sup>2</sup> of colony. The area-dependent predation rates were comparable between Tres Torres (tree ferns) and Inocentes Bajos; however, nest density was lower in the tree fern habitat of Tres Torres, thereby suggesting that predation pressure may be greater in that area. Neither vegetation density nor vegetation height appeared to affect predation intensity, although the relationship between predation and habitat characteristics such as vegetation density and height, slope aspect, and slope angle is not currently understood.

Our results thus far suggest that predation pressure during the 2003 season was not high in the areas surveyed, but even a small increase in adult mortality rates can have

population-level impacts. We have only preliminary burrow occupancy data and, thus, cannot derive a robust estimate of predation rate. However, using these data we estimate a 2-3% adult mortality rate in the areas surveyed. It is important to note that we have surveyed only a small percentage of the total colony area and habitat types and that the impacts of predation may differ. For example, we did not conduct surveys more than 300m distant from the ridge crest, and predation rates may vary farther down the slopes. In addition, it was not possible to determine categorically the reproductive status of the predated adults. If there are behavioral differences between breeding and non-breeding petrels (as suggested above) then predation impacts may disproportionately affect one of these populations.

### **Predation observations**

*Methods.* During our night-time colony observations we also opportunistically searched for feral cats using spotlights and our night-vision equipment. We conducted basic behavioral observations during the two instances when we observed cats and they were unaware of our presence. These observations continued until the cat was lost to view.

*Results.* We observed four different feral cats in the vicinity of our campsite on Cordon de los Inocentes Bajos, recording markings of each cat to identify them individually. Three of the cats were observed along the tree fern boundary while the fourth was seen at the edge of a patch of ferns beyond the tree fern boundary. We did not observe any of these cats killing petrels although two of them walked amongst clusters of petrels before disappearing in the tree ferns. It is noteworthy that none of the petrels reacted in any noticeable manner to the presence of a cat. In one instance, a cat walked between two petrels, neither of which even looked at the cat.

*Discussion.* Combined with cat observations from March 2002, we have identified seven different feral cats within the colonies. This represents an absolute minimum population size as we have not systematically attempted to quantify feral cat abundance. We have also either seen cats, evidence of cat predation, or tracks in track pads (March 2002) in the Tres Torres sector and along more than 2km of Cordon de los Inocentes Bajos. Estimates of cat predation rates from Marion Island and Kerguelen Island exceed 300 petrels killed per cat per year. Assuming cats in the Selkirk colony are preying primarily on petrels during the breeding season, the number of petrels killed by just these seven cats alone would number in the thousands each year.

### **Predation by red-backed hawks (*Buteo polyosoma exsul*)**

*Methods.* As part of our daily rounds of marked burrows, we conducted censuses of the open areas along Cordon de los Inocentes Bajos ridge, recording counts of hawk-predated petrels. We recorded evidence of predation including wounds, condition of carcass, and presence/absence of hawks at the carcass.

*Results.* We did not witness predation directly, but on several occasions we encountered hawks with freshly killed petrels. In our censuses of the open areas along the Inocentes Bajos ridge we regularly encountered the remains of Juan Fernández and Stejneger's petrels which showed evidence consistent with hawk predation. Of 28 Juan Fernández petrel carcasses we found during our surveys, the remains of 25 were consistent with hawk predation. In contrast, in our predation impacts plots in the heavily

vegetated tree fern and canelo forest we found no petrel carcasses that had been disarticulated as described above, suggesting that the predation was not due to hawks.

Stejneger's petrel remains found in open areas were characterized most commonly by nothing more than one or both wings plus feathers. Eleven of 16 carcasses found during our surveys had only wings remaining.

*Discussion.* If this predation evidence is attributable to hawks, then they prey on both species of petrels breeding on Selkirk. Based on work conducted in 1986, M. de La Brooke estimated that Juan Fernández petrels were approximately seven times more abundant than Stejneger's petrels (comprising approximately 87.5% of the breeding petrels) and also reported that predation appeared to disproportionately affect Stejneger's petrels. If we use these relative abundances derived from de La Brooke's results then our observations also suggest that Stejneger's petrels are disproportionately preyed upon by hawks since they comprise approximately 13% of the breeding petrel community yet 36% of the carcasses found in our censuses.

Predation by native hawks is a selective pressure that breeding petrels have had to confront historically and is, thus, a natural part of the system. This contrasts strongly with the predation pressure of relatively recently introduced mammals such as cats and rodents. The absence of a response to cats by petrels likely indicates that petrels on Selkirk have had little time evolutionarily to respond to a novel selective pressure, predation by introduced mammals, and demonstrates why introduced mammals pose such an extreme threat to the seabird community of the archipelago.

## **Trapping**

*Methods.* We used a combination of Victor snap traps and live traps to capture Norway rats *Rattus norvegicus* and house mice *Mus musculus* within the petrel colony. We set lines of snap traps along the boundary between the grassy plain and the tree ferns in the Tres Torres sector. Because of the greater density of burrows along the ridge of Inocentes Bajos we used rat live traps and mouse snap traps to minimize the possibility of unintentionally catching a petrel. No petrels were captured in any of our traps. We baited traps with peanut butter and cheese, and traps were checked and reset daily during the trapping effort.

*Results.* In 24 nights of trapping in Tres Torres (229 trap nights; 8 Feb.-5 Mar.), we captured 10 rats and 36 mice. We captured no rats and 13 mice on Inocentes Bajos in 22 nights of trapping (249 trap nights; 9 Feb.-3 Mar.). We collected muscle samples from all 10 rats and 16 mice from Tres Torres and from 11 of the mice trapped on Inocentes Bajos.

*Discussion.* Compared with the 2002 trapping effort (63 trap nights; 10 rats trapped) in the same area of Tres Torres, rats appeared to be considerably less abundant this season. We intend to continue trapping in subsequent seasons to compare relative rat abundance between years. We are unsure if the lack of rats in the Inocentes Bajos traps is due to an actual absence in the colony along the ridge or to an unwillingness to enter the live traps. Muscle samples from the trapped rodents will be used in stable isotope analyses of diet to determine if rats and mice are preying on petrel eggs and/or chicks.

## RESEARCH ON THE KERMADEC PETREL (*Pterodroma neglecta*)

Determining the status and trends for the breeding population of Kermadec petrels (*Pterodroma neglecta*) in the archipelago remains an important priority for our project. Prior to the beginning of our 2003 field season we began to compile data on the global distribution and abundance of Kermadec petrels, and our findings suggest that the species should be listed as “vulnerable” based on IUCN criteria. We are currently preparing a manuscript to present this information and propose that the species be listed. Given their uncertain status globally, the long-term monitoring program of the population breeding on Morro Juanango that we proposed and initiated during 2002 takes on additional importance and relevance.

*Methods.* During the 2003 season we marked and monitored the breeding success of 44 Kermadec petrel nests through the mid-chick period on Morro Juanango. We visited three times (6 January, 13 February, and 25 March 2003) during which we recorded the status of every marked nest within the monitoring quadrat. During our 25 March visit we collected blood samples (100-200 $\mu$ L) and measurements from chicks to be used for stable isotope analyses of diet composition and for interannual comparisons of nestling growth, respectively.

*Results.* Of the 44 nests, 28 (64%) were active during the season, meaning that an egg was laid at the nest. Twenty-one of the eggs hatched (75% hatching success) with 15 chicks surviving to the mid-chick stage at the end of March (71% chick survival and 54% breeding success through this stage).

Nestling measurements are summarized in Table 9. Note that chick ages for these individuals are not known.

**Table 9. Comparison of Kermadec petrel chick measurements between seasons. Mean  $\pm$  1 SD. Sample sizes provided in parentheses below year.**

Year	Measure date	Mean mass (g)	Mean wing length (mm)	Mean tarsus length (mm)	Mean culmen length (mm)
2002 (n=4)	27 March	516 $\pm$ 100	128 $\pm$ 20	41.1 $\pm$ 1.5	28.8 $\pm$ 1.8
2003 (n=12)	25 March	501 $\pm$ 137	128 $\pm$ 49	40.1 $\pm$ 3.7	28.4 $\pm$ 2.4

*Discussion.* We had expected that egg laying would have been completed by early January, but females at three nests laid eggs after our 6 January census. Only one of these three late eggs hatched. Similarly, we expected that hatching would have finished by mid-February but we found eight nests that still contained an egg during our February visit with four of those eggs ultimately hatching.

If we can continue this monitoring program over multiple years, we will be able to use hatching dates combined with chick measurements at standardized time(s) of the season (i.e. late March) to assess overall chick condition. This, in turn, may be a useful indicator of conditions in the surrounding marine environment. Results from the 2002 and 2003 seasons suggest that nestling growth was comparable through late-March.

Consistent with our findings from 2002, we also found abandoned eggs of DeFilippi's petrels (*Pterodroma defilippiana*) and white-bellied storm-petrels (*Fregatta*

*grallaria*) within the Kermadec petrel study plot. Population estimates for the two species, however, are currently not available.

## **COMMUNITY INVOLVEMENT**

### **Public lectures and drawing contest t-shirts**

On 27 January 2003, we held a public seminar at the Casa de la Cultura (town museum/library/internet facility), which over 70 adults and children from the community attended. Our presentation included a description of the seabird community in the archipelago and our current research and conservation efforts.

During this event, we also presented entrants in the 2002 drawing contest (see 2002 Season Report) with t-shirts printed with the winning drawings. Remaining shirts were donated to the Corporación Cultural of the Juan Fernández Municipality, and proceeds from their sales will in turn be donated to community programs related to conservation, including environmental education.

In addition, we presented a set of posters displaying all of the 2002 drawing contest entrants' artwork to both the Casa de la Cultura and the Juan Fernández Municipality office. Finally, we donated a set of biology books for primary school students to the Casa de la Cultura library collection.

### **Field courses**

We offered field courses to high school age residents as part of the Campamento del Verano (Summer Camp), a series of workshops coordinated by a grassroots youth group, la Juventud Robinsoniana. We conducted four courses, each lasting 24 hours, allowing youths to visit Vaquería with two members of our research team. Groups of 8-10 teenagers were given the opportunity to learn about the conservation and ecology of their islands, collect data and experience field work alongside biologists studying local systems. The courses were a success due to the enthusiasm, support and cooperation of all those involved, including the administration and park rangers of CONAF, La Juventud Robinsoniana, the Campamento del Verano and the participants.

### **Primary school activities**

Four members of our research team visited the Escuela Dresden on 1 April 2003. We visited each of the school's nine classrooms and gave an introductory talk about local seabird communities (basic biology and conservation). The format was informal to allow students and teachers to ask questions and understand more about the islands' native avifauna.

After school the same day, we invited all primary school children to the Escuela Dresden to participate in a kite making workshop. The 30-40 children in attendance learned hands-on the characteristics of, and necessities for, flight. This workshop was complemented by a reading and book donation of Spanish editions of *The Lorax*, a children's tale of conservation by Dr. Seuss.

### **Local pink-footed shearwater reserve**

In 2002, we met with CONAF representatives, the town mayor (Leopoldo Charpentier), and other municipality officials to discuss our proposal to create a

shearwater reserve on municipal land on Labrador Ridge (immediately southeast of the current urban area, see Season Report 2002). The municipality agreed to set aside the reserve area defined in the proposal such that it would not be available for future urban construction; however, the authority of this agreement is valid only through the term of the current mayor. In 2003, we prepared a proposal, with the assistance of Hernán Gonzales (CONAF) and Juan Torres de Rodt (municipality), to Bienes Nacionales, the federal land granting agency (see Appendix A). If our proposal is successful, this area would be granted and protected as a biological reserve for a minimum of 25 years, allowing us to continue to expand the possibilities for community involvement and education at the proposed site.

We organized visits to Labrador Ridge during the season, during which we invited all interested parties to explore the colony and examine burrows with us, using infrared burrow cameras. The most successful visit was held in early April, with over 50 adults and children (including residents and tourists) in attendance to see a pink-footed shearwater chick and discuss basic biology and conservation concerns.

The reserve is within the municipality, and therefore streetlights line the road that cuts through the reserve area. Bright lights serve to disorient shearwaters, especially fledglings dispersing from the colonies. Though uninjured, these disoriented birds can more easily fall prey to cats, dogs, and rats. We successfully worked with a lighting company in Santiago (Acting Electric) to find a solution to the problematic streetlights. Acting Electric has donated red streetlight panels for existing lights within the colony, and the municipality and public works have graciously installed them. The emitted red light does not negatively impact shearwater orientation, as did the white light. We are currently working with Acting Electric to consider alternatives for general streetlighting in town, where light pollution also disorients seabirds.

## **CONSERVATION CONCERNS**

### **Eradication and restoration**

There is no question that introduced mammals and vegetation have had a devastating impact on organisms native and endemic to the archipelago. The Juan Fernández-Dutch Cooperative Project (JF-DCP) implemented control programs for several exotic plant species, goats, and rabbits; however, we feel strongly that these measures provide only a temporary stop-gap and that complete eradication efforts are necessary. Our efforts this season continued to suggest that predation by rats, coatis, and feral cats on seabirds is a significant threat. The presence of introduced predators is a particularly dangerous situation because, due to the life-history strategy of these birds (long lifespan, delayed reproduction, etc), even a small increase in adult mortality can have a disproportionately large impact on population stability.

In 2003, we coordinated contact between CONAF and the US non-profit organization Island Conservation, which specializes in introduced mammal eradications on islands worldwide. To date, a proposal and budget are being negotiated between the organizations for a rabbit eradication effort on Isla Santa Clara, and we are hopeful that an eradication will be conducted by late 2003. Combined with the successful efforts of CONAF/JF-DCP personnel to dramatically reduce the Santa Clara rabbit population, we feel that a collaborative effort between Island Conservation and CONAF hunters will be

able to eliminate rabbits from the island while providing additional training and experience to local park rangers. Ideally, Island Conservation personnel will be able to survey Isla Robinson Crusoe during their visit, providing a first step to formulating potential eradication projects in this much larger and more complicated system.

We continue to lead and expand concerted efforts to educate the local community about the necessity and benefits of complete eradication and the threats of the continued presence of introduced species. We feel that this education and understanding will be critical to a lasting eradication and conservation effort in the Juan Fernández Islands.

We discussed the multiple benefits of, and our eagerness to assist with, well-planned, scientifically robust restoration efforts in our 2002 Season Report. We reiterate that herbivore eradications be completed prior to investing in plant restoration projects. We view a successful rabbit eradication on Isla Santa Clara as a perfect opportunity to begin direct restoration efforts there, as well as to use the island as a restoration “laboratory” for additional restoration strategies on Robinson Crusoe and/or Alejandro Selkirk.

### **Other fauna**

The endemic Juan Fernández firecrown (*Sephanoides fernandensis*) has a restricted breeding range and a quickly diminishing population (an estimated decline from 800 to 400 individuals from 1999 to 2002), is listed by the IUCN as endangered, and is of primary conservation concern. In the austral spring of 2002 we financially supported a collaborative firecrown research and conservation effort with F. Johow (UNORCH, CODEFF) and CONAF. We provided support for field season expenses such as transportation, food and lodging for volunteer field assistants responsible for nest searching and monitoring. In April 2003, we met with Mr. Johow to discuss future hummingbird conservation strategies and will continue to collaborate and assist whenever possible.

### **ACKNOWLEDGEMENTS**

We are indebted to the Wallis Foundation and the National Geographic Society for their financial support and enthusiasm for this project. We also thank Wildlife Conservation Society for administrative assistance. These efforts would not have been possible without the assistance and permits provided by Mario Galvez, Leonardo Moder and Javiera Meza of CONAF, and Agustín Iriarte and Horacio Merlet of SAG (Servicio Agrícola y Ganadero). We thank the regional CONAF staff based in Viña del Mar for welcoming us this year, and for their interest and input during our presentation and meetings. We appreciate the collaborative efforts of Dr. Roberto Schlatter of the Universidad Austral de Chile and his student Alejandro Sepulveda. We also thank Adolfo Navia of Acting Electric for his generous support and enthusiasm.

We cannot express sufficient gratitude to the local CONAF personnel, who are too numerous to list individually. We are particularly indebted to Gastón Correa, Hernán Gonzales, Gert van Leersum, the entire corps of park rangers and the JF-DCP staff, the CONAF administrative officers, and their families. The successes of our project were due to the continuous and enthusiastic logistic, programmatic and conceptual support from CONAF, and we consider our time in the field with rangers and hunters invaluable.

We thank everyone at CONAF for their willingness to assist our efforts and to share their knowledge, impressions, and skills with us.

We thank Leopoldo Charpentier, Juan Torres de Rodt, Gastón Arredondo and the mayor's office for their guidance, collaboration, and support. We also thank Don Victorio Bertullo and the Casa de la Cultura, Eric Bravo, the teachers and children of the Escuela Dresden, and the Juventud Robinsoniana. We are indebted to the *Francis* and *Calypso* for continued assistance with transportation and daily existence on Santa Clara. We also appreciate the enthusiasm and support of the Selkirk community, all of whom contributed to what we accomplished during our season on that remarkable island. Finally, we wish to extend special thanks to the Recabarren Green and López Chamorro families, and general gratitude to the local population as a whole. We treasure the sense of welcome and enthusiasm with which we were treated. Our efforts to return and continue working on the islands are fueled as much by the unique ecosystem as by the enormously rewarding experience of working with our above-mentioned colleagues.

APPENDIX A

(for English translation please contact M. Wainstein or P. Hodum)

**Propuesta a Bienes Nacionales para una reserva  
local de fardelas blancas en Isla Robinson Crusoe**

**Responsables**

**Michelle Wainstein, Universidad de Washington, EEUU  
Peter Hodum, California State University at Long Beach, EEUU  
Juan Torres de Rodt, Corporación Cultural de Juan Fernández  
Enero 2003**

## Introducción

Existe un claro desconocimiento de la biología y de la situación actual de las aves presentes en el Archipiélago Juan Fernández. Sin embargo, está claro que la actividad antrópica desarrollada desde el descubrimiento del archipiélago ha traído consigo alteraciones de los hábitats de estas especies, que sumado a la introducción de animales dañinos las estarían afectando insospechadamente.

Para remediar esta situación se requiere de investigaciones permanentes y censos a lo largo del año. Esta necesidad de realizar estudios que revelen los aspectos más trascendentes de la biología de las especies y el conocimiento de los factores que estén poniendo en peligro su preservación, generalmente están asociados a investigaciones que realizan universidades y entidades extranjeras. Este es el caso de los investigadores Michelle Wainstein y Peter Hodum, directores de Proyecto Fardelas, que actualmente se encuentran realizando estudios en el archipiélago destinados a aclarar la situación particular de las fardelas, especies de aves marinas muy poco estudiadas y que sin embargo están en categorías de conservación delicadas básicamente por ser especies muy sensibles a factores negativos.

Dentro de sus actividades estos investigadores se han preocupado fuertemente por el traspaso de conocimiento que pueden entregar a través de diferentes actividades de difusión. A este respecto es importante dar la posibilidad a la comunidad de conocer a estas especies en un ámbito de acercamiento científico, esto permitiría la valoración de las especies, además de ser un apoyo fundamental para la educación ambiental a nivel Insular. Es importante destacar que durante su ejercicio han ubicado una colonia de fardelas (una fardelería) inserta en el área de la población que reviste gran importancia. Este tema pasa a dar origen a una propuesta (adjunta) que dadas las consideraciones previas reviste gran importancia para toda la comunidad en términos educacionales, turísticos y principalmente de investigación.

### Estado de la Fardelería

La fardelería es una colonia de la fardela blanca (*Puffinus creatopus*). El lugar se ubica en el cordón "El Labrador". Tiene una superficie de aproximadamente 3000 m<sup>2</sup> y está ubicada entre los 53 y 86a msnm. En el lugar hay por lo menos 14 cuevas ubicadas a menos de 25 metros del camino que va al Pangal. Hay 9 ubicadas arriba del camino y 5 abajo.

Examinamos todas las cuevas con una cámara de infra-rojo en febrero de 2002 (en la mitad de la temporada de nidificación) y encontramos 4 cuevas activas, 2 vacías, y el estado del resto no se había clarificado porque el largo de la cueva era demasiado para la cámara. No obstante, basado en evidencia directa como guano fresco, plumas, y olor fuerte de fardela nos parecía que 5 de estas cuevas estuvieron activas.

A finales de enero 2003 encontramos 6 cuevas activas, 5 vacías, y 3 desconocidas, 2 de las cuales muestran evidencia de actividad.

### Importancia de la Fardelería

Aunque ahora esta fardelería está pequeña todavía tiene una importancia que sobresale su tamaño. La sobrevivencia de la fardelería es importante por varias razones diversas.

#### *Conservación*

La razón principal por extinción de aves mundialmente es pérdida de hábitat apropiado. La existencia de esta fardelería tan cerca a la zona urbana de la isla demuestra las posibilidades para las aves y los humanos a convivir y compartir recursos naturales. Proteger lo que queda de esta colonia representaría un esfuerzo importante de

conservación para esta especie endémica a Chile y para la comunidad de Juan Fernández, que ya tiene una ética de conservación bastante desarrollada.

### *Educación*

La educación está al fondo de todos los esfuerzos, y es importante enseñar como se puede convivir con especies de importancia en el patio de nuestra casa, tratando de minimizar nuestro impacto (recordemos que ellas estaban antes que el hombre llegara). La educación nos ayuda desarrollar respeto por el entorno y por el hábitat de animales y plantas nativos. También nos deja entregar las herramientas a través de la ciencia para que la comunidad se sienta inmersa en la tarea de conservar los recursos naturales del Archipiélago.

### *Interés turístico*

La mayoría de las colonias de aves marinas en el archipiélago no son muy accesibles a turistas ni a la gente de la comunidad. Esta reserva podría servir como una atracción cerca del pueblo. Desde el pueblo, turistas podrían caminar y ver una colonia de un ave endémica a Chile y aprender algo de su historia natural, las amenazas que las confrontan, y como se pueden cuidar.

### *Investigación científica*

Además de las oportunidades educativas la colonia nos proveería con oportunidades científicas para mejorar nuestro conocimiento sobre la biología de la fardela blanca, una especie casi desconocida. Un programa de monitoreo comunal, junto con las investigaciones de Proyecto Fardelas, sería muy útil a determinar las fechas de la postura, la eclosión, la salida de los volantones, y el éxito reproductivo de una colonia urbana. También se puede comparar esta colonia con colonias más aisladas en las islas de Robinson Crusoe y Santa Clara que el Proyecto Fardelas ya está estudiando. Además un programa científico basado en esta fardelería les proveería a personas que estén interesados una oportunidad a experimentar aspectos de investigaciones científicas.

### *Significación histórica*

En el pasado esta fardelería debió ser de tamaño más grande, pero ha sido disminuida debido al desarrollo de la población en torno ella. Esta fardelería nos provee de una oportunidad para mantener un aspecto histórico del pueblo, particularmente la presencia de fardelas nidificando junta a la comunidad.

## **Establecimiento de una Reserva**

Proponemos y pedimos a Bienes Nacionales establecer una reserva local para las fardelas. La reserva incluiría la colonia y el área circundante. Esta reserva se quedaría abierta y accesible al público y serviría como un recurso educativo, turístico y científico para la comunidad. También sería una oportunidad de desarrollar una reserva al interior de la comuna, que sus habitantes pueden adoptar, involucrarse, y cuidar.

Solo establecer esta reserva como parcela de tierra no disponible a desarrollo urbano sería muy importante para proteger y mantener la población de fardelas en este sitio. Hay evidencia en los recuerdos de mucha gente de la comunidad que hace 30-40 años la colonia era mucho más grande. Por medio de esta protección, se podría en el futuro desarrollar varios objetivos que pertenecen a la importancia de la fardelería anteriormente citada.

Las siguientes ideas de desarrollo que proponemos dependerían totalmente de fondos conseguidos por Proyecto Fardelas, CONAF, y/o la Municipalidad de Juan Fernández. Las ideas y prioridades del desarrollo de la reserva serían aprobadas por Bienes Nacionales en cuando

fondos se consiguen. Listamos posibilidades para desarrollar la reserva si la tierra sea prestada por Bienes Nacionales:

### *Infraestructura*

Para mejorar la conciencia comunal de la reserva sugerimos un letrero informacional. Este letrero puede incluir no solo la designación como reserva sino también materiales educacionales. Además un letrero puede servir como notificación visual de la reserva y como un recuerdo de la presencia de fardelas y del mensaje de conservación medioambiental.

Para mejorar el acceso público a la reserva se puede construir unos escalones en la piedra/tierra y establecer senderos cortos.

Eventualmente una caseta o quiosco con actividades interactivas se puede desarrollada. Por ejemplo, puede incluir actividades que tratan con el ciclo de reproducción de fardelas, como se siente ser un polluelo adentro de unas de las cuevas, etc.

### *Educación e involucración comunal*

Proyecto Fardelas ha preparado materiales para un exposición de muestras colectadas en terreno. Estos materiales pueden ser presentados en la Casa de la Cultura en el centro del pueblo, en el Centro de Información de CONAF que se encuentra en el camino hacia la colonia, y/o en la caseta propuesta anteriormente. Cualquiera de estas opciones que es elegida haría información disponible a la gente de la comunidad y grupos de niños escolares, y aumentaría interés en visitar la reserva.

Proyecto Fardelas ha enseñado a algunas personas dentro de CONAF sobre la biología y historia natural de las fardelas, tal como el uso de la cámara infrarroja. Posiblemente un guardaparque de CONAF pueda estar encargado de supervisar la reserva y coordinar el trabajo con personas de la comunidad que quieran involucrarse en la reserva. Proyecto Fardelas donarían una cámara infrarroja para estos fines.

Una reserva podría servir como un único recurso educativo para la comunidad. Debido a su ubicación accesible la escuela podría aprovechar de la reserva para viajes al terreno. Y serviría como recurso no solo para la escuela pero sino también para la comunidad. Se les ofrecerían viajes a la reserva para enseñarles sobre la biología de las fardelas, las amenazas que las confrontan, y varios conceptos que tratan con la conservación de sistemas naturales. Un calendario de estas visitas programadas pueden ser desarrollado durante la temporada de nidificación, principalmente para observar los contenidos de las cuevas usando la cámara infrarroja. Anuncios con la fecha y horario de estas visitas con personas entrenadas en la ecología de las fardelas y en el uso de la cámara pueden ser hechos en la radio comunal y con carteles en la comunidad.

Aprovechando de esta mejora en la conciencia de la comunidad que una reserva puede animar, se podría desarrollar un programa “Hay fardelas en el patio de tu casa?”. Tal programa enfocaría en la búsqueda para otras fardelerías chicas en la cercanía del pueblo. Si se encuentran cuevas se puede ir con la cámara a ver si están activas (esto lo hay que pensar bien con el tema de la construcción – queremos que la comunidad vea el encuentro de una fardelería como algo positivo, no negativo, ya que quizás después no se podría construir en esa zona).

También se podría desarrollar un programa “Adoptar-una-fardela”. Los jóvenes que demuestren interés, o cada nivel el la escuela basico de la isla, pueden “adoptar” a un nido/polluelo. Al elegir uno recibirían un paquete informativo sobre el crecimiento del polluelo, materiales educativos, etc. Esto se realizaría en conjunto con los programas de monitoreo y por medio de anuncios de radio se informaría a la comunidad del estado de los nidos, etc.

Antes del inicio de próximas temporadas de reproducción, los involucrados pueden realizar una limpieza del área de la fardelería, incluyendo el sacar hojas y ramas de las entradas de las cuevas.

Instalación de tecnología con una cámara permanente, donde cualquier persona pueda ver los nidos, y, quizás llegar a poder transmitir las imágenes a los televisores o computadoras en casas en tiempo actual (estilo “web-cam”?).

#### *Interés turístico*

Muchas de las ideas propuestas para educación comunal también servirían como atracciones turísticas, como viajes a ver las fardelas adentro de las cuevas con la cámara infra-rojo, o observación en tiempo actual en las computadoras disponibles en la Casa de Cultura.

Un foyeto y/o otras materiales educativos se podría desarrollar para ofrecer en la Caseta de Información de CONAF a la entrada del pueblo, donde turistas presentemente reciben información sobre senderos, flora, etc de la isla.

Poder ver una colonia de aves endémicas de las islas sería un buen método para iniciar interés en la ecología y conservación del Parque Juan Fernández en general. Este entusiasmo puede también extenderse a interés en productos artesanales y turísticas generados por isleños que sean relacionados a la naturaleza de las islas.

#### *Investigación científica*

Biólogos del Proyecto Fardelas han estado durante parte de la época de reproducción de 2002 y 2003, pero en general no se ha seguido el etapa temprano de puesto de huevos, o el etapa tarde de salida de volantones de los nidos. Esta información sobre la fardela blanca es actualmente desconocida, y obtener estos datos sería muy importante para el campo de ornitología. Con las cámaras infra-rojos donados, las personas entrenadas también podrían continuar con seguimientos durante el inicio y el final de las temporadas de reproducción. Estas personas pueden chequear los nidos con regularidad y continuar con una busca meticulosa de las áreas circundantes en busca de otras cuevas.

Otro método de investigación de aves muy común es la construcción de cuevas artificiales para estimular el uso de la fardelería. Además de proveer nidos para nuevos inmigrantes a la colonia, también es una técnica que da acceso directo a la cámara de nidificación de las aves. Esto dejaría desarrollar estudios de monitoreo y crecimiento de los pollos, índices muy importantes de la salud de la población. Si se establece cuevas artificiales para estudios científicos, también se podría ofrecer visitas a la comunidad y a turistas para mirar adentro de la cámara de nidificación. Este tipo de acceso a esta especie de ave marina sería una experiencia posible en ningún otro lugar en el mundo.

Como una parte de nuestras investigaciones quisiéramos probar varias técnicas de atraer fardelas a la colonia y estimular el uso. Quisiéramos intentar a aumentar el tamaño de la colonia para mejorar su estado a largo plazo. Una técnica que ya está bien establecida y que podría complementar el establecimiento de cuevas artificiales es el uso de vocalizaciones grabadas. Esta técnica de emitir vocalizaciones grabadas ha sido usada para atraer fardelas en otras islas para restaurar/aumentar poblaciones (i.e. Hawaii, Nueva Zelanda, y Canada). Además tal proyecto sería una fantástica oportunidad educativa y turística.

Como describimos antes, estamos buscando fondos para investigaciones a largo plazo y tenemos muchas ganas a realizar las ideas anteriormente citadas. Aunque sea posible no realizar todas estas ideas inmediatamente no obstante el establecimiento de una reserva para que las fardelas puedan seguir nidificando allá serviría como un recurso único desde muchas perspectivas.

## APPENDIX B

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