SCIENCE AND RESEARCH
INTERNAL REPORT NO.50

DEPARTMENT OF CONSERVATION, SCIENCE PROGRESS REPORTS 1988/89

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CONTENTS PAGE

Preface

SOCIAL SCIENCE
Evaluation of Project Conservation 1

MARINE MAMMALS
Hooker's sea lion 6

REPTILES
Ecology of Whitaker's skink at Pukerua Bay, Wellington 10

Lizard translocation research: *Cylodina whitakeri* on Korapuki Island 13

BIRDS
A study of remote radiotracking: methodology and reliability 19

Conservation of the Chatham Island Taiko 26

Ecological and economic aspects of Canada goose feeding of Grassmere Station, North Canterbury 32

Foods and foraging behaviour of South Westland forest birds 37

Habitat use by forest birds in temperate rainforests, South Westland, New Zealand 41

Kiwi Call Scheme 49

Population dynamics and breeding biology of the known aged population of red-billed gulls, Kaikoura Peninsula 62

The breeding biology, population dynamics, diet, habitat requirements and movement of takahe in the Murchison Mountains, Fiordland National Park 66

The population dynamics, breeding biology, diet, habitat requirements and movement of kakapo 69

Translocation of Black Petrels from Great Barrier to Little Barrier Islands 74

PREFACE

This Internal Report contains the extended summaries from a range of science investigations carried out by Science & Research Division in the 1988/89 financial year. (Executive summaries of all Science & Research Division science investigations are in Internal Report No. 46 Part 1.)

The extended summaries give additional details on a few selected investigations. Extra information on these and any other science investigations can be obtained from the investigation leader.

INVESTIGATION NO: S8085/501
CORPORATE OBJECTIVE: 7.3

INVESTIGATION TITLE:	Evaluation of Project Conservation
INVESTIGATION LEADER:	Bev James, Science & Research Directorate
STUDY VENUE:	West Coast Region, Murihiku District, Whangarei District, Coromadel District, Hauraki District, Tainui District, Rakiura District, Central Office.
INVESTIGATION LEADER:	Bev James
INVESTIGATION STATUS:	Fieldwork completed, manuscript in process
CLIENT:	DOC (Advocacy & Extension Directorate)
EXPECTED FINISH DATE:	September 1989

INVESTIGATION SUMMARY:

Project Conservation, an Advocacy and Extension Directorate responsibility, aims to encourage public involvement in conservation work. This has occurred:

(i) through voluntary, unpaid work,
(ii) through trainee schemes, such as ACCESS.

Four pilot programmes, in West Coast Region, Murihiku, Whangarei and Coromandel Districts were underway in 1988. These were the subject of a sociological evaluation of the success and benefits of the programme to date.

The evaluation examined the process of setting up Project Conservation: structure and organisation, staff and participants' experiences and perceptions, and whether the programme is implemented as designed.

The evaluation also investigated the extent to which Project Conservation has achieved its goals.

OBJECTIVES:

1. To analyse the process of setting up and developing Project Conservation in each pilot area.

2. To examine the extent to which the goals of Project Conservation have been achieved in each pilot area.

3. To compare the development of Project Conservation in the pilot areas.

4. To compare Project Conservation in the pilot areas with Project Conservation in three non-pilot districts ('comparative districts').

METHODS:

Research design and literature research were undertaken during October-November 1988. Fieldwork, which involved a visit to each pilot scheme and to two comparative districts (Hauraki and Tainui) occurred from 22.11.88 to 9.12.88. During the visit to Murihiku it was decided to include Rakiura in the study. Although unable to visit, the researcher had contact with the District Conservator at that time and after returning to Wellington.

Field work methods consisted of indepth interviews with key people involved in Project Conservation. These included Project Conservation Coordinators, District Conservators, staff directly involved in Project Conservation activities, volunteers, trainees (limited to West Coast districts, as the other areas did not have such programmes), and individuals outside of the department who have input into the development of Project Conservation.

Most respondents participated in a structured interview during which responses were both tape-recorded and written by the researcher. Some volunteers and the trainee group were interviewed in a group context. The researcher also attended meetings and conducted unstructured interviews as appropriate. Owing to time constraints, some staff could not be contacted for interview, but information was obtained from them via a questionnaire. It was also necessary in a few cases to interview individuals over the telephone.

In addition to the variety of methods used during the fieldwork, this information is supplemented by data from the following sources:

- collection of relevant statistics pertaining to the areas studied,
- documentary research including investigation of files, reports and other written materials pertaining to Project Conservation.

ACTIVITIES:

Since completion of the fieldwork, a great deal of time has been spent analysing the interview material. An oral report, outlining preliminary results was presented to Central Office staff involved in the development of Project Conservation on 30.1.89. A written summary of preliminary results was sent to the areas who participated in the study in early March.

The next stage of the project is to produce the final report, which will go to key people for comment. When completed, the final report will be available for interested districts, regions and directorates.

RESULTS TO DATE:

A. Positive Aspects of Project Conservation

1. Project Conservation has the potential to be an effective advocacy tool in building up public support for the department, and encouraging greater commitment to conservation. Staff regard advocacy as Project Conservation's most important role.

2. Project Conservation provides opportunities for district staff to develop closer relations with their local communities, which enable them to more effectively carry out conservation work.

3. Demands for input into conservation policy and management from various interest groups can be catered for in part through Project Conservation, which opens up channels for community liaison and consultation.

4. Work on the conservation estate is achieved through Project Conservation. Volunteers have achieved some work that would not have been done otherwise. But the main contribution has been to help with low priority or routine work, thus ensuring earlier completion. However, most staff regard the work outcome as less important than the advocacy benefits to be derived from Project Conservation.

B. Negative Aspects of Project Conservation

1. Project Conservation puts strain on district resources as it places additional demands on staff and the operational budget.

2. Poor communication is evident between staff and Project Conservation participants. In particular, inadequate staff knowledge of volunteers' skills and expertise, and some problems in making the best use of volunteers is apparent.

3. Training is required for staff involved in Project Conservation so that they can more effectively communicate with and manage volunteers and trainees.

4. Training is required for Project Conservation participants, including introductory orientation to the department and Project Conservation, understanding of conservation and tutoring in specific skills.

5. The perception of volunteers and trainees being used as a substitute labour force is not easy to dispel. This is not only held by some staff, but also by some members of the public. A real difficulty for staff is to maintain cordial relations with the Workers' Union over this matter. There is a danger that perception of Project Conservation as a means of providing labour for the department, rather than as an advocacy strategy, will jeopardise its success.

6. The Project Conservation goals lack clear, concise definition. Furthermore, appropriate guidelines based on the goals are not provided for the development of Project Conservation. The relevance of two of the goals are questioned by some staff; Goal IV (to provide training in basic conservation tasks) is regarded as the least relevant; Goal II (strengthening links between the department and conservation organisations) is not considered to be an important goal for Project Conservation by some staff, but something which should occur throughout the department's activities. Staff consider the most relevant goal for Project Conservation is Goal III (to provide new opportunities for people to experience the values of the natural environment).

7. Owing to problems in goal definition, the extent of goal achievement cannot be easily measured.

8. Project Conservation lacks a clear policy focus. This is an overriding issue, which has implications in a number of areas mentioned above, such as training and goal formulation.

ADDITIONAL FINDINGS:

1. Although volunteers and trainees constitute a source of cheap labour, there are associated costs with running Project Conservation programmes which suggest that they are ineffective as a cost-cutting measure. It should further be noted that programmes have not been designed as cost-cutting measures.

   Costs involved in running programmes include the financial costs of materials, transport and sometimes accommodation. There are also the costs of maintaining the work that is done after a project is finished (e.g. new tracks). Furthermore, there are personal costs on staff,

including increased workload, stress, and Project Conservation responsibilities impinging on out-of-work time.

2. An outstanding contrast between the pilots is the differences in time spent on volunteer activities, as compared to trainee activities. Murihiku has given volunteer programmes top priority. At the time of the research, the co-ordinator spent about 80% of his time on volunteer activities. Much less emphasis was given to volunteer programmes on the West Coast; about 20% of the co-ordinator's time being spent on those. Coromandel and Whangarei have more evenly balanced their efforts between volunteer and trainee activities. The main reason for West Coast's emphasis on trainee programmes is that ACCESS is a significant source of funding for Project Conservation in that area.

3. The experience of several areas (West Coast, Whangarei, Coromandel and Hauraki) shows there is an untapped supply of volunteers who are willing to assist the department, but who cannot be used because of lack of resources to provide the infrastructure to support voluntary work.

4. Initiatives from participants in trainee programmes in 3 areas (West Coast, Whangarei, Coromandel) have resulted in volunteer activities. The involvement of trainees more broadly in Project Conservation through volunteer work could go some way towards achieving the goal of providing new opportunities for people to experience the natural environment.

5. A wide variety of local groups and institutions support Project Conservation, by providing resources ranging from funding to equipment and personnel. There are indications that the community is an untapped source of support.

CONCLUSIONS TO DATE:

It is appropriate that Project Conservation has been evaluated at this time. The programme in West Coast Region has been in operation for 18 months, and in the three districts for about 6 months. One significant finding is that the organisational environment of restructuring and difficult financial circumstances in which Project Conservation is being developed, have an impact on the success of the programme. These factors which are external to the programme are not the only significant influences. Factors intrinsic to Project Conservation also affects its success. These are:

- funding specifically allocated to Project Conservation
- staff training
- appropriateness of Project Conservation activities to the local community's requirements, interests and resources
- development of policy and guidelines for Project Conservation.

While those involved in Project Conservation may not be able to substantially alter the external factors impinging on the programme, they have a responsibility to address the problems specific to Project Conservation. It is however acknowledged, that these 'internal' factors are also linked to external matters, such as the department's overall allocation of resources.

The data from the study so far suggests that a primary task is to develop coherent policy and guidelines for Project Conservation which build on the valuable work that has been done in the four pilot areas. Committed staff have gone a long way in their attempts to interpret Project Conservation within their local contexts. Now a broader overview, incorporating this experience, is needed to address the problems the evaluation identifies.

RECOMMENDATIONS:
At this stage, the following recommendations emerge:

1. Development of a coherent policy and guidelines, including concrete definition of goals, and attention to how Advocacy goals can be achieved through Project Conservation.

2. Development of a training programme for staff involved in Project Conservation.

3. Greater attention to training and educational requirements for volunteers and trainees. This should include a more explicit conservation education component in the programmes.

4. Investigation of potential sources of community support and the types of resources offered. This exercise needs to be done for each district.

5. Identification of the nature and extent of volunteers' skills/expertise and how this may be fitted within the district's work plan.

6. The potential for involving trainees in volunteer programmes requires further development.

COMMENTS:
A follow up project will concentrate on drawing up a set of guidelines for monitoring and assessing the social impacts and social values of departmental programmes. It is envisaged that a User Handbook, outlining and explaining appropriate social science methods of evaluation, will be produced. A seminar/workshop is also planned.

INVESTIGATION NO: S5010/173
CORPORATE OBJECTIVE: 3.3

INVESTIGATION TITLE: Hooker's sea lion

STUDY VENUE: Southern, Murihiku, subantarctic.

INVESTIGATION LEADER: M W Cawthorn

INVESTIGATION STATUS: Current

CLIENT: DOC, Fishing Industry

EXPECTED FINISH DATE: February 1992

INVESTIGATION SUMMARY:
Hooker's sea lion *(Phocarctos hookeri)* is New Zealand's largest indigenous mammal. The population has been reduced from initial level by Maori subsistence harvesting, commercial sealing and subsistence catches by castaways at the Auckland Islands. A current constraint to population recovery is from incidental catches of sea lions in the trawl squid fishery to the south of New Zealand.

Information is being sought on the population size and status, biology, behaviour and fisheries interactions of this sea lion so that the appropriate management decisions can be made to ensure the long term survival of the species.

OBJECTIVES:
1. To continue to monitor the size and status of the Hooker's sea lion population.

2. To investigate the biology, physiology, behaviour and distribution.

3. To monitor levels of interactions between sea lions and commercial fisheries and the effect of incidental catches on the continued viability of the population.

METHODS:
Population censusing is carried out at the rookeries during the breeding season. Ground counts are augmented by aerial photography. Pups are tagged at their natal rookeries to quantify numbers and mortality in the first few months of life, to assess interchange between rookeries and monitor dispersal and range. Biology and physiology is investigated through sampling in the field and instrumentation and radio tracking of individuals at sea. All sea lions taken incidentally during fishing operations are returned to New Zealand for autopsy.

RESULTS AND ACTIVITIES (1988):
No field work was conducted at either of the key rookeries at the Auckland Islands in the last two season. A total of 43 sea lion pups was tagged at Campbell Island and observations made at the Snares Islands between November and December confirm that the Snares have not yet become a regular breeding site.

RESULTS TO DATE:

All work in the field at the rookeries has to take place during the short one and a half month long breeding season from December to mid-January. Annual surveys at the Auckland Islands and Campbell Island indicate that the world population of Hooker's sea lion is currently between 5,500 and 7,500 animals. Because of the difficulty of landing on the principal rookery (Dundas Island) at the Auckland Islands and the habit sea lions have of roaming far inland at Campbell Island, an absolute population size has, so far, been impossible to obtain. All pre-breeding animals go through a vagrant stage when they roam far from the rookeries. For this reason, and others, it has not yet been possible to accurately gauge the effect on the population of continued incidental catches of sea lions in the trawl squid fishery. Repeated censuses at the major rookery suggest the population may be in a slow decline. In the 1985-86 season, 24 sea lions were returned from the squid fishery, 21 in 1986-87, 12 in 1987-88 and 7 so far in 1988-89. An initial analysis of incidental catch data indicated that an annual catch of about 125 adult sea lions would halve the population in a little over 50 years. This analysis was limited by a lack of knowledge of many parameters affecting both the fishery and sea lion recruitment and behaviour. Although the recent incidental catches of sea lions are small the high proportion of adult females taken is cause for concern.

The key to an understanding of the incidental catch problem lies in the maintenance of maximum observer coverage of all trawlers working the fishery. Observers aboard the vessels record behavioural data in a standard format noting, for example, the number, species and size of seals around each vessel, whether the seals approach or avoid the ship when the gear is being hauled or shot away and whether the animals are feeding from the net or waste chutes. From this information, added to catch data, it is possible to detect changes in vulnerability and mortality by year class.

Observations of tagged animals have shown that pups only five months old can make open-sea journeys of more that 250 nautical miles, unaccompanied by adults. Sub-adult and non-breeding males roam farthest from the rookeries, some being observed as far north as Banks Peninsula and as far south as Macquarie Island. Recently, a tagged juvenile from the Enderby Island rookery appeared in Lake Waihola, confirming the propensity for this species to roam, by way of rivers and drainage systems, up to 18 km inland.

Female sea lions produce their first pup at age 4-5 years. There is no evidence of twinning. Males, although sexually mature at 5-6 years, are not socially mature until 8 years or more. The oldest and the heaviest sea lions recorded so far are 18 years and 160 kg for females, and 23 years and 326 kg for males. Few females are likely to exceed 160 kg in weight, but large males probably reach a maximum of 450 kg at the beginning of the mating season.

Physiological investigations in 1985-86 and 1986-87 concentrated on diving ability, behaviour and adaptation to prolonged apnoea and extreme pressure. Female sea lions at Enderby Island were instrumented with time, depth and flow recorders to monitor their underwater activity. Results show a remarkable ability to make repetitive dives to over 400m with no apparent fatigue. In one 320-hour feeding excursion one small mature female took just 70 minutes rest.

Studies of diet and feeding behaviour are crucial to understanding the relationship of these animals to the local fisheries. Hooker's sea lions show a preference for squid, octopus and fish in the summer. During autumn large quantities of the Auckland Island spider crab *(Jacquinotia edwardsi)* appear in regurgitations, along with the remains of southern blue whiting, sharks and rays. The sea lion has a varied diet and will consume food ranging from bivalves to penguins and fur seal pups.

During the trawl squid season (February-May) sea lions of all ages will associate closely with trawlers. They are intelligent animals and are particularly inquisitive. Accounts from ships crews and observers suggest sea lions are learning to climb over floating net cod-ends to pull squid from the meshes without being caught. Once the gear is aboard, they take up station beneath the factory discharge chutes to feed on the continuous supply of fish scraps dumped overboard. They will investigate large commercial crab pots and small sea lions will swim into the pots to investigate the bait. Large crab and crayfish traps are a potential cause of mortality if any fishery were to be opened up at the Auckland Islands (which is currently a zone closed to all fishing).

The annual natural mortality rate of adults is unknown. A likely major contributing factor is predation. White sharks, killer whales and leopard seals, all of which are known to kill sea lions, are found in the vicinity of the Auckland Islands. At least 30% of all animals observed at the rookeries bear scars from attacks by one or other of these predators.

INTERIM CONCLUSIONS:

Until sufficient data are gathered to prove otherwise, it would be prudent to assume that the Hooker's sea lion population is declining.

Breeding is restricted to small rookeries close to major commercial trawl fisheries, Recruitment rates are slow and any addition to natural mortality, such as incidental catches in the fishery, will only show recovery to pre-exploitation levels.

Any inshore fishery development is likely to adversely affect the population, especially at rookeries easily accessible by man.

Improved population estimates require long-term monitoring of pup production at the rookeries and the maintenance of adequate manning levels of observers on vessels fishing the subantarctic area.

COMMENTS:

Like most large marine mammals, the Hooker's sea lion has a low reproductive rate. With continued catches incidentally to the squid fishery taking over 60% females of breeding age, the impact on this polygynous species will be seen to gradually accelerate. It is particularly important that an accurate pup count is made at intervals no greater than each two years to establish an index to pup productivity which will provide the most accurate gauge of the population status. This can only be achieved with dedicated funding, a major proportion of which should be provided by the fishing industry.

INTERIM RECOMMENDATIONS:

1. Annual pup production at all rookeries must be monitored carefully to assess any fluctuations in recruitment.

2. Aerial photography techniques should be developed as an adjunct to ground counts in censusing the population.

3. Preferred feeding grounds should be identified through instrumentation and radio telemetry.

4. The discreteness of breeding units and amount of interchange of breeding sea lions between rookeries should be investigated using genetic techniques.

5. Commercial trawlers working the trawl squid fishery should continue to carry observers, and Masters should be strongly encouraged to continue reporting all incidental catches of sea lions and other marine mammals and return required specimens to New Zealand.

INVESTIGATION NO: S5040/161
CORPORATE OBJECTIVE: 3.3

INVESTIGATION TITLE: Ecology of Whitaker's skink at Pukerua Bay, Wellington.

STUDY VENUE: Wanganui Region, Raukawa District.

INVESTIGATION LEADER: David Towns

ASSOCIATED RESEARCHERS: Dr C.H. Daugherty, Victoria University of Wellington

INVESTIGATION STATUS: Fieldwork completed

CLIENT: DOC

EXPECTED FINISH DATE: March 1990

INVESTIGATION SUMMARY:

A study of the distribution, abundance and habitat requirements of Whitaker's skink at Pukerua Bay was carried out between December 1982 and March 1987. Whitaker's skink was the rarest of the five lizard species at Pukerua Bay, had the most restricted distribution, was the least frequently recaptured species, and was the species whose capture frequency was most clearly influenced by environmental conditions. The ecological and behavioural characteristics shown by Whitaker's skink indicate that it is a species highly vulnerable to habitat destruction and disturbance.

OBJECTIVES

1. To determine the distribution, habitat requirements and abundance of Whitaker's skink at Pukerua Bay.

2. To obtain an assessment of the long-term prospects of the species.

3. To obtain data on the abundance and habitat preferences of other lizard species at Pukerua Bay for comparison with Whitaker's skink so that these can be fitted into models of the effects of habitat change.

4. To use multivariate statistical analyses as a means of predicting the effects of reserve management on the lizards' environment.

5. To propose management techniques which will ensure the continued survival of Whitaker's skink at Pukerua Bay.

6. To determine whether the Pukerua Bay population of Whitaker's skink was genetically distinctive from other populations, and therefore requires separate conservation status.

METHODS

Information on distribution of lizards was obtained using pitfall live-traps set on transects through all potential habitat, and focused on a 640 mz study grid for details of movement and recruitment. Information on capture frequency, growth and longevity were obtained from animals marked and released at the point of capture. Surface and subsurface conditions were measured by using maximum-minimum thermometers. Distribution of captures relative to vegetation and physical factors was mapped using a modified Point Height Intercept technique.

The genetic identity of the Pukerua Bay population was checked against all other populations of the species by the Genetics Unit, Victoria University of Wellington.

RESULTS TO DATE

Analysis of data is yet to be completed, so figures below are provided in rounded form.

1. Whitaker's skink was the least commonly captured species at Pukerua Bay. Only 80 captures of 70 individuals were made over 30,000 trap days (covering 4 summers), compared with 1600 captures on common skinks, 400 brown skinks, 500 copper skinks and 300 common geckos (each includes multiple recaptures).

2. Whitaker's skink was the most narrowly distributed species, being confined to the stable, deep bouldery scree at the base of the hill slope. The species was captured most frequently where *Muehlenbeckia* cover was dense (Towns 1985).

3. Recapture rate (all summers lumped) was lowest for Whitaker's skink (20%), compared with 40% for brown skinks and 30% for all other species.

4. Capture rates for Whitaker's skinks were strongly influenced by climatic conditions, and showed high within-season and between-season variability. Capture rates were highest in summer when night-time air temperatures exceeded 15°C, but were depressed by high daytime surface temperatures. Most captures were in January and February.

5. Recaptures of marked Whitaker's skink show a high level of site specificity and slow growth rate. Males appear to take three years to reach sexual maturity and females four years. Mature animals may live for long periods. The oldest known-age animal was 7 years, but other, larger individuals were probably older.

6. There is little genetic difference between the three populations of Whitaker's skink, indicating that they were once part of a much larger continuous gene pool. Similar lack of divergence occurs in the copper skink and common gecko, from the same, or nearby locations as Whitaker's skink, indicating a common pattern to the way in which the Pukerua Bay, Castle Island and Middle Island populations became fragmented.

7. Until 1987 stock (sheep and wandering goats) were continuing to reduce the native vegetation cover at Pukerua Bay, thereby reducing stability of the scree and exposing the Whitaker's skink population to predation and climatic (temperature) extremes. Further disturbance was being caused by collectors (presumably of unprotected lizards). These problems hastened the purchase and fencing of the present reserve and establishment of a draft management agreement with Porirua City Council.

INTERIM CONCLUSIONS

1. The combination of narrow habitat requirements, sensitivity to climatic conditions, and slow growth rate makes this species highly vulnerable to predation, habitat destruction and disturbance.

2. The proximity of the Pukerua Bay site to an urban area places restrictions on management activities, such as predator control. The area is also a high fire risk and because of these dangers, the Whitaker's skink population at Pukerua Bay should continue to be regarded as highly vulnerable. Habitat restoration and predator control elsewhere must therefore be used to lessen pressure on the species (see Project S 5040/163) (Towns et al in press).

COMMENT

1. Fencing of the Pukerua Bay site was completed in 1987, but the reserve is still not gazetted. At present prosecutions cannot be brought against collectors disturbing the Whitaker's skink habitat in search of the unprotected lizards. Disturbance had reached such a high level in the late 1970's that Whitaker's skink was regarded as being extinct at this site. Habitat disturbance is still apparent today.

2. Habitat enhancement, involving planting species such as mahoe and karaka around the screes should improve the quality and stability of habitat available to Whitaker's skink. This action would also reduce the spread of *Coprosma propinqua,* a species under which these skinks are rarely found. Recommendations for planting are provided in the draft working plan.

3. The study indicates that Whitaker's skink is one of a group of species with unusual physiological needs. An understanding of these requirements holds the key to determining the effectiveness of management activities for this species at Pukerua Bay.

PUBLICATIONS AND REPORTS

Towns, D.R. 1985a: The status and prospects of the rare New Zealand lizards *Leiolopisma grande* (Gray), *Cyclodina whitakeri* Hardy and *Leiolopisma otagense McCann* (Lacertilia Scincidae) *In* "Biology of Australasian Frogs and Reptiles" (Eds G. Grigg, R. Shine, H. Ehmann) Royal Society of New South Wales *(N.Z Wildlife Service Publication No. 298).*

Towns, D.R. 1985b: Pukerua Bay Wildlife Refuge Draft Working Plan. N.Z. Wildlife Service Unpublished Report, Department of Conservation File SRE/0045

Towns, D.R. 1987 (updated 1989) Rare species register : Whitaker's skink. Whitaker's skink.

Towns, D.R., Daugherty, C.H., Pickard, C.R. (in press.) Developing protocols for island transfers: a case study based on endangered lizard conservation in New Zealand. Proceedings of International Workshop on Herpetology of the Galapagos. University of New Mexico Press.

INVESTIGATION NO: S5040/163
CORPORATE OBJECTIVE: 3.3

INVESTIGATION NAME: Lizard translocation research: *Cyclodina whitakeri* on Korapuki Island

INVESTIGATION LEADER: David Towns

ASSOCIATED RESEARCHERS: Ian McFadden DOC - Rodent and rabbit eradication, Murray Douglas DOC - Data logger development, Dr Charles Daugherty Victoria University of Wellington, School of Biological Sciences - Ecological genetics, Dr Ian Atkinson, DSIR, Botany Division - Vegetation studies, Mrs H Polly McColl - Litter invertebrate studies

INVESTIGATION STATUS: Current

CLIENT: DOC

EXPECTED FINISH DATE: March 1992 (Field work)

INVESTIGATION SUMMARY:
Protocols for island transfers of endangered lizards are being developed which address questions of genetic identity, maintenance of heterozygosity, minimum viable population size and habitat selection. The long-term goal is to use endangered lizards as a model when planning the rehabilitation and management of small offshore island ecosystems.

OBJECTIVES:
1. To develop techniques and planning criteria for the rehabilitation of island ecosystems.

2. To eliminate kiore *(Rattus exulans)* and rabbits from 18 ha Korapuki Island.

3. To measure the response of resident lizard populations to removal of an introduced predator and to compare this with neighbouring islands predatory rodents remain, and where they have never been present.

4. To measure the microhabitat conditions under which the endangered Whitaker's skink *(Cyclodina whitakeri)* occurs on Middle Island.

5. To establish Whitaker's skink from Middle Island on Korapuki Island in appropriate microhabitats following rodent eradication.

METHODS:
Criteria for transfer
Korapuki Island was chosen as a suitable site for transfer of *Cyclodina whitakeri* using the criteria established by Towns et al. (in press). These criteria were based on three considerations: the ecological value of remaining predator-free locations; feasibility of habitat rehabilitation following eradication of predators; and the genetic basis for establishing populations in new locations.

Rodent eradication

Eradication of kiore from Korapuki Island was undertaken using poison dispensing silos described by McFadden (1984). One hundred and twenty silos were installed on the island in November 1986, baited with kibbled maize, and left for four nights. By the fourth night bait take was locally high, with much scattered grain and rat faeces in the silos. All grain was then removed and replaced by kibbled maize dosed with bromodialone, an anticoagulant rodenticide.

Lizard populations

Lizard population densities and composition are being studied using pitfall traps along fixed transect lines on Middle Island (rodent free), Korapuki Island (rodent eradication) and Stanley Island (rodents still present). Each island has at least three transect lines set in each of shoreline and forest habitats. The transects are 100m long and consist of 20 traps set in blocks of four 2m apart at 20m intervals. Within each block one trap is baited with meat, one with fish, one with fruit, and one left unbaited. All lizards captured are identified, weighed and released.

Genetic diversity of the scattered populations of Whitaker's skink is being studied using allozyme analysis of blood, muscle and liver tissue in collaboration with the Genetics Unit, Victoria University of Wellington. Results of these analyses are being used as the basis for identifying suitable populations of Whitaker's skink for transfer to Korapuki Island.

The most appropriate population structure and demography to be used for transfer has been determined using computer models developed specifically for this project by Ross Pickard (DOC). The models make it possible to predict likely mortality rates (and therefore population expansion rates) under different release regimes. Data from the genetic studies have then been added to this model to determine the most appropriate sex ratios of the groups of released animals.

Invertebrate studies

Invertebrate community structure on Korapuki Island is being studied in collaboration with Soil Bureau, DSIR. The studies are aimed at determining the impacts of the presence of rodents and the response of the fauna to rodent eradication. Controls are provided by neighbouring islands which lack rodents and those where kiore are still present. The data provided enable sites of high invertebrate density to be identified on Korapuki Island. These are then assessed for their suitability as release sites for Whitaker's skink.

Vegetation analyses

Invertebrate densities on Korapuki Island are strongly influenced by composition of the vegetation and this in turn reflects the impacts of soils and browsing by kiore and rabbits. An understanding of the course of vegetation succession on the island following removal of all browsers will enable estimation of the extent of available habitat for the transferred lizards. Soil structure and vegetation changes on Korapuki Island are being studied in collaboration with Botany Division, DSIR.

Microhabitat requirements

Field studies on the relationship between intensity of activity and microclimate indicate that Whitaker's skink has unusually narrow thermal requirements as well as a need for high moisture levels. These conditions are likely to be met in the seabird burrow complexes in which the species is found on Middle Island. What these conditions are, and the extent to

which they are duplicated on Korapuki Island, are likely to influence the success of the release programme. Microhabitat conditions (temperature and humidity) are therefore being studied on Korapuki and Middle Islands using electronic data loggers.

RESULTS AND ACTIVITIES (1988):

Rodent eradication

A ship rat was caught in an index snap-trap on Korapuki in August 1988. This species has not been reported previously from the smaller Mercury Islands. The one caught on Korapuki almost certainly originated from an illegal landing after being accidentally transported by boat from Great Mercury Island where ship rats are common. Following this event, all grain silos on Korapuki were baited with prefeed, 60 snap-traps were set, and two talon-block bait stations were established. There has been no further sign of rats and it is likely that only the one animal was able to land.

Lizard populations

A further visit to check lizard populations was made in November 1988, and trips are planned for March and November 1989. The capture rate of lizards on one coastal transect on Korapuki has consistently increased since rats were removed, and now equals the rate for a physically similar site on Middle Island.

Islands Conference

A two-day seminar presenting results of the Korapuki programme was held in the Northern Regional Office in November 1988. A recommendation from the seminar was that a conference on island restoration should be held. This conference is planned for November 1989 and was given Executive Management Group approval in January.

RESULTS TO DATE:

Rodent eradication

Korapuki Island was checked for kiore approximately six weeks after the poison was laid in November 1986, but although all silos were refilled with unpoisoned kibbled grain, there was no further take by rats. There has been no sign of kiore in 15 checks of Korapuki Island since the poisoning operation.

Rabbits were eradicated by shooting, with the last animal being seen in August 1987. A flush of growth of highly palatable seedlings since late 1987 indicates that the rabbit eradication has been successful.

Lizard populations

Korapuki Island locally supports high densities of lizards which are diurnal and live in coastal areas. Forest dwelling species are rare and large ground-dwelling skinks of the genus *Cyclodina* are absent. Lizard densities are low everywhere on Stanley Island, and so far no lizards have been captured in the forested transect. Middle Island supports high densities of lizards in coastal habitats and although fewer individuals are captured in forest areas, these sites are distinctive for their high biomass of *Cyclodina* skinks (Towns in press).

There has been no measurable increase in the frequency of captures of lizards in forest areas, nor evidence of expansion of coastal species into forest areas, following eradication of the rats from Korapuki. This is not surprising in view of the low litter size (2) and slow growth rate of the forest dwelling species.

None of the three populations of Whitaker's skink can be distinguished on genetic criteria, despite the geographic range of 500 km. This is consistent with the low levels of genetic diversity now found in a range of unrelated terrestrial reptile species with distribution patterns similar to that of Whitaker's skink. This implies that many island populations of lizards are the result of continuous populations fragmented by rising sea levels following the last glaciation (Daugherty et al in prep).

Twenty five Whitaker's skink were transferred from Middle to Korapuki Island in February 1988 into an area whose suitability was determined from microhabitat data and invertebrate density. Two of these lizards were recaptured in March 1988. The release site is being checked twice a year and the number of lizards released is being increased gradually to 50.

Invertebrates

Mahoe and tawapou groves have been identified as supporting the highest density and diversity of invertebrates on Korapuki Island. Based on these findings an area of almost pure mahoe forest was chosen as the first release site for Whitaker's skink. Other studies relating invertebrate diversity to vegetation composition and the effects of predation are being continued by Mrs McColl. One significant feature is the unusually low number of beetle species present on Korapuki Island compared with Middle and Stanley Islands.

Vegetation

Since rabbits have been removed there has been a proliferation of seedlings in some parts of Korapuki Island. Most common species include taupata, mahoe, karo, poroporo, and ngaio. The latter species has become particularly widespread with some plants growing over lm in less than 12 months. More detailed studies of vegetation and soils are being continued by Dr Atkinson.

Microhabitat requirements

Use of the data loggers has demonstrated that temperatures and humidity fluctuate little within seabird burrows. Temperatures often remain near 20°C and humidity at over 90%. Conditions vary little between islands but do change according to exposure to prevailing winds and the form of the burrows being investigated. Fluctuations are least in burrows with a narrow aperture such as those produced by diving petrels.

CONCLUSIONS TO DATE

1. Korapuki Island is undergoing a rapid change in vegetation composition following removal of rabbits.

2. Following the removal of rats from Korapuki, resident lizard populations have undergone measurable change only in coastal sites with forest areas still supporting very low lizard densities.

3. Forest habitats represent "empty" habitats for lizards on Korapuki Island, making them suitable for the introduction of forest species such as *Cyclodina whitakeri,* as long as these transfers are conducted soon after rodent removal.

4. There is little genetic divergence between populations of *Cyclodina whitakeri,* indicating that they are fragments of a continuous population isolated by rising sea levels. Such a model supports the great antiquity and high levels of endemism now being proposed for the New Zealand lizard fauna (Daugherty et al in prep).

COMMENTS

1. The appearance of a ship rat on Korapuki Island has highlighted the need for management backup for eradication campaigns. This support should include advocacy and surveillance as part of a comprehensive management plan.

2. The success with kiore eradication on Korapuki has raised the prospect of ecological restoration of larger islands. These prospects have been addressed in a broader project proposal for integrated research and management in the Mercury Islands (Towns 1988).

PUBLICATIONS

Towns, D.R. 1988 Rodent eradication from islands - the conservation potential. *Forest and Bird 1988.* 32-33

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Papers delivered at Australian Bicentennial Herpetological Conference, August 1988: Daugherty, C.H., Towns, D.R., Hitchmough, R., Voss, M., French, D., Thorn, C. Relationship between genetic distance and geographic isolation in some rare New Zealand reptiles *(Sphenodontidae, Gekkonidae, Scincidae).*

Towns, D.R. Rats revisited: the impact of kiore *(Rattus exulans*)on the lizard assemblages of some New Zealand offshore islands.

(Also delivered to Society for Amphibian and Reptile Research in New Zealand Annual Meeting, November 1988. Abstract to be published in New Zealand Journal of Zoology).

Towns, D.R. 1988. Project proposal: an integrated approach to island rehabilitation and ecological planning in the Mercury Islands. 28p.

INVESTIGATION NO: S5020/548
CORPORATE OBJECTIVE: 8

TITLE: A study of remote radiotracking : methodology and reliability.

INVESTIGATION LEADER: B. D. Lloyd

STUDY VENUE : Stewart Island, Victoria University, Wellington

INVESTIGATION STATUS: Manuscript in process

CLIENT: DOC

EXPECTED FINISH DATE: September 1989

INVESTIGATION SUMMARY:

Since 1981 radiotelemetry techniques have been essential to the study and management of kakapo. Hand radiotracking with portable receiving antennas has provided the means to study diet and breeding, to monitor survival, to target predator control and to recapture kakapo for transfers. Remote radiotracking, with rotatable directional receiving antennas at fixed sites, was used to investigate the home range, behaviourial interactions and habitat use of radiotagged kakapo on Stewart Island.

Remote radiotracking has been used widely to study the ecology and behaviour of free ranging wild animals as disturbance to the study animals is minimised and location estimates for a large number of animals may be obtained at regular intervals for a minimum of effort. Recently several authors (e.g. Springer 1979, Hupp and Ratti 1983, & Lee et al. 1985) have drawn attention to the errors in location estimates obtained using the technique. In this investigation currently accepted methods for analysing remote radiotracking data were examined critically, and new more rigorous methods developed. The angular accuracy and precision of the radiotracking system on Stewart Island were measured and used to estimate the precision of location estimates generated from the remote radiotracking data.

OBJECTIVES:

1. Develop improved analytic methods for remote radiotracking data:
   - To estimate the precision of location estimates obtained from the intersection of radiobearings.
   - To generate the best location estimate from the intersection of more than two radio bearings.

2. Obtain estimates of the angular accuracy and precision of radiobearings collected using the remote radiotracking system on Stewart Island. Identify factors affecting these estimates.

3. Estimate the precision of location estimates generated using the remote radiotracking system.

METHODS:

Determining the angular accuracy and precision of radiobearings

Field methods : Replicate radiobearings were taken from four receiving sites to radiotransmitters at over 70 surveyed locations in the study area. The data set consisted of 4000 observations and was collected by six trained observers. Factors likely to affect system accuracy and precision were recorded for each observation.

Analytic methods : The angular error of each radiobearing was calculated as the difference between the true bearing and the radiobearing to the radiotransmitter. The angular accuracy and precision of a sample of radiobearings were then estimated as the mean and standard deviations of the angular errors of the radiobearings. Observations in which the absolute value of the angular error exceeded 5 degrees were considered outliers or spurious observations. Sample statistics (mean, standard deviation, kurtosis and percentage of outliers) for sub-samples of the angular errors were compared to assess the influence of various factors on the reliability of the radiotracking data. The sub-samples were also tested for goodness-of-fit to the normal distribution.

Describing the precision of location estimates

Two methods were used to describe the precision in location estimates:

1. Error propagation techniques were used to derive contour plots of the precision of location estimates throughout the study area for selected values of radiobearing angular precision.

2. The distances between the true and the estimated locations of test transmitters were calculated.

RESULTS:

Improved analytic methods for remote radiotracking data

The precision of location estimates : A realistic description was devised for the error region around location estimates obtained by the intersection of radiobearings. Two methods have previously been proposed in the literature to describe these error regions: the method of error polygons (Springer 1979) and the method of Lenth (1981) (White 1985 and Garrot et al. 1986). These two methods were examined critically:

- It was demonstrated that error polygons are neither realistic descriptions nor good approximations of the error regions around location estimates.

- It was shown that although the error ellipses obtained using the methods of Lenth (1981) are good approximations of the real error regions the circular statistics required for this method are unnecessary and add considerable complexity to the analyses.

In this study a new method to provide estimates of the error in a location estimate was developed using error propagation technique. The proposed method was based on linear statistics and was considerably less complex than the methods of Lenth. The method provides statistics for error ellipses.

Best estimates of location : A recurring problem in analysing remote radiotracking data is how to obtain a single best estimate of location from the multiple intersections which arise when using radiobearings from more than two receiving sites. Most workers have used informal procedures (e.g. Deat et al. 1980, Cederlund et al. 1979) but White (1985) and Garrot et al. (1986) proposed the use of complex estimators based on circular distributions

as described by Lenth (1981). In this study a new rigorous method to provide a single best estimate of location was developed using the method of least squares adjustment. The method is simpler than that of Lenth (1981) as linear statistics are used in place of circular statistics.

The angular accuracy and precision of radiobearings

Unmodified data : Sample statistics for the entire unmodified sample of angular errors in radiobearings are:

N.(non-missing) = 3592; N.(missing) = 406;

Mean = 2.5 degrees; S.D. = 26.5 degrees; Kurtosis = 21.927;

Percentage outliers = 16%

Censorship using signal characteristics: Certain values of attributes of observations (such as signal strength or radiation pattern) were associated with outliers and could therefore be used to identify and remove outliers from the data set (i.e. censor the data). Even using the best censor that could be devised the method was not completely effective, some good observations (15-30%) were wrongly rejected while some outliers (10-55%) were wrongly accepted. The effectiveness of censorship varied between observers.

Observer experience : Censored radiobearings collected by observers with more than 60 hours experience were of better quality than those collected by less experienced observers. The statistics for two comparable samples of the angular errors collected by the two types of observers were significantly ($p<0.05$) different:

Observer	**Sample 1**		**Sample 2**	
Experience	S.D.	%.Out.	S.D.	%. Out.
> 60 hrs.	2.56	1.7	12.17	7.1
< 60 hrs.	14.49	4.0	31.70	22.6

The differences were so great that data from inexperience observers was considered too unreliable for further analyses.

Transmitter movement: Censored radiobearings to moving test transmitters were of better quality than radiobearings to stationary test transmitters. The statistics for samples of the angular errors collected by experience observers from the two types of transmitters were significantly different:

Transmitter	S.D	Kurtosis	% outliers
Moving	1.97	12.14	1.0
Stationary	12.86	45.04	9.2

The estimates of statistics obtained using moving test transmitters are probably the most appropriate estimates to describe system performance during real radiotracking of radiotagged kakapo. The estimates of precision of radiobearings from each of the four sites to moving transmitters were: 0.96, 1.04, 1.42, & 1.78 degrees.

Wave path from transmitting to receiving sites : The nature of the wave path from transmitting to receiving sites affects the precision and accuracy of radiobearings. There was a complex interaction between wave path, transmitter movement, and censorship.

- There were many outliers among radiobearings to transmitters where there was no line of sight along the wave path to the receiving antenna. But most of these outliers were removed during censorship.

- There were few outliers among radiobearings to moving transmitters in line of sight.

- There were many outliers among radiobearings to stationary transmitters in line of sight. These outliers were not removed during censorship.

The last result was unexpected and important as it decreased the reliability of the remote radiotracking system substantially. This will be described in the next section.

Site bias as a consequence of the calibration method : Each receiving site was calibrated using radiobearings to a stationary transmitter at a known location in direct line of sight. During real radiotracking the sites were calibrated for each session. Error in the calibration of a site results in a bias (i.e. a non-zero mean for the angular errors) in radio bearings from that site. Data was collected from twenty calibration events. The means for the angular errors ranged from + 2.31 to -1.632 degrees. Thirteen of the 20 means were significantly different from zero. Thus the calibration method introduced an unpredictable bias (i.e. non zero mean) into samples of radio bearings taken from each site. A best estimate of the influence of this site bias on precision is that the standard deviation of site errors increases from one degree to eight. The site bias could have been reduced to a negligible level by modifying the calibration technique (e.g. using several moving transmitters in place of a single stationary transmitter).

The precision of location estimates

Error propagation techniques

Figures 1 a & b are contour plots of the precision of location estimates throughout the study area for selected values of radio bearing angular precision (1 degree an approximation of the precision of radiobearings from a single site with no site bias; 8 degrees an approximation incorporating site bias). The precision of location estimates was expressed as the length, in metres, of the semi-major axis of the 95% error ellipse. The following table is the proportions of the four kilometre square, around two receiving sites, falling within each of five contoured areas in the contour plots.

	Precision boundaries for contour			
S.D.	0-100	100-200	200-500	500-1000>1000
1	17.3%	18.5%	33.4%	17.2%13.6%
8	0%	0%	9.4%	12.9%77.7%

Estimation of actual linear errors

10,059 estimates of the location of 14 test transmitters were computed from a total of 590 replicate radiobearings taken from the four receiving sites. Figure 2 is a plot of the frequency distribution of the linear errors in the location estimates (i.e. the distances between the true and the estimated locations of the test transmitters). Approximately 95%

of the errors are less than 100 m. Plotted on figure la the 14 test transmitters would be within the 100 m contour. Therefore there is agreement between the results from the two methods.

DISCUSSION:

In order to maximise the precision of location estimates only censored radiobearings collected by experienced observers should be used. In that case the most realistic approximation of angular precision, incorporating site bias, is eight degrees. This provides a location estimate precision of 200-500 m (the length of the semi-axis of 95% error ellipse) over 9.4% of the central 16 square km of the study area. Nowhere is location estimate precision better than 200 m.

With improved field techniques to remove the site bias it would have been possible to achieve a one degree angular precision. This would provide a location estimate precision of less than 100 m (the length of the semi-axis of 95% error ellipse) for 17.3% of the central four square km of the study area.

These levels of precision are not adequate to investigate the home range, social interactions and habitat use of kakapo on Stewart Island because:

- Kakapo home ranges are relatively small (approximately 30 hectares), complex, and often multimodal with restricted nuclei of high activity. Adjacent home ranges probably overlap.

- It is probable that kakapo 50 metres apart could be unaware of one another because of the complex habitat structure and the behaviour of non-breeding kakapo.

- The study area comprised a finely divided mosaic of distinctive habitat types including small patches and narrow bands of distinct habitat types. Location errors as small as 25 metres would frequently lead to errors in the identification of habitat types.

Improvements in the precision of location estimates from the collected data set could be achieved if only location estimates obtained from more than two intersecting radiobearings are used. This is only possible for a small proportion (<10%) of the data.

CONCLUSIONS:

It must be concluded that the location data for radio tagged kakapo collected using the remote radiotracking system on Stewart Island were not sufficiently reliable to provide the basis for a biological investigation of kakapo. Refined field techniques could have provided more reliable data but the levels of error in location estimates would still have precluded meaningful analyses of phenomena such as habitat use, home range and territorial interaction.

The results of this study and a critical appraisal of the results of other studies (eg. Heezen and Tester 1967 and White and Garrot 1986, Hupp & Ratti 1983, Lee et al. 1985) lead to the conclusion that remote radiotracking is not a suitable tool to investigate the biology of free living wild animals. There are intractable problems inherent in remote radiotracking systematic variation in the magnitudes of both linear errors and linear resolution; non-systematic biases in location estimates; and the occurrence of spurious radiobearings. These problems undermine the credibility of the technique.

PUBLICATION LIST:

Remote radiotracking - a study of the methodology M.Sc. Thesis presented to Victoria Uni., May 1988.

In process

Mathematical techniques for remote radiotracking data.
Is remote radiotracking a useful tool for investigating wildlife behaviour?

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Figures 1 a & b. Contour plots of the precision of location estimates around two receiving sites, calculated for angular precisions of 1 & 8 degrees. The grids are 1 km NZ map grid. Contours are the length in metres of the semi-axis of the 95% error ellipse around the true location.

a) Angular precision = 1 degree.

b) Angular precision = 8 degrees.

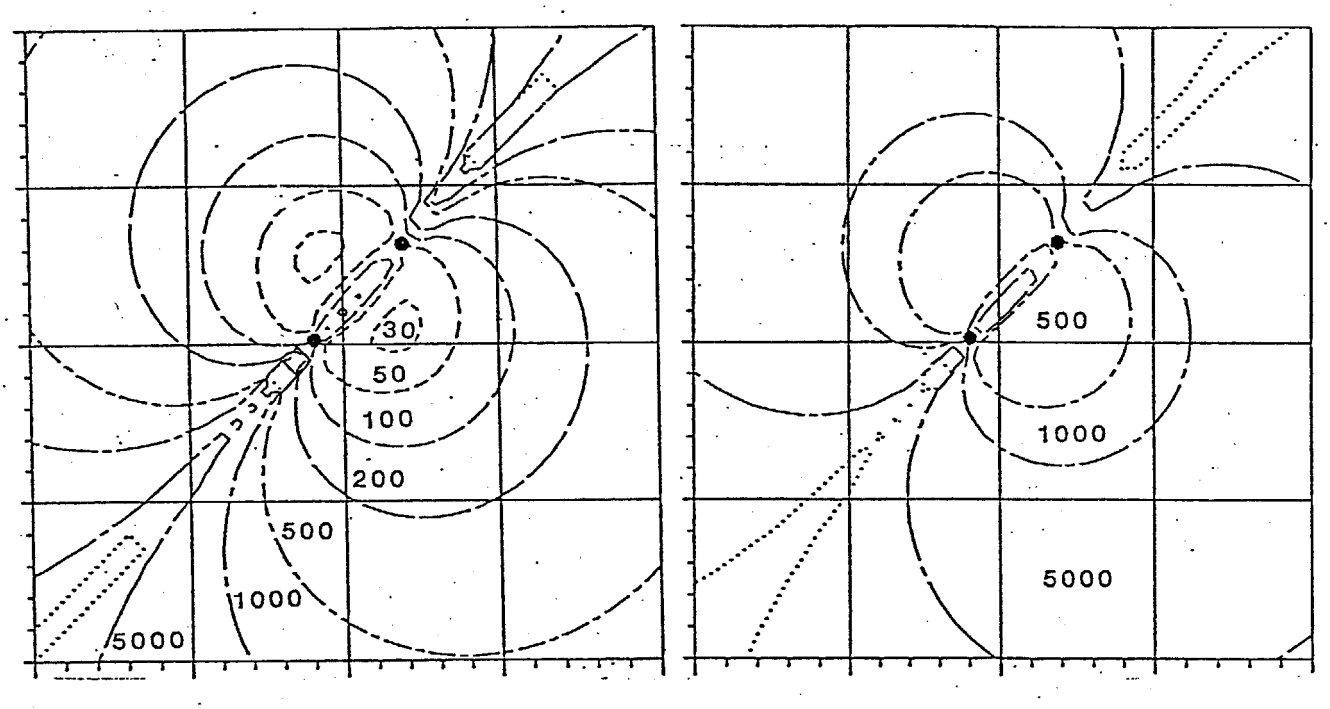
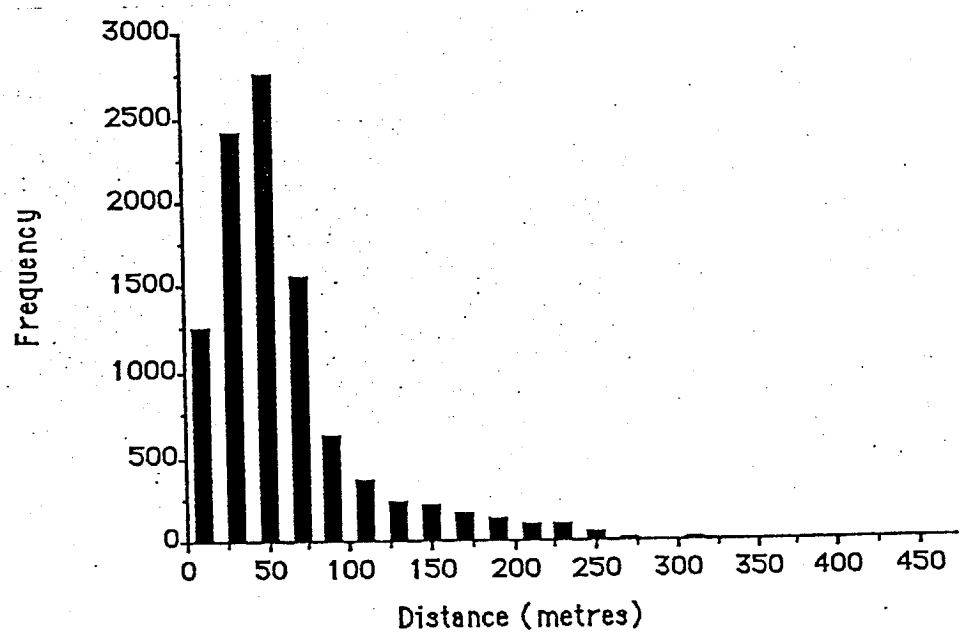


Figure 2. The frequency distribution of the distance, in metres, between the estimated and true locations of test transmitters.



INVESTIGATION NO: S5030/131
CORPORATE OBJECTIVE: 1.3

INVESTIGATION TITLE: Conservation of the Chatham Island Taiko

STUDY VENUE: Canterbury Region, Waimakariri District

INVESTIGATION LEADER: M J Imber

ASSOCIATED RESEARCHERS: D E Crockett (leader of the independently-funded Chatham Island Taiko Expedition); H A Best, DOC (aerial systems); M E Douglas, DOC (electronics); R Colbourne, DOC (dog-handling, predators).

STATUS: Fieldwork completed

CLIENT: DOC

EXPECTED FINISH DATE: 1991

INVESTIGATION SUMMARY:

The Taiko or Magenta Petrel, *Pterodroma magentae,* is endemic to the Chatham Islands. Subfossil bone deposits show that this seabird was very abundant on the main island before and during the early part of Polynesian colonisation (ca. 1600 AD). Undiscovered by early European biologists it was thought to be possibly extinct until re-discovered in 1973. Subsequent searches throughout Chatham Islands have concentrated on finding the breeding burrows of the bird. As conventional searches failed, radio-tracking systems were developed and tested. The first burrow was found in 1987, using radio-telemetry, 4 km inland in bush in the south-west of Chatham Island.

The project aims to locate most or all of the burrows, obtain data on numbers and on the breeding biology of Taiko, assess the threats from predators and, hence, make recommendations for the conservation of the species. As the Taiko population is limited by factors affecting it where it breeds, it should respond positively to effective management.

OBJECTIVES:

1. To carry out radio-telemetry tracking of Taiko caught at the Tuku light-station so that further nesting burrows of the bird might be found.

2. To search for more Taiko burrows around those already known and in adjacent areas of apparently similar topography, identified using aerial photographs.

3. To use Rogan Colbourne's dog, Tess (labrador), to search for additional Taiko burrows.

4. To monitor the known burrows so as to gather further data on breeding biology of Taiko.

5. To run trap-lines for potential predators around the known burrows.

6. To assist in a general survey of fauna on Chatham Islands by making bird counts in ca. 60 x 1 km^2 grid squares in the south-west of Chatham Island.

METHODS:

The light-station in Tuku valley was operated nightly from 3 October to 11 December 1988, except when the level of moonlight rendered the light ineffective. Two shifts of personnel worked whenever the light was run for more than 4 hours. The cumulative time of the operation of the light was greater than in any previous season, with no nights off and no short nights (other than due to moonlight). A few hours only were lost in the early stages because of generator problems.

Four tracking stations were set up during the first two weeks. Two of these were in the same positions as in 1987 (Base, Murphy's), while Lookout (to the north) and Otawae (above Ron Seymour's woolshed) were new. The latter was to serve as an early warning station, with a restricted reception arc but considerably closer to Base than 1987's South Coast station for ease of setting up and servicing.

Burrow searching was done in Taiko valley; alongside the adjacent stream to the south-west (which forms less of a valley than Taiko Stream); along the banks of a lesser stream north-east of Taiko valley; and along the dissected headlands running south from North Taiko Hill (hills and headlands to the north were well searched in April 1988).

Rogan considers that he was unable to use his dog effectively because he needed but did not get, a captured Taiko to re-train her, having previously discouraged her from showing interest in shearwater burrows elsewhere. She was encouraged to sniff around an occupied Taiko burrow but this was not enough.

Monitoring of burrows began on 21 October after the busy initial phase of setting up stations and running the light during the first moonless period. Some track clearing was also done to improve access to Taiko valley, particularly to ensure swift access at night in the event of a transmittered Taiko going to ground there. A track was made to give access to North Taiko Hill, as we initially had difficulty finding our way to it through the surrounding dense bush and rather featureless landscape.

Between 25 October and 11 November, night watches were maintained at the 3 breeding burrows to try to catch the occupants. From 11 November to 11 December all Taiko burrows found (n=5) were merely screened and checked daily.

Because of the length and depth of all the burrows, I decided against trying to make observation holes to the nest chambers.

Traps for predators were operated in Taiko valley from 4 November to 11 December, except for 7 days in late November when the fauna survey was in progress. Up to 27 gin traps were used. Ten traps were operated on the track to North Taiko Hill for 10 nights in late November only.

The fauna survey was carried out from 18 to 24 November. During this period all other activities were suspended (moonlight prevented the light trap being used).

RESULTS AND ACTIVITIES (1988):

No Taiko were caught at the Tuku light, though 12 good sightings of Taiko were made. Only two birds responded briefly to the spotlights. The others flew straight through, or veered, or circled and departed.

On 3 November, another light station was set up near the tracking station above Seymour's woolshed. In 1987, transmitter-carrying Taiko often flew in that general area. This light was run intermittently, usually on nights when conditions were considered good for catching, but only one Taiko was seen.

There was an impression amongst experienced workers at the Tuku light that fewer petrels of all species were seen or caught this season. However, this statistic cannot be determined by banding data because we deliberately tended to ignore other species this season (not bring them down) as soon as we saw they were not Taiko. Even those other species we did try to catch seemed to be more difficult to bring down this year than in previous seasons.

Inevitably the weather has been implicated in this season's poor results but, to those in the field, conditions seemed normal. October was probably windier than usual. There was much more north-westerly wind this year, whereas south-westerlies were prevalent in 1987. Nevertheless there were numerous nights that, in previous years, would have been considered good for catching Taiko.

Burrow searching was done in all intended areas but without result.

Listening for Taiko calls was undertaken at the burrows and at Otawae Point. We hoped to find a site where we could in future record the calls to identify Taiko and possibly attract Taiko to safe nesting areas. No consistent calls were heard. A call was heard once each at Otawae Point and at North Taiko Hill that might have been a Taiko.

During burrow-watches, one unbanded Taiko was caught at burrow 1 on 27 October (it occupied the burrow at least from 25 (a.m.) to 30 (p.m.) October, i.e. 6 days). No other Taiko visited the breeding burrows (1, 3, 4) after 24 October (male in 1, pair in 3) or 31 October (pair in 4) until 24 November (4), 26 November (3) and 27 November (1). Thus the pre-laying exodus (when breeders are absent from mating to laying) lasted about one month.

Burrow 5 (non-breeding) was visited on 9 and 24 November, but burrow 2 (being dug) was not visited at all.

During 716 trap-nights in Taiko valley, 66 possums, 17 wekas, 6 feral cats, 6 Rattus rattus, 3 blackbirds and 1 thrush were killed. House mice were confirmed present (one killed). From 97 trap-nights near North Taiko Hill 12 possums, 2 weka and 1 feral cat were caught. Examination of feral cat scats revealed that rodents were the cats' main prey. One trapped cat's stomach contained remains of 7 rats.

FINAL RESULTS:

How many Taiko?

Results of the 1988 season's work lead to the conclusion that there are fewer Taiko than previously estimated. Taiko now seem to be increasingly avoiding the light station and ignoring the spotlights (Table 1). We noted in 1987 that transmitter-carrying Taiko avoided the Tuku light.

TABLE 1: Numbers of Taiko seen and caught at Tuku light in years of major effort. Partial data for 1982, 1983 and 1985; full data for 1987 and 1988.

YEAR	WEEKS	TAIKO SEEN	TAIKO CAUGHT	
19824	4	13	5	39%
1983	2	7	5	71%
1985	2.5	10	3	30%
1987	9.5	23	12	52%
1988	10	12	0	0

The proportion of the Taiko population caught at the light has been increasing. We know this because petrels have an average life span of 15-20 years so, if we band a population within a time interval of less than 15 years (first Taiko banded in 1978) the proportion banded will increase. Apparently these (banded) Taiko are becoming light shy. Because of this, population estimates based on mark-recapture are biased upwards.

The best estimate of numbers is probably based on actual numbers caught. Up to December 1987, 40 Taiko had been banded. The mortality rate is unknown, but in other petrels of similar size it is about 5% per year. Taiko survival may be better because of the abundant food supply likely to be available to this diminished population, but this will be balanced by the risks of predation (one cat-killed Taiko has been found near the coast). With 5% p.a. mortality, 33 banded Taiko should still be alive (including the one banded in 1988).

The balance of numbers is made up of adults that we have not caught and immatures (probably up to 4-years-old) that have not returned to land. If we could catch all the birds using known burrows, we would have an independent estimate of the proportion of the adult population banded.

How many breeding pairs?

In 1987 we captured 12 Taiko and placed transmitters on 10 of them. Only 2 of these subsequently went to a burrow. However, comparisons of dates of their burrow visits in 1987 with those of visits of the breeders in 1988 raises doubts about their breeding status. They visited burrows during the pre-laying exodus. In addition, one of the two Taiko not fitted with a transmitter was too young to be breeding (incubation patch mainly down-covered). Thus only 2 of 11 Taiko caught were occupying a burrow.

We subsequently found 5 burrows. Three were occupied by breeding pairs, one was being visited only by a bird and one was being dug: a total of 8 burrow-occupying Taiko. Thus, assuming a similar proportion of burrow-occupying Taiko in the whole population as in those 1987 captures (2 of 11) we found the burrows representing a population of 44 adult Taiko.

This figure may be a small exaggeration (we could expect breeders to be more difficult to catch) but it can be seen that two sides of the equation may be nearing balance:-

No. of adult Taiko = 33 banded + uncaught adults
= (44 - correction for overestimate) + adults using any undiscovered burrows.

What size of population can be supported by 3 to 4 breeding pairs?

On Codfish Island the depressed (through Weka predation) Cook's Petrel population achieves 66% breeding success despite some rat predation of eggs and chicks. Taiko may breed at least as successfully because there is no evidence that rats enter the burrows. Screening of burrow mouths has not revealed any rat movements. Thus the 3 breeding burrows could have an average annual production of 2 to 2.5 young. If the second burrow at North Taiko Hill has recently been bred in (externally it appears to be a completed burrow), then annual production could have approached 3.

Allowing 10% mortality in year 1 and 5% thereafter, 2.5 young p.a. would produce a population of 38-43; 3 young p.a. would produce 48-52.

CONCLUSIONS:

The search for Taiko burrows has produced 5 burrows in two areas 4 km apart. Of these 5 burrows, 3 are in very active use consistent with their being occupied by breeding pairs; one seems to be suitable for breeding but is not being so used at present; the fifth is still being dug. There are odd short holes around each breeding burrow that might be diggings of young Taiko hatched in these burrows.

The size of the Taiko population cannot be determined yet, but may be about 50. If more birds occupying burrows can be caught, then the proportion of them banded would give an estimate of the adult Taiko population.

Meanwhile management should proceed on the assumption that there are only about 50 Taiko, that such a population can be supported by 3-4 breeding pairs and, therefore, it is possible that no more burrows will be found.

RECOMMENDATIONS:

Short-term management

1. Predator control: The main threat is from feral cats. Trapping for these should be done every breeding season (October to early May). It does not need to be continuous. Either a big effort in October- November and again in April, or intermittently through the season, would probably suffice.

2. Protection of fledglings: Prior to the fledglings leaving (approx. 20 April - 15 May), they should be caught when emerging at night, banded, weighed and checked for abnormalities. Each burrow area should be regularly checked (for predators, fledgling in trouble) until burrow screening confirm the bird has departed.

   By banding all fledglings we will eventually be able to find out if there are other burrows (by catching unbanded sub-adults at Tuku light).

Long-term management:

1. Fencing off areas around the burrows.
   As predator control would have to continue annually, and become more intensive as colonies establish, predator-proof fences should be considered urgently. The area fenced off does not need to be great - probably less than a hectare at each Taiko valley site, probably about 5 hectares at North Taiko Hill (landowner permitting). The latter site certainly would be best for the first fencing attempt. It is a small hill with good potential for further burrowing by Taiko and no streams to restrict fencing.

Because it is imperative not to create easily followed tracks into the burrow areas, which could encourage cats, pigs, cattle, people to use them, I strongly recommend that the NZ Navy be approached for assistance with a frigate-based helicopter to ferry in fencing materials and equipment. The Navy recently sought bids for use of frigates in 1990, so an approach should be made as soon as possible.

If the Navy co-operates, I further suggest that consideration be given to putting a but (or materials for it) (2/3 persons) at both northern and southern sites at the same time as fencing is flown in. These huts could be used for ongoing and future maintenance and management work.

2. Translocations to establish a new colony in a safer site (e.g. smaller island).
I do not consider this to be a realistic option within the next 10-20 years unless resistance to fencing by local landowners makes it impossible to protect the Taiko where it is now.

3. Tape-recordings and artificial burrows to encourage non-breeders to settle in protected areas. Research on Dark-rumped Petrels presently in progress on the Galapagos Islands (Kress and Podolsky 1988) is showing positive preliminary results. Tape-recordings of Dark-rumped Petrel calls are being broadcast at an unoccupied site with artificial nesting holes. In the first (1988) season, numerous nests were visited and occupied by petrels.

   The problem with the Taiko is to hear, let alone record, any sort of call. It may be possible to induce (then record) calls by broadcasting calls of a related species such as Grey-faced or White-headed Petrels.

   This project should be left until fencing is secure. North Taiko Hill seems the best site to dig artificial burrows.

REFERENCE:

Kress, S.W.; Podolsky, R. 1988. From Egg Rock to the Galapagos Islands. *Egg Rock Update, 1988 report. 1-2.*

Continue to next file: ir50a.pdf