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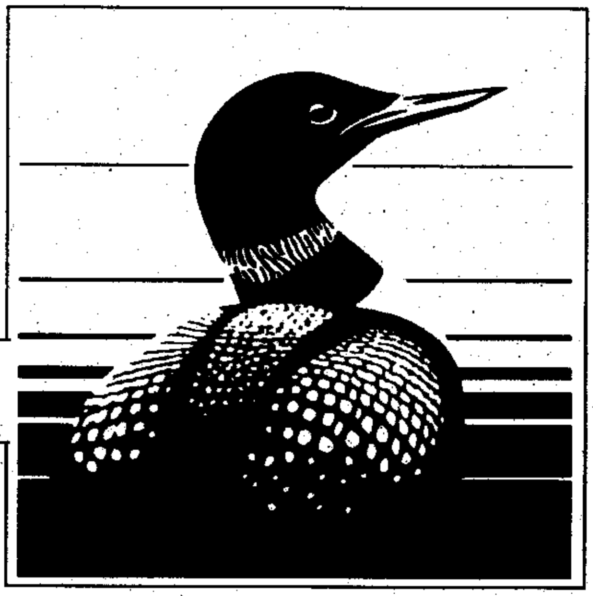
Pacific and Yukon Region 1997
Canadian Wildlife Service
Environmental Conservation Branch



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THE LANGARA ISLAND SEABIRD HABITAT RECOVERY PROJECT:

ERADICATION OF NORWAY RATS - 1993-1997

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Our ships have carried a colony of rats to these uncivilized countries and these, having multiplied prodigiously, cause serious damage...

- José Mariano Moziño Losada Suarez de Figuerao at Nootka Island, 1792

José Mariano Moziño was the first biologist born on this continent to work in what would become Canada. He graduated from the University of Mexico in 1787 and was 29 years old when he started his voyage (Moziño 1970).

ABSTRACT

Norway rats (*Rattus norvegicus*) were introduced to Langara Island in the Queen Charlotte Islands (Haida Gwaii), British Columbia, and contributed to the decline of Ancient Murrelets (*Synthliboramphus antiquus*) and other seabirds nesting on the island. Funds to restore breeding habitat for seabirds on Haida Gwaii became available from the litigation settlement of the Nestucca oil spill. Accordingly, Environment Canada established the Langara Island Seabird Habitat Recovery Project (LISHRP) which planned to eradicate rats from Langara Island and its associated islands in five distinct phases: feasibility studies and environmental review in 1993, pilot tests and site preparation in 1994, eradication in 1995, monitoring through 1996 and 1997, and finally clean-up in 1997. LISHRP employed a technique used successfully in New Zealand which involved dispensing anti-coagulant poison baits from bait stations fixed at regular intervals all over the island.

The eradication appears to have succeeded. No positive signs of rats have been detected on Langara Island and its associated islands since February 1996. Common Ravens (*Corvus corax*) likely suffered greater than 50 % mortality from the eradication after apparently gaining access to the poison directly from the bait stations and from scavenging rat carcasses. Evidence exists that Dusky Shrews (*Sorex monticolus*), Bald Eagles (*Haliaeetus leucocephalus*), Song Sparrows (*Melospiza melodia*), and Northwestern Crows (*Corvus caurinus*) were exposed to the poison but suffered no detectable population decline.

Boat traffic or barges servicing the fishing lodges on Langara Island present a major risk of re-introducing rats onto the island. Failure to implement effective protection measures will negate any benefits from the project. Proactive planning by the managers of the fishing lodges and the development of conservation initiatives by local groups must be encouraged.

RÉSUMÉ

Des rats surmulots (*Rattus norvegicus*) ont été introduits sur l'île Langara, qui fait partie de l'archipel des îles de la Reine-Charlotte (Haida Gwaii), en Colombie-Britannique. Ces rats ont contribué au déclin des populations d'alques à cou blanc (*Synthliboramphus antiquus*) et d'autres oiseaux marins nichant sur l'île. Des fonds destinés à rétablir l'habitat des oiseaux marins sur Haida Gwaii sont devenus disponibles à l'occasion du règlement du litige relatif au déversement d'hydrocarbures par le *Nestucca.* Environnement Canada a donc mis sur pied un projet de réhabilitation de l'habitat des oiseaux marins sur l'île Langara, qui avait pour but d'éradiquer les rats sur l'île Langara et les îles avoisinantes en cinq phases distinctes : études de faisabilité et étude environnementale en 1993, essais pilotes et préparation du site en 1994, éradication en 1995, surveillance de 1996 à 1997 et finalement nettoyage en 1997. Dans le cadre de ce projet, on a fait appel à une technique, utilisée avec succès en Nouvelle-Zélande, qui consistait à distribuer des appâts renfermant un poison (anticoagulant) à plusieurs endroits répartis uniformément sur tout le territoire de l'île.

L'éradication semble avoir réussi. On n'a décelé aucun signe de la présence de rats sur l'île Langara et les îles avoisinantes depuis février 1996. L'éradication des rats s'est accompagnée d'un taux de mortalité élevé dans la population de grands corbeaux (*Corvus corax*), lesquels ont apparemment eu accès au poison directement aux points d'appât. Des données indiquent que des musaraignes sombres (*Sorex monticolus*), des pygargue à tête blanche (*Haliaeetus leucocephalus*), des bruants chanteurs (*Melospiza melodia*) et des corneilles d'Alaska (*Corvus caurinus*) ont été exposés au poison, mais que les populations n'en ont pas été affectées outre mesure.

La circulation des bateaux et le mouvement des barges desservant les camps de pêche sur l'île Langara présentent un risque important de réintroduction des rats sur l'île. L'absence de mesures de protection efficace annulera tout résultat positif du projet. Il faut inciter les gestionnaires des camps de pêche à faire de la planification proactive et les groupes locaux à prendre des mesures de conservation.

PREFACE

This project was sponsored by the Canadian Wildlife Service, Pacific and Yukon Region, Environment Canada. It was funded by the Nestucca Environmental Recovery Trust Fund. The trustees at the project's initiation were Dr. A. M. Martell, Regional Director, Pacific and Yukon Region, Canadian Wildlife Service, and D. R. Halladay, Director, British Columbia Wildlife Branch, B.C. Ministry of Environment, Lands, and Parks. The trustees technical advisory committee included Don Howes, Gary Kaiser, Carey McAllister, W. T. Munro, and Colin Wykes.

ACKNOWLEDGMENTS

The Langara Island Seabird Habitat Project was very labour-intensive and its success resulted from the efforts of a very large team. We have endeavoured to include everyone and apologise for missing any of our co-workers.

1993

Science Party

Phred Collins, Anne Harfenist, Gary Kaiser, Yolanda Morbey, Chris Naugler, Pat Taylor, Rowley Taylor.

1994

Science Party and Lucy Island Pilot Study

Peter Buck, Kim Cheng, John Elliott, Kyle Elliott, Bruce Fitzearle, James Hageman, Gregg Howald, Jason Lee, Pierre Mineau, Ian Moul, Trevor Welton.

Camp Construction Party, Huksta Forestry

Bill Lawson, James Hageman, Andy Smith, Mike Williams, Floyd Young.

Trail-cutting Crew, Huksta Forestry

Arnie Bellis, Sylvia Doll (cook), James Hageman, Jason Lee, Albert Liddle, Dwight Russ, Clarence Thompson, Mike Williams.

Survey and layout crew, Huksta Forestry

Peter Buck, Phred Collins, Virginia Collins, Terry Fortune, Colin French, Terry Grey, James Hageman, Jason Lee, Brent McIsaac, Andre Reverdy (cook).

1995

Survey and layout crew, Huksta Forestry

Phred Collins, Larry Greenhough, James Hageman, Rob Kelly, Brent McIsaac, Andre Quirelle (cook), Rob Werner, Jim Williamson.

Science Party

Rebecca Barry, Tara Burke, Mark Drever, John Elliott, Kyle Elliott, Bruce Fitzearle, James Hageman, Gregg Howald, Ryan Kraftcheck, Brent Matsuda, Pierre Mineau, Scott Webb.

Crew Leaders and coordinators

Gene Bell, Peter Buck, Phred Collins, Colin French, Larry Greenhough, James Hageman, Tillie Jones, Gary Kaiser, Rob Kelly, Jason Lee, Bronwen Lewis, Loralei Parker, Rowley Taylor, Sandra Thompson.

Cooks and camp managers

Sylvia Doll, Eric Lund, Andre Reverdy, Sylvia Scott, Stephen Smyth.

Data managers

Jesse Grigg, Lynn Lougheed, Dwight McCullough.

Volunteer assistants

Delphine Brosselier, Pat Taylor.

Bait Station Operators

Ralph Amos, William Bedard, Derrick Belcourt, Buster Bell, Kevin Bell, Vincent Bell, David Boldt, Delphine Brosselier, Tara Burke, Eddy Chutter, Roy Collison, Brent Daschuk, Alan Davidson, Kristen Davies, George Davis, Ryan Decock, Gwaii Edenshaw, Guy Edgars, Lana Geier, Terry Hamilton, Gavin Hooton, Laura Husband, Trevor Husband, Cornell Idu, Jonathon Kawaguchi, Jordan Luckow, David McIntyre, Matt Nyeholt, Linden Parker, Ben Penna, Jason Pettit, Paul Polak, Veronique Ressonat, Chris Ritchie, Trevor Russ, Rodney Schatz, Luke Sell, Gabrielle Tambre, Michael Thorn, Peter von Niessen, Jennifer Weston, Ted Williams, Wendell Williams, James Williamson, Daysun Wrubel, Justin Yeltatzie.

September Station check crew

Colin French, Larry Greenhough, Rob Kelly, Loralei Parker.

1996

February Emergency response crew

Peter Buck, Tara Burke, Colin French.

May - August Station Monitoring Party

Derrick Belcourt, Tara Burke, Sebastian Disney, Guy Edgars, James Hageman, Lynne Hart (co-ordination), Peter Lantin, Johanne Young.

Science party

Pascal Dehoux, John Elliott, Bruce Fitzearle, Anne Harfenist, Gregg Howald, Gary Kaiser, Rob Kelly.

1997

Station Monitoring Party

Guy Edgars, James Hageman, Lynne Hart (co-ordination), Peter Lantin, Geoff Parnell, Johanne Young.

Science Party

Mark Drever, Gary Kaiser, Rowley Taylor, Trevor Welton.

1994-1997

Academic supervision

Dr. Kim Cheng, University of British Columbia; Dr. J.E. Elliott, Pacific Wildlife Research Centre; Dr. Alton Harestad, Simon Fraser University; Dr. Pierre Mineau, National Wildlife Research Centre, Environment Canada; Dr. Tom Sullivan, University of British Columbia. Dr. C. Pharo and Dr. R. Elner kindly reviewed early versions of the manuscript.

1995-1997

Finance and management, British Columbia Conservation Foundation.

Melinda Coleman, Krista Convey, Deborah Gibson (Executive Director), Gloria Rodriguez.

A BRIEF CHRONOLOGY OF MAJOR EVENTS

December 1988 - Oil from the barge *Nestucca* comes ashore at Pacific Rim National Park, B.C., killing ~50,000 seabirds.

May 1989 - D. F. Bertram, N. Holmes, and H. Hay investigate cause for the decline in the Ancient Murrelet population on Langara Island.

January 1992 - Litigation over the oil spill is settled.

July 1992 - Nestucca Trust Fund for Environmental Recovery established under the BC - Canada Wildlife Cooperative Agreement.

October 1992 - Langara Island Seabird Habitat Recovery Project approved by Nestucca Trust Fund Technical Committee.

May 1993 - *Feasibility study initiated with visits to Langara and other islands in the southern archipelago.* A. Harfenist, Environment Canada, finds further decline in Ancient Murrelet abundance.

September 1993 - Feasibility report submitted by R.H. Taylor and Environmental Review completed. Target date for eradication advanced from 1996 to 1995.

October 1993 - Public consultation and meetings with Old Massett Village Council. Canadian pesticide registration sought for special outdoor use of a brodifacoum-based bait.

January 1994 - Initiation of non-target and secondary toxicity research.

May 1994 - Field studies of rats and species susceptible to non-target poisoning.

June to August 1994 - Field test of the baiting process on Lucy Island.

August to November 1994 - Surveys, mapping, and trail layout on Langara Island.

March to June 1995 - Completion of trail layout, placement of bait stations, construction of field camps.

June 1995 - J. Vakenti, B.C. Ministry of Environment, Lands and Parks, presents special pesticide applicator's training program to field personnel.

July-August 1995 - Eradication campaign, non-target poisoning research. B. Moen records the project for the Knowledge Network and produces the film 'Getting the Last Rat.'

September 1995 - Bait station monitoring and eradication of surviving rats at Henslung Cove.

January 1996 - G. Schweers, Langara Light Station, traps rat at light station.

February 1996 - Check of stations near the light station for continued rat activity.

April through August 1996 - Bait station monitoring and search for rat activity. Modification of stations to discourage ravens.

May 1997 - Bait station monitoring and search for rat activity. Decision to declare the island free of rats.

June through August 1997 - Removal of bait stations, flagging tape, and other signs of the project.

September 1997 - Plastic bait stations recycled in Vancouver, British Columbia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION.

The Langara Island Seabird Habitat Recovery Project (LISHRP) began in 1988 with the realisation that the remnant breeding colony of Ancient Murrelets (*Synthliboramphus antiquus*) on Langara Island near McPherson point (Fig. 1) was declining precipitously and that colonies of Cassin's Auklets (*Ptychoramphus aleutica*), Rhinoceros Auklets (*Cerorhinca monocerata*), Tufted Puffins (*Lunda cirrhata*) and Storm-petrels (*Oceanodroma spp.*) had already disappeared (Campbell *et al.* 1990, Bertram 1995, Rodway *et al.* 1994). Although Bertram (1989, 1995) found evidence that several factors exerted stress on local seabird populations, the presence of fresh carcasses and skeletal remains of adult murrelets in and around the nesting burrows pointed to Norway rats (*Rattus norvegicus*) as an important factor in the population decline. Rats have devastated seabird populations throughout the world (Atkinson 1985, Moors and Atkinson 1984), although this was the first time they were recognised as a significant problem in Canada (Bailey and Kaiser 1993, Harfenist 1994).

Planning for effective conservation action did not begin until 1992 because it was assumed that protecting breeding colonies on large islands was prohibitively expensive and required repeated investment in the form of annual rat control and/or the maintenance of fencing. However, a successful technique for clearing rats from small islands using toxic baits in fixed stations had been developed and tested in New Zealand in 1988 (Taylor and Thomas 1989, 1993). The first reports of these developments reached Canada while Environment Canada was pursuing litigation for damages from the Nestucca oil spill which had impacted the southwest coast of Vancouver Island. Some 50,000 wintering seabirds had died as a result of that spill and most were species which typically bred in northern British Columbia (Burger 1993a, 1993b). Rat eradication was put forward as a way of mitigating that loss through recovery of habitat for a similar number of birds.

The successful rat eradications in New Zealand became part of the mitigation proposal put before the court and the subsequent settlement agreement specifically required restoration or replacement of some of the injured natural resources. The Canadian Wildlife Service decided to investigate the practicality of eradicating rats on Langara Island and applied for support from the Nestucca Environmental

Recovery Trust Fund which had been set up under the Canada-British Columbia Nestucca Agreement in 1992 to handle the funds from the court settlement.

The general absence of rats on most of British Columbia's seabird breeding colonies (Bertram and Nagorsen 1995) made it easy to select Langara Island and its neighbours for restoration. Langara Island is large (3105 ha) and presents many logistic difficulties, but it has a long history of colonization by several species of seabirds (Munro and Cowan 1947). We believed that it had the potential to regain its status as a major breeding site quickly because there were surviving colonies, nearby sources for absent species of seabirds, and the general habitat was ideal (Kaiser and Forbes 1992).

Several other colony islands in the South Moresby archipelago (Gwaii Haanas National Park Reserve) are infested with rats and were considered for eradication even though their locations inside a national park reserve would normally preclude experimental use of a toxic chemical. St. James Island (51 ° 56' N, 131° 01' W) was too small (19 ha) to meet the population replacement target of 50,000 birds implied by the litigation settlement agreement. The size of Kunghit Island (51° 57' N, 130° 56' W) (12,330 ha) entailed immense logistic problems. Murchison Island (52° 36' N, 131° 27' W) was an appropriate size (425 ha) for an attempt at rat extermination. However, this island was very close to Faraday Island (52° 36' N 131° 29' W) (308 ha) which also has rats and offered a stepping stone for re-infestation by rats from Lyell Island. Lyell Island (52° 44' N, 131° 29' W) was also far too large to consider for an eradication campaign (17,452 ha). Some of these other islands were also accessible to racoons (*Procyon lotor*) and removal of rats alone would not be sufficient to allow recolonization by seabirds. The racoon is yet another introduced species which threatens the continued existence of colonial seabirds on the Queen Charlotte Islands (Gaston 1992).

We planned LISHRP in five discrete phases: feasibility studies and environmental impact review in 1993, pilot tests and site preparation in 1994, extermination in 1995, monitoring through 1996 and into 1997, and, finally clean-up and removal of the bait stations. This report concerns the biology and wildlife management aspects of the project.

1A. PROJECT OBJECTIVE.

Recover habitat for seabird breeding colonies in Kiisgwaii (Langara, Cox, and Lucy Islands) which had been lost to rats.

1B. PROJECT GOALS.

i. Eradicate the population of Norway rats before the breeding colony of Ancient Murrelets disappeared.

ii. Meet the terms of the Nestucca oil-spill litigation settlement by recovering breeding habitat capable of supporting 50,000 or more seabirds.

iii. Avoid damage to non-target populations potentially at risk from primary and secondary poisoning.

iv. Develop and implement a plan to minimise the risk of re-introduction of rats and negate the effect of the expected arrival of house mice (*Mus musculus*) once the rats were exterminated.

v. Create employment and other economic opportunities for local residents, especially members of the Haida Nation.

1C. STUDY SITE.

1Ci. Habitat.

Kiisgwaii (54° 12' N, 133° 01' W) is the historic name of a small archipelago at the northwest tip of the Queen Charlotte Islands (Haida Gwaii) and consists of Langara (3105 ha), Lucy (37.2 ha), Cox (10.6 ha) and Lacy (< 1 ha) islands and a few offshore islets and rocks (Fig. 1). We use this name to refer to the whole archipelago throughout this report. Kiisgwaii is separated from Graham Island by Parry Passage, a 1.0-km stretch of turbulent sea with strong tidal currents. The 3 main islands have a coastal forest of Sitka spruce (*Picea sitchensis*), but Langara and Lucy islands are large enough for inner stands of western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*). Langara Island has several small lakes and permanent streams, extensive sphagnum bogs, large, dense thickets of tall salal (*Gaultheria shalon*), and grass patches (*Calamogrostis* and *Elymus spp.*) particularly on headlands and old village sites (Rodway *et al.* 1994, Vermeer *et al.* 1984). Lucy and Cox Islands have no bodies of freshwater.

From a distance, Langara Island has a low-lying, slightly rolling topography (Fig. 2). The maximum elevation is 160 m. The south, west, and north coasts are rocky and deeply dissected by steep-sided ravines, whereas the east coast is more gentle with large sand and cobble beaches. Safe landing sites and secure moorage are scarce. Lucy Island, a low-lying boat-shaped island in Parry Passage, lies 250 m off the south tip of Langara Island, and is completely covered in Sitka spruce and western hemlock with dense thickets of salal on its south side. A rocky bluff rises to 69 m at its western tip. Lucy Island is completely surrounded by submerged rocks and patches of bull kelp (*Nereocystis luetkeana*) but safe landings are achievable at many places along its shore. Cox Island is a towering rock (114 m) with Sitka spruce trees and patches of grass covering its top, eastern side and scree slopes. Landings on Cox Island are safe only on the eastern beach, which is separated from Langara Island by about 200 m of water at low tide. None of the offshore rocks played a role in the project but near-shore islets and stacks with permanent vegetation were considered to be rat habitat.

1Cii. Wildlife.

The native mammals of Langara Island include dusky shrew (*Sorex monticolus*), little brown bat (*Myotis lucifugus*), river otter (*Lutra canadensis*) and at least historically, deer mouse (*Peromyscus maniculatus*). Except for a solitary deer mouse found in August 1994, none have been seen on Kiisgwaii since 1946 (I. McTaggart-Cowan pers. comm.). Reports of marten (*Martes americana*) and ermine (*Mustela erminea*) have not been confirmed. Black bear (*Ursus americanus*) may reach the island periodically, but have not remained as permanent residents. Beaver (*Castor canadensis*), red squirrel (*Tamiasciurus hudsonicus*), muskrat (*Ondatra zibethicus*), black rat (*Rattus rattus*), Norway rat, house mouse, racoon, house cat (*Felis catus*), and Sitka deer (*Odocoileus hemionus*) have all been introduced to the Queen Charlotte Islands. All of these species, except the squirrel, have been reported from Langara Island, but only rats and deer have become abundant. The possible presence of racoons on Langara is based only on unconfirmed reports of footprints. Both house cats (S.J. Darcus letter to J.A. Munro 1926, Kaiser 1996) and black rats were present in the past but seem to have completely disappeared. The most recent specimen of black rat was collected in 1966 while the earliest record for Norway rat is 1988, which suggests that the Norway rat excluded the black rat (Bertram and Nagorsen 1995) and perhaps the native deer mouse. Cox and Lucy islands had resident populations of shrew and river otter, and deer visited these islands during the project.

Most of the land birds which occupy the Queen Charlotte Islands occur on Langara Island (Harfenist 1994). However, it was the threat to colonial seabirds which sparked this project and they have received most of the attention. Historic records show that Kiisgwaii supported breeding colonies of Tufted Puffin, Rhinoceros Auklet , Cassin's Auklet, Ancient Murrelet, Pigeon Guillemot (*Cepphus columba*), Fork-tailed Storm-Petrel (*Oceanodroma furcata*), Leach's Storm-Petrel (*O. leucorhoa*), Pelagic Cormorant (*Phalacrocorax pelagicus*), and Glaucous-winged Gull (*Larus glaucescens*). Marbled Murrelet (*Brachyramphus marmoratus*) may breed on the islands and are often active over Langara Island's forest, but Darcus' report of eggs from Cox Island in 1926 is no longer accepted (Munro and Cowan 1947). At the start of this project, Ancient Murrelet were the only colonial species which remained in large numbers

(Vermeer and Sealy 1984, Bertram 1989, 1995), while small groups of guillemots, cormorants, and gulls nested on scattered cliffs. Several dozen guillemots nested on Testlatlints Rock, a solitary flower-pot boulder on the tidal flats near Dadens (Campbell *et al.* 1990), and 6 to 10 puffins were regularly seen at the summit of Cox Island and on nearby cliffs of Langara Island. Auklets and storm-petrels appear to have abandoned the islands, although they were abundant in adjacent waters and continued to nest on nearby Frederick Island (53° 56' N, 133° 10' W) and Forrester Island (54° 50' N, 133° 31' W) in Alaska.

There are three important avian scavengers in Kiisgwaii: Bald Eagle (*Haliaeetus leucocephalus*), Common Raven (*Corvus corax*), and Northwestern Crow (*C. caurinus*). Bald Eagles were abundant, with at least 20 to 22 nesting territories on Langara Island between 1991 and 1996 (Elliott *et al.* in press). We recognized the eagles as potential scavengers of rat carcasses and made use of ongoing coast-wide surveys of annual productivity (Elliott *et al.* in press) to monitor them on Langara Island throughout the period of rat-extermination in 1995. Ravens and crows were abundant in the area and scavenge food near the fishing lodges in Henslung Cove but the total numbers have never been assessed. Northwestern Crows are abundant throughout Kiisgwaii and frequently form shoreline flocks of 20 to 50 birds in late summer; nothing is known of their reproductive activity.

There are no amphibians on Langara Island. Neither the introduced Pacific treefrog (*Hyla regilla*) nor the native western toad (*Bufo boreas*), which occur elsewhere on the Queen Charlotte Islands, were found on Langara Island during this project.

Langara Island has a diverse terrestrial invertebrate fauna which includes molluscs (2 abundant land snails, *Vespericola columbiana* and *Haplotrema sportella*) and 3 slugs, including the banana slug (*Ariolimax columbianus*), millipedes, and many insects. Of particular interest to this project were the abundant scavenging organisms such as sexton beetles (*Nicrophorus spp.*), carrion beetles (e.g., *Necrophilus* and *Catops spp.*), and various flies (especially *Calliphora spp.*). These scavengers could be important in the disposal of rat carcasses, thereby potentially contributing to tertiary poisoning of insectivores.

1D. ENVIRONMENTAL IMPACT ISSUES.

The Canada Environmental Assessment Act (1995) required the completion of an environmental review and public consultation. As part of that review we prepared a feasibility report (Taylor 1993) which included the environmental review as an appendix. More than 200 copies were distributed before the initiation of the project and 100 afterwards. We also distributed explanatory pamphlets to 200 households and held public information sessions at Old Massett and Skidegate villages. The project proceeded with the agreement in principle of the Old Massett Village Council (Appendix III).

The environmental review addressed secondary and non-target poisoning, persistence, leaching into water systems, preparedness for accidental spillage, and mechanical damage to the environment. We discuss the characteristics of the poison used (brodifacoum) in sections 2A and 2B. The consideration of mechanical damage was based on plans by the Old Massett Village Council to develop Duu Guusd Tribal Park on the north end of Graham Island which will include Kiisgwaii. As the project finished, the Old Massett Village Council was beginning a series of trails which would make the north coast of Graham Island and Kiisgwaii accessible to tourists.

We designed trails and campsites to minimise permanent damage to the island. Signs of abandoned villages, fish camps, and military bases have gradually disappeared from the land in spite of long occupation and we expected the impact of our shorter stay to be equally transitory. We anticipated maintaining a full complement of staff (30 to 70 persons) for 4 to 6 weeks during the actual eradication and smaller parties at some sites for parts of 5 summers from 1993 through 1997.

2. METHODS: PREPARATORY PHASE.

2A. ADAPTATION OF THE NEW ZEALAND APPROACH.

2Ai. Strategy.

We applied the fixed bait station approach developed and tested in New Zealand (Taylor and Thomas 1989, 1993) with as few modifications as possible to accommodate differences in climate, working conditions, and non-target species. The fixed bait station approach depends on a single strategy which is closely adhered to throughout the campaign and requires little additional input for eradication. This approach is well founded on the ecology of rats and takes advantage of their behaviour. The process progressively kills rats within a predicable and short period of time. It is self-monitoring in the sense that damaged baits offer clear and straightforward evidence of activity by surviving rats while the increasing frequency of undamaged baits, in the later stages, demonstrates progress towards the goal of extermination. The short period of activity helps limit the risk to non-target species and the constant level of effort with demonstrable effects helps maintain the confidence of administrators and the morale of field personnel.

The most important feature of the New Zealand technique is the regular and continuous replacement of consumed baits in fixed bait stations (Fig. 3). Norway rats rely on their conspecifics in deciding where and what to eat, and prefer sites that conspecifics are exploiting. When given a choice of diet, rats that have smelled a particular food on another's breath prefer it, even to other more familiar foods (Shorten 1954, Galef and Heiber 1976, Galef 1987). As a result less-dominant and/or bait-shy rats can learn from others that the bait is palatable and available (Taylor and Thomas 1989, 1993). Observations of Norway rats at bait stations on Hawea and Breaksea Islands in New Zealand showed that their behaviour of removing and caching poison baits, and chasing away subordinate rats, means that not all rats have ready access to the bait during the first few days of a poisoning campaign. Consequently, dominant individuals may eat a surfeit of bait and die in the first 3 to 4 days. Less dominant rats should successively gain access to bait, whether in bait stations or in caches down burrows, and be poisoned over the following two or three weeks, until all are killed (Taylor and Thomas 1989). At 3150 ha, Langara

Island and its neighbours are much larger than any land mass where rodent eradication has previously been successful. However, there was no obvious reason why the New Zealand technique could not be expanded to such larger areas (Taylor and Kaiser 1993, Taylor 1993).

2Aii. Bait acceptability.

The bait used in New Zealand was Talon 50 WB (ICI Crop Care, NZ), a wax briquette formulation containing brodifacoum. Talon 50 WB had been designed following laboratory and field tests to be very attractive to rats and mice (ICI Tasman 1984). This formulation contains ingredients which include tallow, castor sugar, blood and bone, and wheat (Eason 1991, ICI unpub.). The wax that binds the baits together makes them weatherproof and suitable for use in bait stations under damp conditions. Environment Canada registered this bait as RATAK+ Weather blok, specifically for clearing rats from seabird colonies (Appendix II). RATAK+ Weather blok was manufactured for this project by ZENECA Agro.

The field experience in New Zealand showed that the bait was extremely palatable to wild rats at all times of year. Problems occurred only where constant exposure to poison for many years has led to the existence of resistant or neophobic rats. Kiisgwaii is a wilderness area and the rats on Langara Island had not been exposed to poisons except for occasional control attempts at the light station and the fishing lodges. Rats on Lucy or Cox islands had likely never been exposed to poisons. We tested acceptability of the baits on Lucy Island in July 1994 (see 3A below).

2Aiii. Anticoagulant poisons.

When first developed in the 1940s, anticoagulant poisons revolutionised rodent control, and about 12 varieties are now in common use (Lund 1988a, Ware 1989). They act by blocking the vitamin K1 oxidation-reduction cycle in the liver, thus preventing the production of blood clotting proteins. They also cause capillary damage. Death results from massive internal haemorrhaging (Smith and Greaves 1987). Anticoagulant rodenticides have a major advantage over other toxins: pre-baiting is not required because rats will consume a lethal dose before they begin to experience toxic effects. Very high kill-rates can be achieved (100% with correct application technology), and bait-shyness does not become a problem. Enhanced human safety is another advantage, since Vitamin K1 is a very effective antidote. At the time of our investigation into these compounds, we found no reports of fatal, accidental poisoning in humans (Lund 1988a).

Brodifacoum (3-[3-[4'-bromo(1-1'-biphenyl)-4-y1]-1,2,3,4-tetrahydro-1- naphthalenyl] -4-hydroxy-2H-1-benzopyran-2-one), the rodenticide used on Langara Island, is a member of the coumarin group of anticoagulant poisons (Ware 1989). The first coumarin, dicumarol, was produced as a rodenticide in the 1940s, after it was identified in moist, mouldy sweet-clover hay which caused internal bleeding and high mortality in cattle (Lund 1988a). Also, coumarins give the Central American plant 'mata rata' (*Gliricida sepium*) rodenticidal properties (Hochman 1966). Warfarin, dicumarol, and the other 'first-generation' coumarins (e.g., coumatetralyl, coumachlor, coumafuryl) required repeated ingestion of the poison over several days to cause death. Brodifacoum, bromadiolone, and flocoumafen are 'second-generation' coumarins that have been developed since the mid-1970s (Lund 1988a, 1988b). They can kill after a single feeding and their potency makes them effective against rodents that have developed resistance to warfarin or other first-generation anticoagulants (Redfern *et al.* 1976). Ideally, for efficient eradication of the target species, ingestion of one mouthful of bait should lead to death (Eason 1991). Only brodifacoum and flocoumafen approach this requirement and brodifacoum has been widely used in successful rodent eradication campaigns in New Zealand.

In a typical concentration of 50 ppm brodifacoum (as found in TALON WB50 or RATAK+ Weather Blok Bait), about 1.3 grams of bait contains an LD50 for a typical adult Norway rat of 250 g (Taylor and Thomas 1989). The acute LD50s of flocoumafen are 0.25-0.56 mg/kg for Norway rats and 1.00-1.78 mg/kg for black rats (Lund 1988a, 1988b). Brodifacoum has slightly lower LD50s at 0.22-0.27 mg/kg for Norway rats and 0.65 mg/kg for black rats (Lund 1988a, 1988b).

2Aiv. Resistance problems.

Rodent resistance to warfarin and other first-generation anticoagulants has been known since 1958, and is now established in many populations of Norway rats, black rats and house mice in all parts of the world (Lund 1984, Greaves 1985). The more potent second-generation anticoagulants were developed for use against resistant strains, but already some rodent populations are resistant to difenacoum and bromadiolone. In regularly poisoned populations, there are strong indications of tolerance to brodifacoum (Lund 1984, Gill *et al.* 1992, Quy *et al.* 1995). On Ulva Island (259 ha), New Zealand, a small number of rats survived and continued to feed on baits long after the rest of the population had been poisoned. Twenty years of almost continuous rodent control, the last 10 with Talon 50 WB, had apparently led to some rats evolving resistance to brodifacoum. The last few survivors were eliminated by trapping (Taylor *et al.* in prep.). Resistance to all the new anticoagulant compounds evolves when used continually, and some rat control treatments may become generally more prolonged and less effective (Gill *et al.* 1992, Quy *et al.* 1995). These findings reinforce the need for eradication at the first attempt, as opposed to control, on islands to reduce the risk of the development of resistance to second-generation anticoagulant (Taylor and Thomas 1989, Taylor *et al.* in prep.).

2Av. Bait station design.

Bait stations used for rodent eradication in New Zealand have included automatic dispensing silos requiring only occasional checking (McFadden and Towns 1991), large drums or similar containers with a bulk supply of poison checked at weekly, or longer, intervals (Taylor and Thomas 1993, and unpubl.), and short (40-100 cm) lengths of plastic pipe checked and replenished every 1 or 2 days (Taylor and Thomas 1989, 1993; Taylor *et al.* in prep.). The selection of bait station depended on acceptability by rats and exclusion of non-target species. In past New Zealand campaigns, bait stations used have sometimes failed to meet the second requirement (McFadden 1992, Taylor and Thomas 1993), and some invertebrates and individual birds have gained access to the poison. However, no long-lasting population effects were detected.

In most operations in New Zealand prior to 1993, bait stations were constructed from yellow, corrugated plastic drainage pipe (Fig. 3). The colour made them easy to find, even among thick ground vegetation, and appeared not to deter rats (Taylor and Thomas 1989); 100-mm diameter pipe was used for Norway rats and 65-mm (or 100-mm) diameter for black rats. Yellow pipe was not available and we used bright orange instead. The length of pipe varied depending on the behaviour of the non-target species to be excluded. In Kiisgwaii, ravens and crows were the only non-target species likely to interfere with the bait stations. We chose a length of 0.5 m so that baits placed in the centre would theoretically be beyond the reach of ravens and crows. We also pinned the stations to the ground with 0.5 m wire hoops to fix them to the ground. Kiisgwaii receives abundant rainfall and we thus placed baits on a plastic or aluminium tray which fit below the lid to keep them dry.

We realised that weather could prevent us from landing on some of the offshore islets and serviced such sites with a simple hopper based on the original station design (Fig. 4). We added a vertical tube to a 0.5 m piece of pipe and threaded 30 baits onto a rod which pinned the station to the ground. Rats would not be able to carry whole baits from these stations and we expected them to function for up to a week without servicing.

2Avi. <u>Bait station spacing.</u>

Regular spacing allows the maintenance of an even distribution and a constant dosage of bait. Previous successful eradications of Norway rats have used station spacings of 40 x 40 m, 50 x 100 m, and 100 x 100 m (Fig. 5) (Moors 1985a, Taylor and Thomas 1989 and 1993, Taylor *et al.* in prep.). The 40 x 40 m spacing used in early operations was later thought to be unnecessarily close (Taylor and Thomas 1993). Research on home range (Moors 1985b, Hickson *et al.* 1986, Taylor 1986) and radio-tagged Norway rats showed that 100 x 100 m spacing ensures all individuals could be expected to have at least 1 bait station within their home range (Taylor *et al.* in prep.). Furthermore, various studies have shown that once neighbours are removed, surviving rats quickly expand their home ranges (Innes and Skipworth 1983, Taylor 1986, Taylor *et al.* in prep.). Wider spacing between bait stations reduces the amount of bait eaten for each rat killed, but extends the duration of the operation (Taylor and Thomas 1993). To a large extent, increasing the number of bait blocks at each station can compensate for increased spacing. On Ulva Island, Norway rats were successfully eradicated using 100 x 100 m spacing between the stations (Taylor *et al.* in prep.).

We used 100 x 100-m spacing (1 per ha) for LISHRP and set additional stations in coastal areas where rats appeared abundant or the terrain was particularly dissected. We also placed stations on all offshore islets with vegetation even though all of these were much smaller than 1.0 ha.

2Avii. Acclimatisation to the stations.

The possibility of neophobia causing some rats to be slow at starting to feed on the baits was countered by setting out unbaited bait stations several weeks before poisoning. Trials have confirmed that there are marked differences in the initial rate of bait-take depending on the length of time involved (Taylor *et al.* in prep.). We allowed a lead time of about 6 weeks for the rats to become used to the presence of the stations.

2Aviii. Dosage.

In selecting bait density or dosage, there is a compromise between speed of eradication and the amount of poison being allowed to enter the environment. If population densities are very high, the amount of bait placed per visit should be sufficient to dose all of the animals present, particularly if dominant rats prevent subordinate rats from gaining access to the baits for long periods of time. During various trials with Talon WB50 baits, increasing the baiting level reduced the time needed to achieve 99% control (Fig. 5) (Taylor and Thomas 1993, Taylor *et al.* in prep.). Populations varying from 2-13 rats/ha took 40 days at 4 baits/ha/day, 21 days at about 9 baits/ha/day, and 11 days at 16 baits/ha/day to reach the 99% control level. We were unable to determine a density of rats on Langara Island but quickly concluded that they were unevenly distributed, based on observations of densities of burrows. We baited the area within 300 m of shore (below the ring trail) with 12 baits/ha where rats appeared to be in high densities. We baited the whole interior area, where rats were at a low density, with 6 baits/ha.

2Aix. Service frequency.

Operations on Hawea and Breaksea Islands in New Zealand demonstrated the advantage of daily visits to check for activity and replenish baits until bait-take almost ceases (Taylor and Thomas 1989, 1993). Less frequent, but regular, re-baiting can be used if the number of baits per station is increased to maintain the required baiting level. In a recent trial on Ulva Island with stations spaced at 100 x 100 m and a bait level of 4 baits/ha/day, the stations were checked and re-baited every second day for the first 4 weeks and at weekly intervals thereafter. Ninety-nine percent of all bait taken by rats had gone on Day 42 (Taylor *et al.* in prep.).

For Kiisgwaii, we set the daily effort at about 60 stations/day/person but could not support 90 persons in the field (60 station operators, 20 support staff, and 8 to 10 scientists) and decided on a 48-hour service cycle. This service frequency reduced the number of operators to 30 and the maximum expected number of other personnel to 25). The selected dosage and service frequency aimed at 99% control on Langara Island over 30 days and complete eradication in 6 weeks.

Once the baits cease to be taken by rats, the interval between each round of checking and replacement of fresh bait was increased. We planned for quarterly checks of the bait stations for 2 years following the main eradication. The function of those checks is to detect activity by surviving rats and refresh the supply of baits over the winter. During the winter, alternative foods are at their lowest availability and rats are most likely to feed on baits.

Nearly all rodent eradications in New Zealand have aimed at clearing rats from all parts of an island at once. This is the classic approach, as used on Breaksea Island, and it is the obvious method to use on small or medium sized islands when sufficient personnel are available. In order to fit the eradication operation into a single summer season, we followed the same strategy in spite of the logistic difficulty of maintaining up to 90 people in the field.

2B. THE ENVIRONMENTAL REVIEW OF BRODIFACOUM APPLICATION.

2Bi. <u>Risks of secondary and non-target poisoning.</u>

Toxic baits may attract species other than rats (primary poisoning of non-target species) and animals which die after ingesting the bait are likely to be toxic to scavenging species (secondary poisoning). We planned to reduce the risk of non-target poisoning by dispensing brodifacoum baits from appropriately designed bait stations (Section 2Av) and by collecting baits scattered by rats outside of the baits stations. Furthermore, we chose the latest possible starting date (July 10) when most birds begin to disperse after breeding and the late summer brings abundant alternate food resources for shrews. Based on the New Zealand experience, we expected most rats to sicken and die in their burrows, thereby greatly reducing the risk of secondary poisoning to scavengers such as crows, ravens, or eagles. We planned to further reduce this risk by collecting all dead animals near bait stations every 48 h.

2Bii. Persistence of the pesticide in the soil.

Brodifacoum is very susceptible to degradation by soil bacteria (ICI 1984, Arnold *et al.* 1978, Ussary 1979). The half life of brodifacoum was expected to be 12 to 25 weeks, but degradation could be retarded on Langara Island because the climate is quite cool with a mean of 8.1° C in May and the soil is strongly acidic. Microbial degradation produces non-toxic metabolites and brodifacoum is eventually reduced to its component carbon dioxide and water (Shirer 1992). Plants do not readily uptake brodifacoum (ICI 1984, Hendley and McIntosh 1982).

2Biii. Leaching of the active ingredient into streams and intertidal areas.

Brodifacoum becomes largely adsorbed to organic materials and sediment and does not travel freely through soil to water supplies (Eason 1992). In laboratory studies which mimicked rain fall of 32 cm over 5 to 7 days, less than 2% leached more than 2 cm (ICI 1984). These tests were conducted at doses of 0.6 and 6 kg/ha, a pH from 4.3 to 7.1, organic content from 6.8 to 71.2%, and a clay content from 5 to 19% (Stevens and Hill 1979). Ussary (1979) found similarly low mobility in field studies. Brodifacoum is not soluble in water (less than 10 mg/l at 20° C and pH 7) (Worthing and Walker 1987). The level toxic to resident fish exposed over 96 hours (0.015-0.05 mg/l) would require the presence of at least one bait in every 15 to 50 l of water (Worthing and Walker 1987, Hill *et al.* 1976a and b, Hill 1978).

We reduced the risk of brodifacoum entering the water system by the use of water-resistant, wax bait blocks placed in plastic bait stations and by enclosing those baits kept in the stations over winter in light weight plastic bags.

2Biv. Accidental spillage of the baits into sensitive environments.

We requested special waterproof containers from ZENECA Agro to reduce the potential damage of an accidental spill during transport to the camps or around the island. We also provided special training on the application of pesticides for the field personnel. In the event of a spill of one or more buckets, we planned to immediately interrupt the project and to divert the field personnel and small boats to collecting the lost material. The planned response included immediate notification of the Environmental

Protection Branch of Environment Canada, Canadian Coast Guard, and the British Columbia Emergency Coordination Office.

3. METHODS: FIELD OPERATIONS.

3A. BACKGROUND STUDIES AND MONITORING THE ENVIRONMENT

3Ai. Testing the method in the field.

We conducted a field trial with toxic baits on Lucy Island in the summer of 1994 (Special Use Permit 253-101-94*RES) to test the method and ensure that the assumptions in the feasibility study (Taylor 1993) were correct. We began in mid-May by laying out 42 stations spaced every 100 m in 3 lines. We waited 6 weeks for rats to acclimatise to the bait stations. We also set out 49 Longworth live traps in a 1-ha grid to assess the density of shrews on the 3 nights immediately before baiting. Twenty sets of paired snap traps were used to assess the density and distribution of rats before and after baiting. Baiting began on 12 July by placing 3 baits in each station. After 20 July, the dosage was increased to 4 baits. Activity was monitored daily and baits replaced until they ceased to be taken on 3 August 1994. All poison baits were removed from the island on 17 August 1994. After the baiting session, we reassessed the shrew population and reset rat traps to detect survivors.

3Aii. Assessing the impact of brodifacoum in the environment

We used Bald Eagles as our primary indicator of the spread of brodifacoum in Kiisgwaii, because eagles were abundant breeders in the area and no effective means to capture ravens and crows was discovered. We chose breeding success as a general criteria for health of the eagle population and measured it by using a standard two-flight approach with at least 2 observers in a helicopter (Fraser *et al.* 1983). We conducted the first survey to determine the number of eagle pairs attempting to breed during early-to-mid-May at both Langara Island and a reference site near Tanu Island (180 km south) in the South Moresby area. The second flight was timed to count nestlings at 5-8 weeks of age and took place in early July. We flew a prescribed route at a steady speed of about 60 km/hr and a height of 170 to 350 m, depending on topology. As budgetary constraints on helicopter use precluded exhaustive searching for every bald eagle nest in the study areas, our objective was to identify a sample of nests along the survey route necessary for productivity assessment. We determined mean productivity at each study area by dividing the total number of young produced per study area by the number of occupied breeding territories, as described in Postupalsky (1974).

Blood samples were collected from adult Bald Eagles around Langara Island before and during the main eradication campaign for analyses of brodifacoum residues and prothrombin times (a screen for deficiencies in clotting factors dependent on vitamin-K). Eagles were captured using a tethered herring floating within a noose mat, and up to 10 ml of blood was drawn from the brachial vein of each captured eagle (Howald 1997). Analyses of prothrombin times were done 6-10 h after blood collection, and analyses for brodifacoum residues were performed at the Department of Agriculture, State of Illinois Veterinary Diagnostic Laboratory, USA (Howald 1997).

3Aiii. Assessing non-target mortality.

We assessed the non-target mortality of birds by collecting and analysing carcasses. To assess the loss of shrews we used both live-trapping for capture-recapture studies and snap-trapping before and after the main eradication campaign (Drever 1997, Howald 1997).

3B. KIISGWAII EXTERMINATION CAMPAIGN.

3Bi. Site preparations on Langara and Cox islands.

Coastal areas of Kiisgwaii are covered by mature coniferous forests in which steep slopes are unconsolidated and vulnerable to erosion. Much of the interior of Langara Island is covered by blanket bogs, slow to recover from trampling. We needed access to each hectare while minimising impact and avoiding unnecessary damage. When servicing the stations, bait station operators would need to be able to find and identify the location easily. We based our initial plans on Forest Cover Maps used by BC Ministry of Forests, but in 1994 we had access to digitised Terrestrial Resource Inventory Maps (TRIM). We continued to base our plan for trails, campsites, and helicopter-landing areas on the paper Forest Cover Maps but were able to plot site locations and summarise data on the digitised orthophoto of the area.

We constructed two types of trails. The first, known as the ring trail (Fig. 1), circled Langara Island. The ring trail followed the land forms and was designed for easy, long-distance travel through the forest roughly 300 m from the coast line. This trail became the most practical border between coastal and interior stations on Langara Island. Much of the ring trail lay near the upper edge of the hemlock forest where there was often little undergrowth. It was about 2 m wide and 3 m high to provide unimpeded access for a person carrying a large pack.

The second type of trail was the station trail which ran from station to station and did not follow the landform. These trails were simple flagged routes which did not require much cutting of undergrowth. They were laid out on a simple rectilinear grid in such a way that 50 to 60 stations could be visited in a day. Along the coast and between the interior lakes, where a rectilinear grid was not feasible and the bait stations were often less than 100 m apart, the trails followed the safest direct route between stations.

We divided the island into 5 convenient working units: McPherson, Dadens, Cox, Fury and Lighthouse (Fig. 1). Each of these held a camp and a crew of sufficient size to service all stations within the unit within 48 hours.

3Bii. Bait station deployment.

We deployed two types of stations: tubes and hoppers. The tubes were similar to those developed in New Zealand but were 0.5 m long (Fig. 3). We bundled them in groups of ten and packed them along the bait station trails from helicopter drop sites scattered over the island. The bait stations were laid out in a 100-m grid over the whole island (Fig. 6), stapled in place with 2 galvanised-wire hoops and given a unique identification number. Initially, these hoops simply held the station to the ground, but were moved over the lid in September 1995 to prevent avian scavengers from lifting the lids.

Most bait stations were placed on site 6 to 8 weeks before arming to allow the rats to become acclimatised to their presence. As arming started, field crews placed additional stations in areas with complex terrain or where signs of rats were particularly abundant.

We found that bait stations at sites with poor access or on small offshore islets could not be visited regularly, particularly during periods of rough seas. At such sites, we used hoppers (Fig. 4) which held a larger supply of bait and allowed a lower frequency of visits without risk. The hoppers were also given an identification number and marked on the base maps.

3Biii. Bait station arming.

We received permission to initiate the eradication on 6 June 1995 (Pesticide Use Permit 253-102-95/96*RES) (Appendix II) and began arming the stations on 10 July 1995. Arming consisted of placing 6 or 12 baits in the centre of the station. All of the hoppers were in coastal areas, usually on offshore islets, and armed with 25-30 baits. This system of arming with a fixed number of baits makes the whole array of stations self-monitoring in that any disturbance is immediately apparent.

3Biv. Bait station servicing.

Each day from 10 July until 15 August 1995, operators were assigned 50-60 stations and given a waterproof data log which contained the history of those stations. Individual stations were visited every 48 h and examined for activity. The operators replaced baits and recorded the number of baits taken by rats, chewed, or heavily invested by moulds. The operators also removed slugs and snails and noted the condition of the station (e.g. lid missing). We also asked the operators to retrieve the carcasses of any animals they found. Hoppers placed on offshore islets were visited about every 6 days.

3Bv. Data collection and compilation.

Data sets were based on the daily records of bait station operators. They recorded the number of baits present in the station and classified them according to their appearance as rat-chewed, shrew-chewed, slug-chewed, or mouldy and were expected to record any other observations such as missing lids or uprooted stations. Crew supervisors collected the individual data records from the bait station operators and prepared summary sheets which they forwarded to the data manager daily. These summary sheets form the basic data set for the project.

We monitored progress of the project through an electronic data base using MAPINFO™ computer software. The data summary sheets were converted to database files (DB IV 5.1™) for each work unit and maps of activity were returned to the crew supervisors. The data management operation required a clean and dry space to protect the hardware (2 Toshiba 1910 laptop computers and an inkjet printer) and house a data manager and a data-entry technician.

3Bvi. Bait station winterising.

Although the plan was to exterminate the rats by the end of August 1995, we were sensitive to the threat posed by surviving and re-introduced rats. The average wild Norway rat has a short life; less than 5% survive 12 months and very few survive to the age of 2 years (Davis 1948, Moors 1990). Stations which remained armed over the winter would both indicate presence of and poison survivors. As rat activity declined in August, we wrapped baits in plastic bags to keep them dry and discourage mould, slugs, snails, or shrews from attacking them. We could wrap baits in the hoppers and depended on cold weather to protect those baits from mould.

3Bvii. Follow-up monitoring for rat activity.

We used snap-trapping lines established in May 1995 to test the efficacy of the eradication campaign (Drever 1997). These trap lines were set at 6 sites (2 in seabird colony, 2 near Henslung Cove and 2 in Hazardous Cove) for 2 sessions, one in early August, another in late August, after poison baits had been placed in plastic bags and rats no longer removed baits from the stations. At each site, 3 parallel trap lines were established, each 400 m long and consisting of 16 traps spaced 25 m apart. The trap lines were 25 to 200 m apart. We used Victor™ snap traps baited with a mixture of rolled oats and peanut butter, and each trapping session lasted 3 nights during which traps were checked every 24 h. During the second session in late August, we also placed 6 apples at 4 sites, 2 in the seabird colony and 2 in Hazardous Cove. Apples are a preferred food for rats and their texture allows for easy identification of tooth marks (Taylor and Thomas 1989). Apples were left for 2 days and checked daily for feeding sign.

Following the main eradication campaign, we planned to monitor rat activity using a series of quarterly bait-station checks. However, we were forced to accept a much longer interval. We omitted winter sessions because we could not meet government health and safety regulations, and consequently could not insure our equipment. Winter conditions increased the risk and difficulty of using small boats to transport crews around the islands and presented too great a likelihood of serious injuries. We did check all of the stations in September 1995, the coastal stations in April and May 1996, and all of the stations again in August and September 1996. The final check began in May and ran through August 1997 and was co-ordinated with the removal of remaining baits and stations.

During each of the checks every bait was examined for signs of mould, attack by slugs and snails, or incisor marks of shrews and rats. When we suspected rat activity, it would be suppressed by daily re-arming until baits ceased to be taken. Undisturbed stations would also be re-armed with fresh baits and damaged or questionable baits (and bags) were to be brought back to camp for closer examination.

In 1996 and 1997, when there was no sign of rat activity at the bait stations, we placed arrays of oiled chew sticks (poplar sticks dipped in bacon grease or cooking oil) beside selected bait stations in the coastal portions of each of the work units, and examined these daily for incisor marks of rats.

4. RESULTS.

4A. BACKGROUND STUDIES AND MONITORING THE ENVIRONMENT

4Ai. Testing the method in the field.

The 42 bait stations on Lucy Island were put in place on 6 May 1994 and armed on 12 July. Rats began taking baits on 14 July. Rat activity built to a peak on 27 July (day 16) and had ceased by 3 August (day 23) (Fig. 7). We made a final check and removed the baits from stations on 12 August. Rats took baits from 74% of bait stations and shrews were active at 28% of stations. At least 1 rat was trapped after the baiting (18 August), and a second carcass was found in a lost trap in May 1995. An additional rat was trapped in April 1995, but it was not clear whether this was a survivor or immigrant which had swum the narrow channel from Langara Island (Drever 1997). The bait stations were re-armed in July 1995 and treated as a part of the main eradication campaign during which several stations showed signs of rat activity.

4Aii. Assessing the impact of brodifacoum in the environment.

Bald Eagle nest occupancy was similar at Langara Island in 1995 and 1996, indicating that there was no apparent impact on the local Bald Eagle breeding population (Table 1). Breeding success in 1996 on Langara Island was significantly lower than in previous years (Table 1). However, breeding success was also significantly lower in 1996 than in previous years at the reference site. Reduced productivity likely resulted from reduced prey availability at both sites. Availability of an adequate food supply appears to be the major factor limiting Bald Eagle reproduction at sites on the B.C. coast (Elliott *et al.* in press). Reduced prey availability was presumed to be caused by stochastic events in the marine environment of the northern Gulf of Alaska.

During the 1995 baiting operation, we trapped adult and sub-adult eagles and collected blood samples to measure possible brodifacoum exposure. Of 23 blood samples collected during the eradication phase of the project, only 3 showed traces of brodifacoum (Howald 1997). One had a plasma brodifacoum concentration of 1.74 mg/kg, equivalent to ~ 3.3 rats, and had likely scavenged dead ravens rather than preyed on rats. The other 2 eagles were likely exposed from eating poisoned rats. The prothrombin times of eagles sampled indicated none were clinically anti-coagulated relative to control samples (Howald 1997). In 1996, remains of 5 eagles were found. The talons exhibited multiple focal areas of reddish discoloration, possibly representative of subcutaneous haemorrhage. However, the talons were too desiccated to distinguish between lesions and artefacts of post mortem change and thus only provide equivocal information (Howald 1997).

4Aiii Assessing non-target mortality.

Bald Eagles: During experiments in 1994, Bald Eagles were not attracted to rat carcasses, even when snap-trapped carcasses were placed on eagle feeding platforms and other theoretically attractive locations (Howald 1997). In 1996, a Bald Eagle carcass and 2 sets of Bald Eagle skeletal remains were collected by the light keeper. The carcass contained brodifacoum residues. Although chemical analysis of the skeletal remains is likely inconclusive, the base of the talons showed subcutaneous bleeding which suggests contact with an anticoagulant. We now know that those eagles would also have had access to recently poisoned ravens. During the nest occupancy survey of 5 May 1996, 2 large Bald Eagle nestlings were observed dead in a nest at Langara Point. Given that 2 of the 3 trapped Bald Eagles with brodifacoum residues in blood came from Langara Point, it seems quite possible that those young eagles were also poisoned when they were fed poisoned ravens by their parents.

Common Ravens: Tests in 1994 with unpoisoned snap-trapped rat carcasses identified ravens as the most common avian scavenger of Norway rats (Howald 1997). However, during the pilot project on Lucy Island in 1994 most rats died underground and few ravens visited Lucy Island. During the eradication campaign, in 1995, we used radio-telemetry to track 15 rats which had consumed baits. The signals led to the discovery of 1 partially consumed carcass in a tree and 1 on the beach, but the remainder were found dead underground. Those observations reinforced our opinion that secondary poisoning offered a small risk to ravens or other scavengers. Nevertheless, we proceeded with a full program to monitor for secondary poisoning throughout the eradication campaign and the follow-up monitoring.

When we found the first dead ravens, we assumed they had consumed poisoned rat carcasses, since those ravens were found in areas with very high densities of rats (McPherson Point and Hazardous Cove). Throughout the eradication campaign, the station operators reported very few baits outside of the bait stations and there seemed little opportunity for direct poisoning. In all, 13 dead ravens were found before the eradication campaign ended on 26 August 1995. Seven additional carcasses were found during follow-up station checks in 1996 and 1997.

In retrospect, there is circumstantial evidence that ravens tampered with the stations from the start of the eradication campaign. As early as 17 July 1995, bait station operators reported that lids were occasionally missing from stations, but we did not attach special significance to those reports, assuming carelessness by other operators. We also noticed puzzling patterns in the bait station activity. When plotted on maps, the activity occasionally appeared in continuous lines of 5 to 8 stations (Fig. 10). Thirty-nine of those stations were in the interior, where there was little rat activity, and those stations were active only once between 12 July and 14 August 1995 (Fig. 10). Rats tended to keep stations active for 2 to 5 days.

The first unequivocal evidence that ravens would readily consume bait blocks came in late August 1995, after the main poisoning campaign. A failure to follow elementary safety procedures resulted in brodifacoum poisoning of several ravens. During the incineration of contaminated packs, bags, and mouldy baits, the lids were left off some buckets of bait which were found by ravens overnight. Three raven carcasses were found nearby. Unfortunately, there were few workers on the island at that time and we were unable to mount a systematic search for additional carcasses.

Early in September 1995, the light keeper alerted us to several more instances of the lids being removed from bait stations and other evidence of disturbance. His suggestion that ravens might be involved led to an immediate campaign to improve security at the stations. We were about to conduct the first post-operation check of all stations and were able to tie or weigh-down the lids at the same time. We found nearly 100 disturbed bait stations on the north side of Langara Island and a few other disturbed stations scattered across the island in addition to obvious rat activity in Henslung Cove (Fig. 24). All of the observers had participated in the eradication campaign and felt that the disturbance on the north side of the island was not typical of rat activity. Nonetheless, some of the disturbance could have been the result of rat activity: removal of baits, removal of bait trays (plastic or aluminium inserts intended to keep the baits dry), or removal of lids. However, some stations were uprooted by an effort far beyond the strength of a rat. At the time, there was no direct evidence linking this disturbance to any particular animal. Several of the uprooted stations were on deer trails and one had clearly been displaced by a deer which had bedded down on top of it. In addition, our experience during the previous summer led us to see river otters as more likely culprits than ravens, although we found no tooth marks on the stations.

In February 1996, we sent a party to investigate a rat trapped by the light keeper. When checking stations within walking distance of the lighthouse, they found that the area east of the lighthouse, which had been extensively disturbed in September 1995, and the stations southwest of the light station, were undisturbed. However, many stations in the Ancient Murrelet colony and other areas towards McPherson Point were disturbed (Fig. 25). There was not sufficient time to check the whole area, and we could not return to the area until spring 1996.

It was difficult to conceive of ravens as the cause of such widespread disturbance, partly because ravens never seemed numerous on the island. We had only found 5 nests on Langara Island, rarely saw more than 6 ravens at our camps, and perhaps 12 scavenged around the fishing lodges in Henslung Cove. Instead, we made the less risky assumption in terms of the project goals and proceeded as though the evidence indicated emigration by rats from survivors at the lighthouse. This interpretation forced us to be prepared to "roll back" a possible outbreak of rats in the spring of 1996.

In the spring of 1996, we began the station check on the southeast coast (Dadens Camp) in case it was necessary to find the southern flank of a rat outbreak near McPherson Point. However, many bait stations in the southeast, particularly within 300 or 400 m of the coast, had been disturbed and left empty. In the Dadens unit, where both coast and interior areas were surveyed, 23% (n = 500) of the bait stations were disturbed but activity was restricted to the coast, open areas, and ravines. In the coastal areas of the McPherson Unit, 45% (n = 184) were disturbed. Of disturbed stations, 15% had been pulled from their anchors and moved and 15% had the plastic bag, which once contained the baits, lying nearby. These bags had been torn open and showed no tooth marks of rats or other larger mammals. Some had been raggedly chewed which indicated attacks by shrews or slugs. Stations which had been weighted down by small logs were often undisturbed but those with the lids tied down were often uprooted. Twelve of the soft aluminium trays which had been pulled out of the stations were retrieved during the station check. Four had large triangular marks, strongly suggestive of the imprint from a raven's entire bite. Four others had only small crescent-shaped depressions that we duplicated by pressing the tip of a raven's beak into the aluminium. Those bait stations which had been re-armed in February had not been re-disturbed.

We found other evidence that ravens were the main cause of disturbance to the bait stations. In the McPherson Unit, we found 12 pellets regurgitated by ravens which consisted largely of the blue wax from bait blocks but also contained fragments of plastic bags. We also collected remains of 7 ravens from various parts of the island, including 1 fresh carcass which had died of pulmonary haemorrhaging (Howald 1997), and found blue raven faeces and fragments of bait blocks around an abandoned raven nest in Dibrell Bay. There were ravens present throughout the summers of 1996 and 1997 but numbers seemed low in comparison to previous years. None of the 5 known nest sites were active.

In July and August, 1996, we modified bait stations by inserting thin (3 mm) bamboo skewers (the type used for kebabs) across the mouths of each station (Fig. 3). The skewers were flexible and seemed strong enough to resist a raven's bill, but could easily be chewed apart by a rat. In a simple test scenario, a very large pet rat easily slipped past a skewer to exit a station. The skewers also helped to stabilise stations by pinning them to the ground at 2 more points. In early April, 1997, the light keepers reported that a raven had broken into one of these stations but none of the other stations on the islands were disturbed by ravens.

Northwestern Crows: Trace amounts of brodifacoum (0.019 mg/kg) were detected in a pooled sample of 3 crow livers collected from Lucy Island, 12 days after the start of the main eradication campaign in 1995, and in one liver sample (0.048 mg/kg) from a crow collected on Lucy Island in May 1995, 9 months after the pilot project on Lucy Island. Only 1 crow carcass was found during the eradication campaign but no brodifacoum residue was detected in its liver. No crows were found during 1996 or 1997 and large flocks occurred regularly around the islands.

Song Sparrows and other birds: Carcasses of 2 or 3 Song Sparrows and skeletal remains of a small woodpecker were found during the station checks in September 1995 and February 1996. These birds could have entered the stations or gained access to baits pulled out of the stations by ravens. However, it is not known whether they died as the result of eating the bait or were normal winter deaths. We found brodifacoum residues in pooled samples of tissues of 9 Song Sparrows collected in late August 1995 (Howald 1997).

Dusky Shrew: Estimates based on a small number of recaptures suggest that shrew densities dropped from 27 individuals per ha to 4 individuals per ha during the pilot study on Lucy Island in 1994, but had recovered by the following spring. During the main operation on Langara Island in 1995, the shrew population showed no significant decrease based on live-trapping data (Howald 1997). However, snap-trapping rates of shrews dropped significantly (Drever 1997). They fell from 5.8 C/100TN (captures per 100 trap-nights) in June and July 1995 to 2.0 C/100TN in August 1995 ($F = 5.6$, $df = 4$, $P = 0.0011$). Any population decrease was likely temporary and in the spring of 1996, shrews were common even though there had been no decrease in the density of armed bait stations. Very few shrews attempted to chew through the plastic bags but some such activity may have been masked by that of ravens and banana slugs.

River Otter: One otter tore up and chewed stations in Henslung Cove, and the baits went missing. This otter may have been reacting more to the scent of human intrusion on his territory than the attraction of the baits. Many otter winter-dens and slides were close to bait stations throughout the armed period (1995-1997) and although there was ample opportunity for additional incidents to occur, none of the other resident river otters are known to have exhibited any interest in the stations or baits. All known otter dens ($n = 3$) were active in 1996.

4Aiv. <u>Mechanical damage to the environment.</u>

Erosion occurred at a few places along the ring trail because of regular traffic by station operators in 1995 and subsequent use by deer. Most of these places will grow over and not worsen in time but 2 small (0.3 ha) naturally-water-logged areas in the seabird colony may continue to slump or contribute to the formation of a gully. The changes at these sites should not affect the nesting Ancient Murrelets.

Because the sites are water-logged, they are not actually part of the nesting habitat for seabirds. Vegetation at the campsites closed in 1995 had largely recovered by 1997, and the sites should soon be undetectable. During the final check, in the summer of 1997, the remaining camp, flagging tape, bait stations, and hoppers were removed.

An archaeological review identified areas of cultural significance which were being damaged by foot traffic during the eradication phase (Mason 1996). These areas were posted and the nearby camps closed during the monitoring phase. Near the house pits at McPherson Point, which were considered particularly sensitive to damage, grass had grown over signs of foot traffic by 1997.

4B. THE ERADICATION CAMPAIGN

4Bi. Bait station arming.

A total of 30,577 baits were placed in the stations between July 10 and 12, 1995. Additional stations and replacements were armed throughout the project where operators felt they were missing from areas potentially harbouring rats. At the beginning of the eradication operation and during the stations checks in 1996 and 1997, a few stations could not be found and were replaced with new ones. Usually, extra stations were placed to accommodate local terrain (*e.g.* on both sides of a steep-walled ravine). The last new stations to be deployed and armed were those placed around the light station in January, 1996.

4Bii. Bait station operation and maintenance.

During the first few days of the extermination campaign, individual operators serviced between 20 and 120 stations daily. Overall we were able to maintain the 50 stations/work day (5 km plus commuting to and from camp) and most operators were able to complete their tasks by mid-afternoon. During the station checks, when modification to the stations was required, we reduced the target to 40 stations/work day. Over the rat-eradication program, the operators replaced 14,500 individual baits that had been taken by rats and many more that had been affected by shrews, slugs, and mould.

4Biii. Effect of baiting.

Baits began disappearing within a few hours of placement and 361 stations were active by 14 July. We reached 95% total uptake of baits taken by 26 July (day 17), and by 30 July (day 21) only 14 stations were active (Fig. 8). Small pockets of activity continued until 9 August (day 31).

The accumulated data include 3881 stations and account for all but a few anomalous records: 24 stations were not included because their identification numbers did not match the recorded geographical locations. During analysis, we rejected data from 74 additional stations which lacked critical information not recoverable from the operators' note books. The analyses are based on 1293 stations (33.3%) in the coastal area (below the ring trail) and 2514 stations in the interior (64.8%).

Stations around the coast were more likely to become active and remain active for longer periods than interior stations (Table 2). On average, stations experienced their first rat activity after a lag of 6.5 days (Fig. 9). Lag time did not differ significantly between coastal and interior stations (Mann Whitney $U = 134431.0$, $p = 0.693$), although lag time had a significant negative relationship with duration of activity (Spearman $R = -0.21$, $n = 1080$, $p < 0.001$).

We began placing baits on 10 July but did not finish arming the stations until 12 July. The record of station activity started 48 h later. Between 12, 13, and 14 July, activity was largely concentrated along the coastline (Fig. 10). In the following days (15 and 16 July), clusters of stations had already become inactive, including all of those on Lucy Island, but large blocks elsewhere became active, particularly in the northeast and on the west coast (Fig. 11). On the northwest coast, activity had moved inland and several previously inactive patches of coastline showed new activity. This new activity was short-lived (Figs. 12 and 13). By 21 and 22 July (Fig. 14), some of the previously large blocks of activity were fragmented. The next 9 maps (Figs. 15 to 23) record the spread and contraction of activity over 48-h intervals until nearly all the stations had become inactive after 8 August 1995. There was no rat activity on Kiisgwaii between 9 August and 15 August.

While other parts of Langara Island became inactive after 1 or 2 bouts of activity, the stations close to Henslung Cove showed alternating bouts of rat activity and inactivity from 12 July through 3 August 1995. These stations were among the last to become inactive. Henslung Cove contains the shore installations for the fishing lodges. There are several kitchens which feed more than 100 people daily. The lodge operators incinerate most of their waste, dump compost at sea, but discard fish offal in the intertidal zone. The buildings are a complex environment, and construction, errant operators, and free-ranging domestic animals may have interfered with our eradication efforts. A few bait stations were moved and at least 1 was buried by construction debris.

4Biv. Follow-up monitoring for rat activity.

No rats were captured during 2 snap trapping sessions in August 1995 over a total of 1728 trap-nights. In addition, incisor marks of rats were not found on any apples in August (48 apple-nights).

After the cessation of rat activity, we scheduled quarterly monitoring for a period of 2 years. However, we could not complete all the checks as planned. Monitoring called for an intensive effort by 5 workers, checking about 4,000 stations over a 20-day period but none of the station checks turned out to be simple monitoring visits. Two checks required localised rat exterminations (Figs. 24 and 25) and 3 checks included time-consuming efforts to reduce the risk to ravens (Figs. 26 and 27).

a. Autumn 1995 check. When all of the stations were checked in September 1995, 7 stations in Henslung Cove showed activity by rats. These were immediately re-armed and a further 17 baits were taken. Rats around the lodges had likely failed to feed on poison baits during the main eradication and began to forage more widely when the lodges closed at the end of the fishing season. In October 1995, one station was disturbed, but this was likely raven activity. We found no rat activity or rat sign at Henslung Cove in May 1996 or 1997.

Five months after the extermination campaign, in January 1996, the light keeper at Langara Point trapped an adult male Norway rat in a grain store. After placement of 8 additional stations around the lighthouse, no further rat activity was observed. Apparently at least 1 rat had survived the July 1995 campaign and only became interested in the bait stations when the grain store was removed. No activity attributable to rats was found in subsequent checks at the lighthouse (Figs. 26 and 27).

b. Spring 1996 check. The scale of raven activity became clear part way during this second general check of the bait stations, between 28 April and 22 May, 1996 (Figs. 26 and 27). We found large numbers of disturbed stations soon after starting. Consequently, we checked only 1675 stations and largely confined our activity to coastal areas, although we checked 300 interior stations in areas that had been preferred by rats along creeks and inland from the Ancient Murrelet colony at McPherson Point. In total, we found 300 disturbed stations: 52 were uprooted and 248 had the contents removed. Eight sets of bagged baits, 29 trays, and 55 empty plastic bags were collected near the stations. Only 2 stations had the lids removed. Some stations showed more than one type of disturbance. We decided that these stations needed to be re-checked several times in case the disturbance was due to continued activity by rats. However, only 4 stations were re-disturbed during these checks. There was no further activity when they were checked later on 9 and 11 May. The McPherson and Dadens areas, which had not been visited since September 1995, accounted for 68% of the disturbed stations.

We became certain that almost all of the disturbance of stations after August 1995 was attributable to ravens. However, the evidence of their interest in the baits was difficult to interpret. There was no clear evidence of rats, such as faeces or tooth marks on bags and baits, at any of the stations visited in May 1996. None of the bags pulled from the stations showed tooth marks of rats, but some had clearly been chewed by shrews or torn open. Several soft aluminium trays, used to keep the baits dry, had been pulled from the stations and showed peculiar triangular impressions consistent with the imprint of a raven's beak. The small number of lids removed suggests that moving the hoops over the lids in September 1995 forced the ravens to develop new tactics to get at the baits.

Snails, slugs and shrews had attacked many baits over the winter but usually left the baits in the station. They opened small holes in the plastic bags which they apparently enlarged and we often found them living in a cavity in the bait block. Some baits had deep excavations of > 1 cm^3 which suggest a long period of residence by the snail. Except for occasional clear shrew incisor marks on the plastic bags, it was difficult to distinguish between damage by slugs and that by shrews. Once the plastic bags were damaged, baits became heavily invested by mould and any evidence of shrew activity was obliterated.

We also looked for other evidence of the continued presence of rats but found none. Inspection of the Ancient Murrelet colony on 1 and 3 May 1996 revealed many patches of murrelet feathers typical of avian predators. Those patches were highly dispersed and centred on some hummock or stump. None were compact feather collections and we saw no gnawed carcasses, both of which would have been characteristic of rat predation (Harfenist 1994). Sets of 3 chew sticks were placed along lines of bait stations at McPherson Point, Cox Island, Fury Bay, and several other areas, but none were gnawed by rats. We found no evidence of fresh rat faeces, runs or paths in dry areas beneath logs. Even year-old rat faeces were scarce.

At the McPherson Point Ancient Murrelet colony, we found more than a dozen egg shells. These suggested activity by some predator but none of the shells had tooth marks from rats or punctures by bird bills. None were opened on one side or at the end, typical of rat predation. These eggs were clean inside and although they were opened around the waist, like hatched eggs, they lacked the faecal material or blood spots found in hatched eggs (M. Lemon pers. comm.). They were also found too early in the season to have hatched normally (Gaston 1992). Such shells are also common on colonies without rats and are thought to be eggs from the oviducts of birds killed by eagles or falcons or perhaps cracked eggs dropped by female murrelets without burrows (M. Lemon pers. comm.).

c. Summer 1996 check. A third check which included all the stations began on 18 July 1996 and was completed on September 3 1996 (Fig. 27). Two-hundred and seventy-five stations were found disturbed. These included 212 stations in the interior which had been unchecked since September 1995. The pattern of disturbance in the interior was similar to that of the coastal stations checked in May, but at a much lower frequency (6% as opposed to 22%). Of the 212 disturbed stations, 14 were uprooted and 59 had the contents removed (Fig. 27). We found 44 empty bait bags. Only 2 station lids were removed and only 4 bagged baits lay outside the stations. We found 63 disturbed stations on the coast, of which 16 had been previously disturbed in May 1996. Forty-seven additional coastal stations were disturbed, mostly along the ring trail.

No evidence of surviving rats was found. Chew sticks placed in groups of 2 or 3 near 114 bait stations did not have rat incisor marks. A single blue faecal pellet was found in a protected site in Fury Bay in August. This pellet was mouldy and likely had been deposited in 1995. We found no tracks of rats in the fine sand of Egeria Bay during 5 1.5-km checks in August 1996 and there were no runs or rat faeces beneath the protective overhang at the top of that beach, under which Winter Wrens (*Troglodytes troglodytes*) and Song Sparrows (*Melospiza melodia*) were roosting and perhaps nesting. Rat faeces and runs were obvious in similar habitat on Lucy Island in 1993, 1994, and 1995. There were abundant bird faeces.

d. Spring 1997 check. There was no evidence from bait station checks of surviving rats in the spring and summer of 1997. Inspections in May 1997 of the Egeria Bay shoreline, the Ancient Murrelet colony at McPherson Point, the lighthouse, Fury Bay, Hazardous and Henslung coves, and Cox and Lucy islands failed to find rat faeces, foot prints, or signs of rat predation. Chew sticks set out in August 1996 were undisturbed in May 1997. Small groups of fresh chew sticks were placed at McPherson Point, Fury Bay, and Hazardous Cove in May 1997 without any indication of activity by rats. The Ancient Murrelet colony was inspected and looked much like it had in 1996, except that there seemed to be an increase in the amount of avian predation.

4Bv. Data management.

During the extermination campaign, the operators gathered data from 1700 to 2300 bait stations daily. The information was used to generate maps of progress for the whole island every 48 h, and provided the basis for the estimated rate of bait consumption. The information was also used to monitor activity by non-target species such as shrews, slugs, and snails and the condition of the baits which were subject to mould.

Only a few of the bait station operators had previously participated in science projects and understood the importance of clear, properly recorded data. We found great variation in the quantity and quality of information collected. A few workers took detailed notes, most provided what was required, but a few needed close supervision until they understood that the project depended on data. As the project progressed, the practice of remembering the stations and completing the field sheets at the end of the day also became a problem because it reduced the accuracy of the report. Overall the collection of primary data (rat activity) was good but the collection of secondary data on shrews, slugs, and mould was irregular at best and has not been suitable for analysis. For information on these species, we relied on the data from a small sample of technically trained operators who better understood the significance of comprehensive information.

4Bvi. Longevity of the bait blocks.

Unprotected blocks did not last long in the field. Those which over-wintered without a plastic wrap inside bait stations were completely decomposed, and blocks carried away by rats were usually taken into burrows where the uneaten portions were quickly invested by mould. One cache of baits found under a log on Lucy Island in May, 1995, 9 months after the pilot project, still showed residues of brodifacoum. Four caches of 10 to 26 decomposed baits were found inside the mouths of burrows, 10 months after the eradication phase. Those were exceptionally large concentrations, and the blocks were almost completely destroyed. The plastic bags delayed but did not prevent decomposition of baits. Typically baits wrapped in 1 layer of plastic decomposed in the 6 months between station checks.

Throughout the project, bait blocks abandoned on the ground and left in bait stations were quickly attacked and consumed by slugs, snails, and millipedes. The plastic bags did not effectively deter these invertebrates; slugs appeared able to enter the bags where the plastic was stretched over the corners of the bait blocks. In coastal areas, more than half of double-wrapped baits were attacked by slugs and snails. In the interior of the island, baits seemed to last longer.

4Bvii. Persistence of the pesticide in the soil and water.

We did not monitor the longevity of RATAK+ Weather Blok Baits in the soil because the application density was extremely low and the pesticide control officer (J. Vakenti, BC Ministry of Environment, Lands, and Parks, Smithers) decided that there was little risk to the environment from persistence in the soil.

We did not monitor the presence of brodifacoum in streams or intertidal areas. We complied with the permit requirement that bait stations be > 10 m from streams and the shoreline and the application density was extremely low. Bait blocks were unlikely to fall into the upper reaches of streams because there was so little rat activity further than 300 m from the sea shore. In the project, risks from transport of brodifacoum into water bodies were further reduced by first encasing the toxin in wax bait blocks and by enclosing the blocks in plastic bags when rat activity had ceased. No bare or wrapped blocks were ever found on the tide line or in streams or lakes.

5. DISCUSSION.

5A. PROJECT OBJECTIVE.

Our objective was to recover habitat for seabird breeding colonies in Kiisgwaii which had been lost to rats. However, it will be several more years before we can be sure of meeting that objective. The re-establishment and growth of seabird colonies is a slow process and partially dependent on stochastic events. The colony survey techniques provide estimates which have large confidence limits (Bertram 1989, Harfenist 1994), and it may not be reasonable to expect detectable growth in the Ancient Murrelet population for 5 or more years. Throughout that period, it will be difficult to prove the continued absence of rats on a land mass the size of Langara Island because there are no absolute indicators of absence. By the summer of 1997, the absence of rats seemed to have led to an increase in the abundance of ground nesting birds such as Winter Wren, Song Sparrow, Semipalmated Plover (*Charadrius semipalmatus*), and Spotted Sandpiper (*Actitis macularia*), although there is no rigorous baseline for comparison.

5B. PROJECT GOALS.

5Bi. <u>Exterminate the Norway rat population before the Ancient Murrelet colony disappears</u>.

The extermination proceeded according to plan and there was no rat activity at the bait stations at the end of the main extermination campaign in August 1995. During the first monitoring operation, we found that a few rats had survived at Henslung Cove. The outbreak was discovered and suppressed during the September 1995 station check and there was no subsequent activity in that area. In January 1996, the light keeper trapped a rat and a small team was dispatched to suppress any other survivors in February 1996. This single animal had apparently survived on a store of livestock feed and no subsequent rat activity was observed. Ancient Murrelets bred in the colony in May 1996 and 1997, with no signs of rat predation.

Rats took baits from ~ 900 of 3,881 stations and all other evidence suggests that only about one quarter of Langara Island, mostly coastal areas, supported rats. In total, rats took approximately 14,500 baits or about 90 gm/ha. A comparison with the consumption of 1185 gm/ha on Breaksea Island, New Zealand (Taylor and Thomas 1993), where the level of baiting was similar to that employed on Langara Island, suggests that the average density of rats for the whole of Langara Island was only 7.6% of that on Breaksea Island. From snap-trapping, Taylor and Thomas (1993) calculated the density on Breaksea Island to be 13 rats/ha before baiting. By interpolation, the average density of rats on Langara Island would have been about 1.0 rats/ha.

This estimate of density is supported by the results of trapping on Langara Island in May-June 1995. A mark-recapture study in the coastal zone near McPherson Point indicated that about 45 rats occupied 15 ha. Snap-trapping also indicated about 3 rats/ha in the coastal zone and about 1 rat/ha overall (16.9 C/100TN along the coast and 4.8 C/100TN in the interior) (Drever 1997). Thus, a coarse estimate of the total rat population on Langara Island would be ~ 3,000 before poisoning. Subsequent analysis of stable-isotopes in rat tissues and rat stomach contents showed that the diet of rats varied around the island. Rats near the seabird colony did consume seabirds but rats in Henslung Cove appeared to be largely herbivorous. The dense and vigorous population in Hazardous Cove (Fury Camp) was feeding heavily on intertidal organisms (Drever 1997).

The varied diet and patchy distribution suggests that the rats were not doing as well as one might expect in that varied and predator-free environment. The rats on Langara Island appeared fit and healthy, but the situation appeared in sharp contrast to that on Great Sitkin Island in Alaska which two of us (GWK and MCD) visited in August 1996. That treeless island did not hold any seabird colonies and was inhabited by arctic fox (*Alopex lagopus*) but still supported dense populations of rats wherever we looked. In the deep grass, there were numerous runs and caches of stored food > 1.0 km from shore and above 300 m elevation. The foxes seemed to keep the rats from the intertidal areas but aside from those predators it seemed much richer rat habitat than Langara Island.

5Bii. Meet the terms of the Nestucca oil-spill litigation settlement.

The agreement makes only a general reference to habitat recovery and this effort clearly satisfies its intent by salvaging breeding habitat for species affected by the impact of that spill.

5Biii. Avoid damage to non-target populations at risk from primary and secondary toxicity.

Bald Eagles: Bald Eagles dominated our plans for mitigating secondary poisoning. Poisoning of eagles was judged to be unacceptable to the public and would be an international conservation concern. Therefore, we undertook a variety of studies to assess the risk of secondary poisoning of Bald Eagles. Although we found traces of brodifacoum in samples of eagle blood, nest occupancy or productivity was not affected by the eradication campaign (Elliott *et al.* 1996, Elliott and Norstrom in press). The cause of death for the remains of 5 eagles could not be directly attributed to brodifacoum poisoning. Carcasses of eagles were also found in 1994 and 1995, before poison baiting took place on Langara Island. Furthermore, eagle populations can have a naturally high mortality rate in the winter (e.g., up to 29% in Alaska (Bowman *et al.* 1995)). Thus, the effect of brodifacoum poisoning on the breeding population appears to have been undetectable (Howald 1997).

Common Ravens: The loss of ravens through secondary poisoning appeared small during the eradication operation of July and August, 1995, but primary poisoning became a more obvious problem between September, 1995 and May, 1996 during the monitoring phase (see section 3Bvii). We were unable to determine the size of the raven population on Kiisgwaii. Extrapolating from Brenchley's (1985) estimate of 26 nests/100 km^2 in the unusually dense population on Saltspring Island, British Columbia, there would have been about 8 nest territories and 20-72 ravens on Kiisgwaii at the start of 1995. In 1996 and 1997, we saw ravens at several sites around Langara Island but never more than 10 in total. It is clear that the local population has been seriously, if temporarily, reduced. The loss, which must have included non-territorial birds, probably exceeded 50% of the local population. The lost birds should be quickly replaced by immigrants from the much larger population on nearby Graham Island.

Raven mortality should be preventable by modifying stations in future projects. For instance, ravens would not be able to take baits from longer stations or s-shaped stations securely anchored to the ground. Methyl anthranilate, a powerful and easily available bird repellent, may make bait blocks unacceptable to scavenging birds (Mason *et al.* 1989). We considered testing this compound as negative re-enforcement to scavengers of rat carcasses, but it has not been tested for acceptance by rats and is not a registered bird repellent in Canada.

Northwestern Crows, Song Sparrows and other birds: Northwestern Crows were far more abundant on the islands than ravens, and had shown more interest in our activities than any other species during the 1994 study of scavengers (Howald 1997). In late summer they formed groups of up to 100 individuals and frequently foraged in the Sitka spruce forest along the shoreline. Although the baits were not too large for them to carry and they could have easily entered the stations, crows did not seem to recognise the baits as food and were never implicated in the raiding of the bait stations, or collecting crumbs or broken baits.

Dusky Shrews: We investigated several options to reduce the impact on the shrews prior to the eradication phase. In tests with captive animals and field trials, neither raising the bait tray 50 cm nor blocking the lower half of the station mouths had any effect on the shrews' ability to reach the baits (Drever 1997). We decided that it would not be practical or possible to raise the entrance to the stations more than 50 cm without impairing entrance by rats. Furthermore, attaching the baits to the roof of the station would not put them beyond the reach of the shrews. When we found that shrews on Lucy Island had nearly returned to densities pre-baiting by May 1995, we decided that modifying bait stations presented too large a risk of deterring rats and would do little to protect shrews.

During the eradication phase on Langara Island in 1995, the density of stations and timing of baiting were the same as on Lucy Island in 1994. There were detectable declines in shrew density in some areas. However, interpretation of live-trapping of shrews was compromised when mice or squirrels disturbed the traps in the control plot on Graham Island (Howald 1997). Snap-trapping was the only tool which demonstrated a decline in shrew populations but this method confounds trap mortality with poison mortality. We found no evidence of local exterminations and shrews remained a common presence on Langara Island through the completion of the project in 1997. It seems likely that shrews in non-breeding condition, which have small home ranges, never came in contact with the highly dispersed (approximately 1/ha) bait stations, and thus a proportion of the population survived (Howald 1997).

River Otter: There was no firm evidence of non-target mortality of river otter.

5Biv. <u>A plan to minimise the risk of re-introduction of rats and negate the effect of re-introductions of house mice</u>.

Sufficient resources to eradicate rats again if they get re-introduced to Kiisgwaii will not likely be available. The best defences are prevention, immediate detection, and rapid response, including the installation of permanent bait stations on the island. Currently, no agency exists to take day-to-day responsibility for either monitoring the continued absence of rats from Kiisgwaii or to monitor the vectors by which rats and mice might be introduced. Environment Canada's mandate is limited to the conservation of migratory birds under the Canadian Wildlife Service Program. BC Ministry of Environment, Lands, and Parks has a mandate for wildlife conservation and management but does not have the resources to dedicate to such a long term issue. Thus, in the absence of an appropriately mandated agency, the diligence and good will of the stakeholders in the island are necessary to protect this large investment in seabird conservation, but this will need co-ordination. This need for co-ordination seems like an ideal opportunity for the involvement of a non-government organisation with modest governmental support. In 1997, Environment Canada began negotiations with the newly formed Haida Gwaii Expeditions Society to exchange logistic support for simple monitoring (placement of chew sticks) to detect newly introduced rats.

Likely sources of rat re-introductions are large vessels carrying supplies to the island. The Canadian Coast Guard has a stringent rat-prevention program which should negate the threat from their frequent visits. Two other types of vessels make regular visits to the island: floating fishing lodges and coastal draggers. The former offer high quality accommodation and meals to their guests, and shipboard rats would not allow them to meet such a standard. However, considerable vigilance is required because the floating lodges spend the winter at rat-infested moorages near Port Clements or in the Fraser River. Little is known about the risks posed by the October visits of the dragger fleet. Most are modern steel vessels which spend long periods at sea and likely do not support rats. In addition, plans for an improved wharf and beaching facilities at Henslung Cove may increase the traffic of large containers to the island. Heavy construction equipment moves to the land-based lodges on old wooden barges from harbours at Masset and Port Clements, ports which have large populations of rats.

It seems unlikely that the house mouse can be prevented from reaching Langara Island. House mice are not an important threat to seabirds but could have significant impacts on vegetation and invertebrates (Taylor 1993). The native deer mouse would likely prevent house mice from becoming established outside of the buildings on Langara Island (Taylor 1993). The solitary deer mouse found in 1994 suggests that they are occasionally transported by natural events from nearby Graham Island. We believe that it would be good practice to speed this inevitable event and re-establish a population of deer mice now that the poison baits are removed from the island.

5Bv. Create employment and other economic opportunities for local residents, especially members of the Haida Nation.

Throughout the project, we purchased groceries, camp supplies and equipment locally from stores in Masset and Queen Charlotte City. Early phases of the project required technical expertise in environmental assessment and toxicology that could not be found locally, but we primarily employed island residents during the preparation of the island, actual eradication process and the follow-up monitoring. About half of all employees were members of the Haida Nation.

6. CONCLUSIONS.

6A. ERADICATION.

We have found no evidence of surviving rats in Kiisgwaii since January 1996; no rats have chewed bait blocks or left signs such as fresh runs, burrows, faeces, gnawed egg shells or dead Ancient Murrelets with wounds to their napes. While we cannot prove the absence of rats from Kiisgwaii with complete certainty, the lack of activity suggests that the last rat surviving on Langara Island was trapped by the light keeper in January 1996. Uncompromisingly negative evidence from follow-up station checks and tests with indicator baits in both 1996 and 1997 also supports this conclusion. The ultimate proof will be the expansion of the Ancient Murrelet colony and re-colonisation by Cassin's Auklet and other seabirds.

6B. METHODOLOGY.

The technique proven on Breaksea Island (Taylor and Thomas 1993) was effectively extrapolated to a much larger site. The pattern of bait consumption and mortality followed the predicted curves. The extrapolation was straightforward and did not require any significant changes to the baiting protocol or to the methodology. LISHRP demonstrated the inherent robustness of the method in that it was carried out by seasonal labourers instead of wildlife technicians supported by dedicated volunteers, and that it succeeded in spite of an inability to carry out the monitoring checks with the planned frequency and completeness. We were forced to omit winter monitoring for reasons of safety and we could not complete early station checks because we were forced to respond to disturbance by ravens.

6C. NON-TARGET SPECIES.

The impact on birds was greater than expected but not catastrophic. Brodifacoum residues were detected in Bald Eagles, Northwestern Crows and Song Sparrows (Howald 1997), but these species suffered no detectable population decline. A few Bald Eagles likely gained access to the poison by scavenging raven carcasses. Common Ravens were secondarily poisoned from scavenging rat carcasses and primarily from raiding bait stations. Probably 50% or more of the local raven population was killed. Immigrants from the much larger population on Graham Island could likely replace the lost ravens on Langara Island. Our inability to reduce the threat to ravens stems from the large land mass involved in this project and our inability to respond effectively in winter. The method can easily be improved to reduce that risk in future efforts by changing the timing of the operation and modifying the bait stations.

Non-target mammals may have suffered a short-term population decline. The rat eradication campaign undoubtedly led to the death of many shrews but the population effects were apparently short lived. Shrews have likely benefited from the absence of rats through reduced competition for insect prey and possibly decreased predation. There was no evidence that the eradication campaign had any effect on Sitka deer or river otter populations.

6D. ARRIVAL OF NEW RATS.

Boat traffic may offer future opportunities for rats to re-invade Kiisgwaii and such traffic will undoubtedly increase as the area becomes more developed. At this time there is no support, and perhaps no official mandate, for regulatory protection of the island. However, failure to implement effective protection measures will negate long-term benefits from this project. Encouraging proactive planning by the managers of the sport-fishing lodges and the development of conservation initiatives by local groups such as the Haida Gwaii Expeditions Society may be most effective to prevent the re-introduction of rats.

6E. OTHER THREATS.

Foot prints of racoons have been reported from the beaches of Langara Island, most recently in August 1996. The establishment of a population of racoons would negate gains made by the removal of rats and Langara Island should be included in the co-operative racoon monitoring program in place for southern portions of Haida Gwaii.

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Table 1: Nest success and production of young for Bald Eagles at Langara Island and at a reference site in the South Moresby area.

Study Area	Year	No. of occupied territories	No. of Successful Nests	% Nest Success	No. of young produced	Young/ occupied nest
South Moresby	1994	19	5	26	6	0.32
	1995	17	6	39	6	0.35
	1996	20	2	10	2	0.10
	Mean	19 ± 2	4±2	25 ± 15	5±2	0.26 ± 0.17[a]
Langara Island	1994	22	13	59	16	0.73
	1995	21	12	57	19	0.83
	1996	20	7	35	10	0.50
	Mean	21 ± 1	11 ± 3	50 ± 13	15 ± 5	0.69 ± 0.17[b]

[a,b] - overall by location, means that do not share the same letter are significantly different ($p<0.05$).

Table 2: Activity at coastal and interior bait stations in Kiisgwaii during the 1995 eradication campaign. Activity is defined as removal of ≥ 1 bait block by rats from bait station.

	Coast	Interior
Total number of bait stations	1293	2514
Number of active bait stations	661	410
Percent of active bait stations	51	16
Mean lag time from arming to activity (days)	6.7	6.5
Mean duration of activity (days)	3.9[a]	2.1[b]

[a,b] Significantly different: Mann Whitney U = 84826.5, $p < 0.0001$.

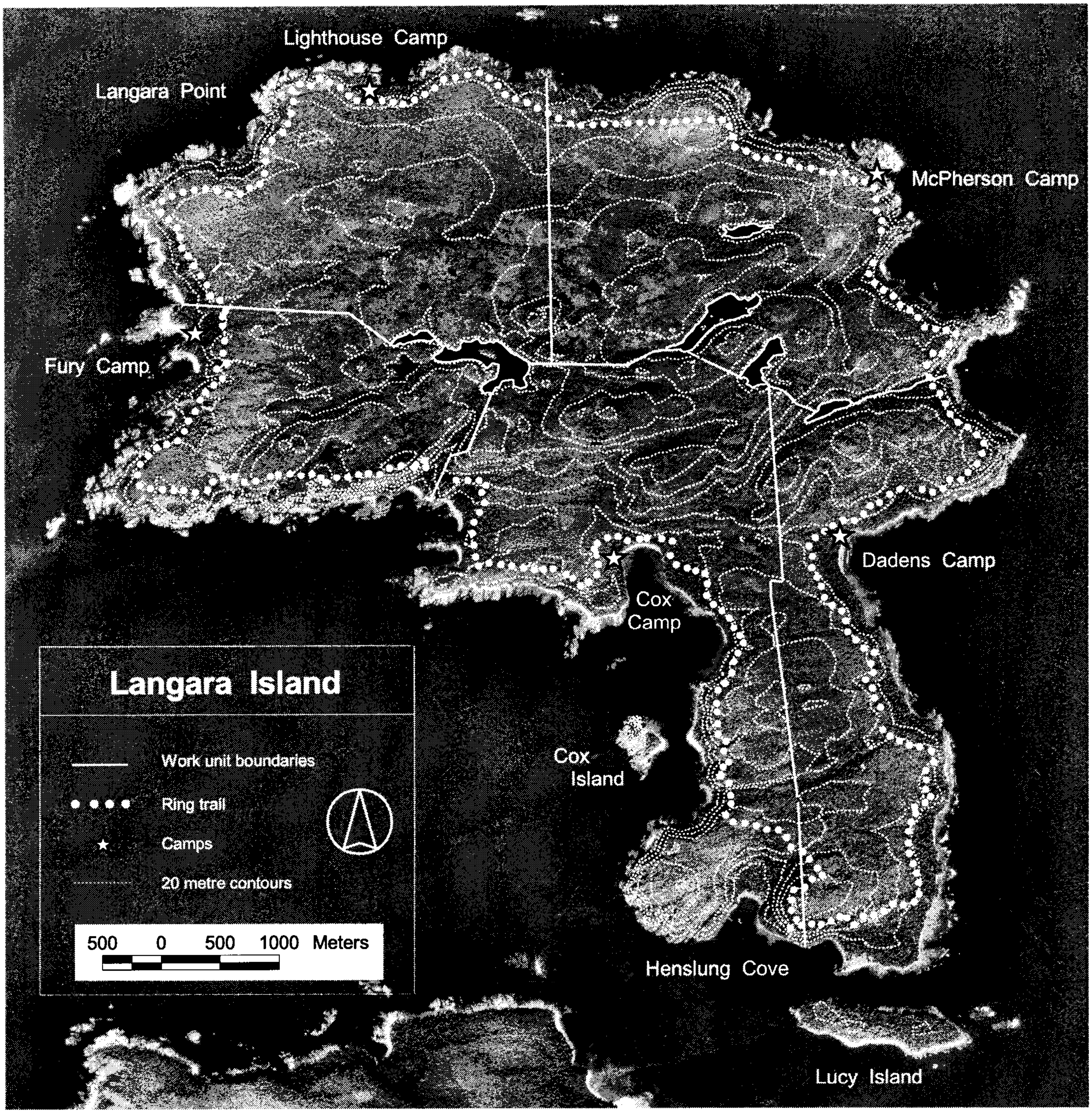

Figure 1. Orthophoto image of the Kiisgwaii Archipelago, which includes Langara, Cox, and Lucy Islands and smaller offshore rocks, showing the general location of the project campsites and the ring trail.

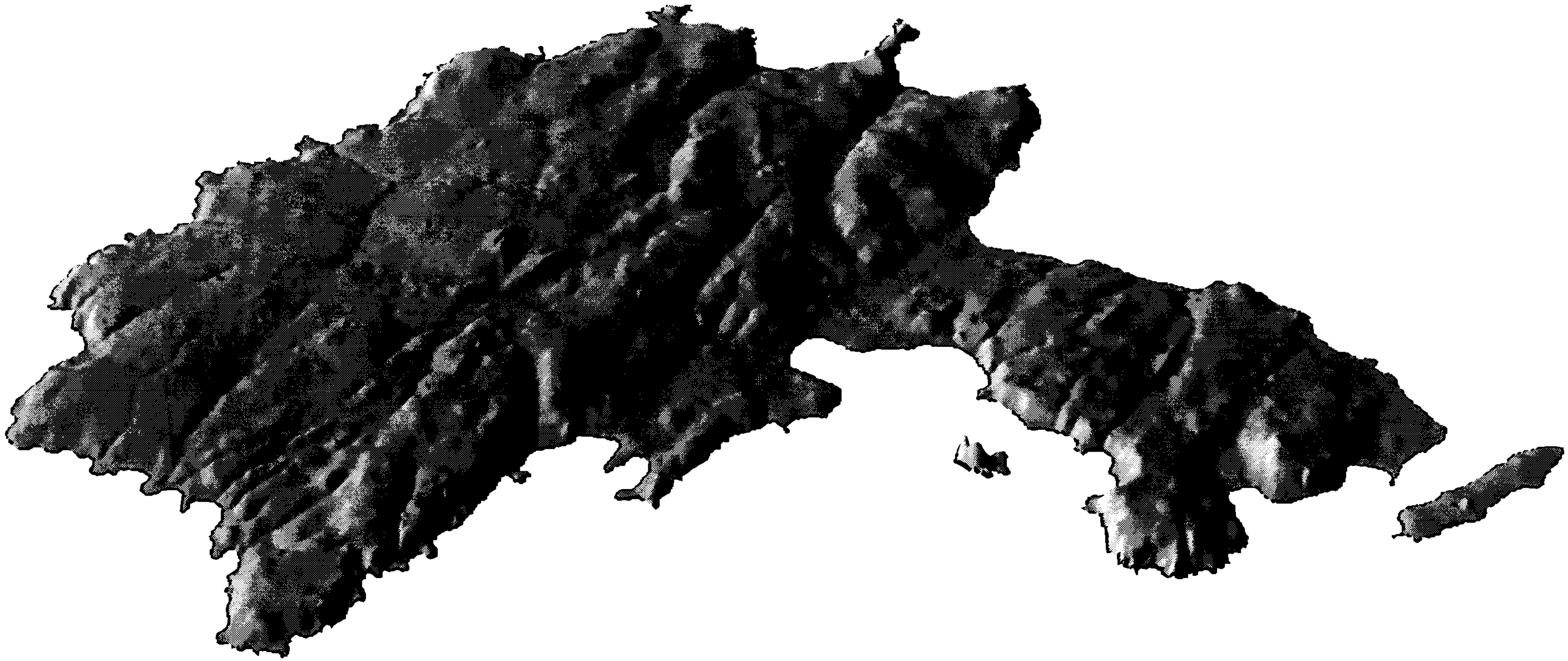

Figure 2. The Kiisgwaii Archipelago viewed from the sourthwest. This image of a virtual model was constructed from the TRIM data, vertical distances are exaggerated by 100% and the archipelago is lit from the northwest to emphasize the topography.

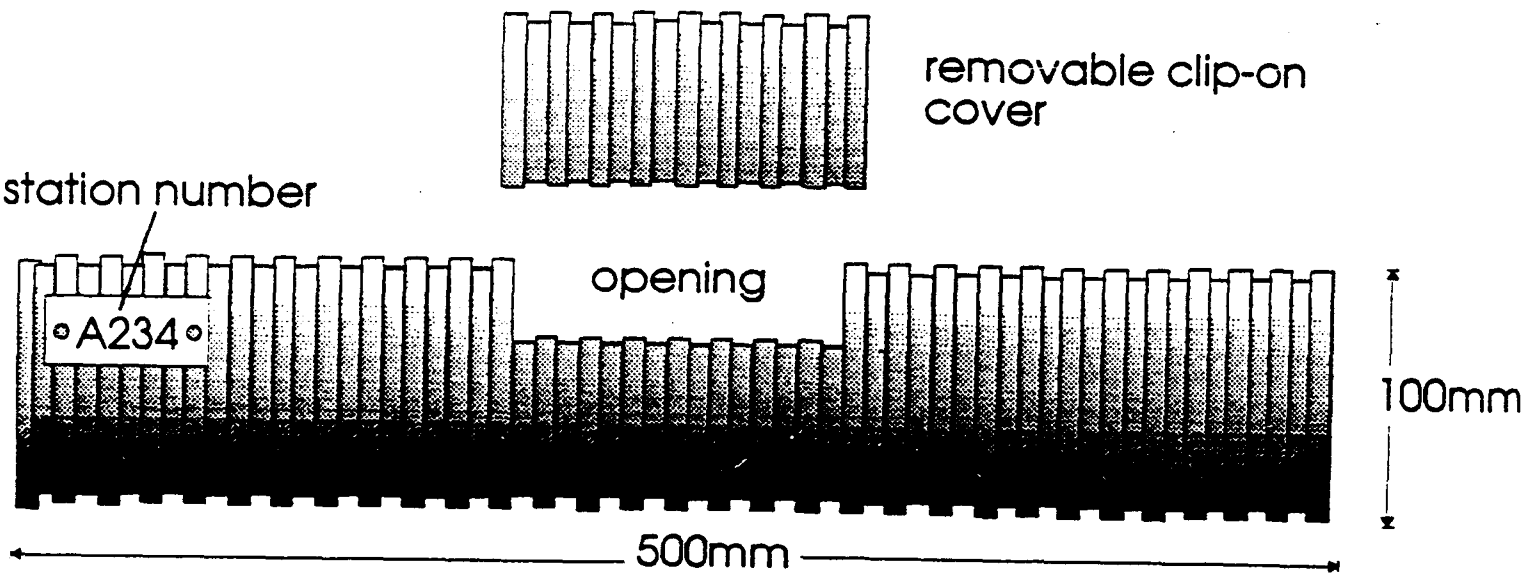

Figure 3: Plan of the bait station constructed from flexible pipe and used in most areas of Kiisgwaii in 1995

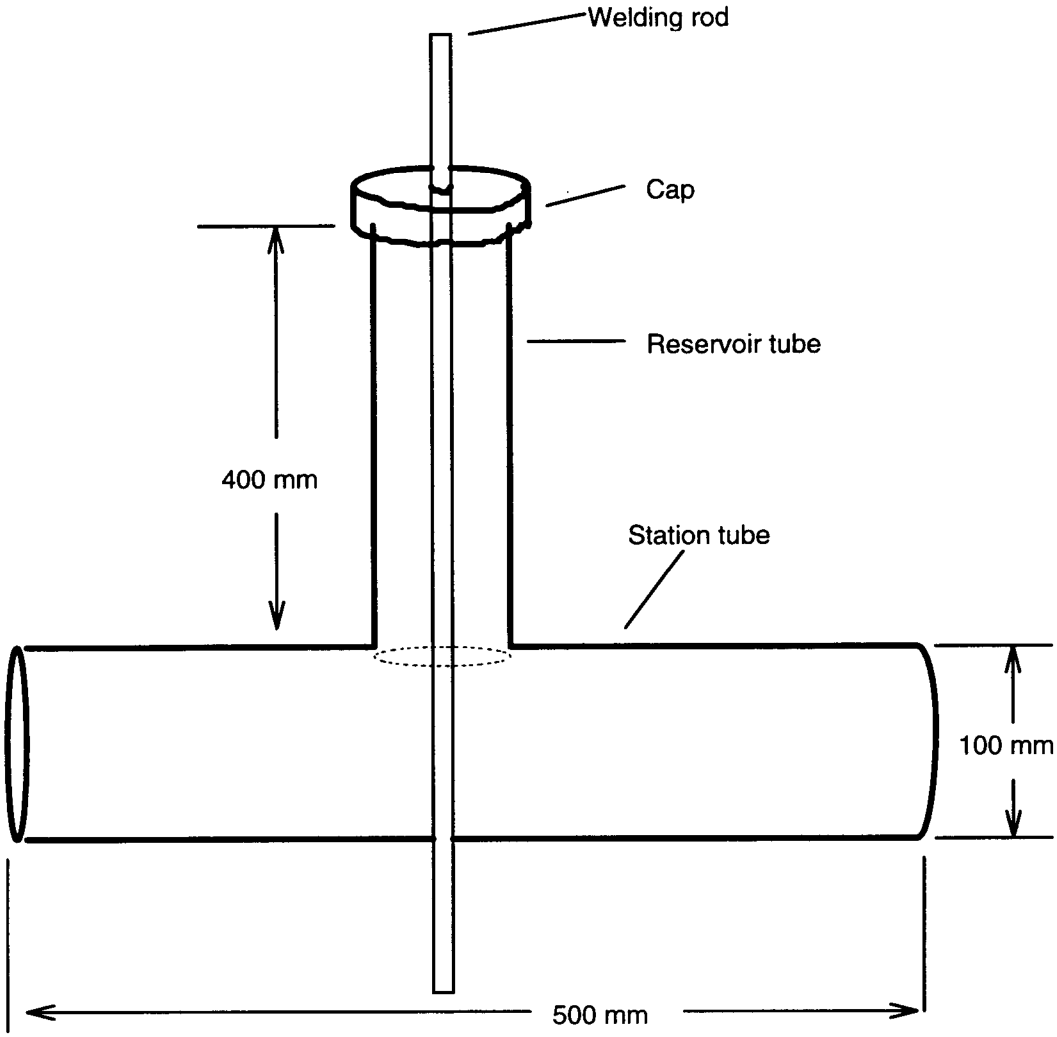

Figure 4: General plan of the hopper used on Langara Island in 1995 where frequent access was not feasible.

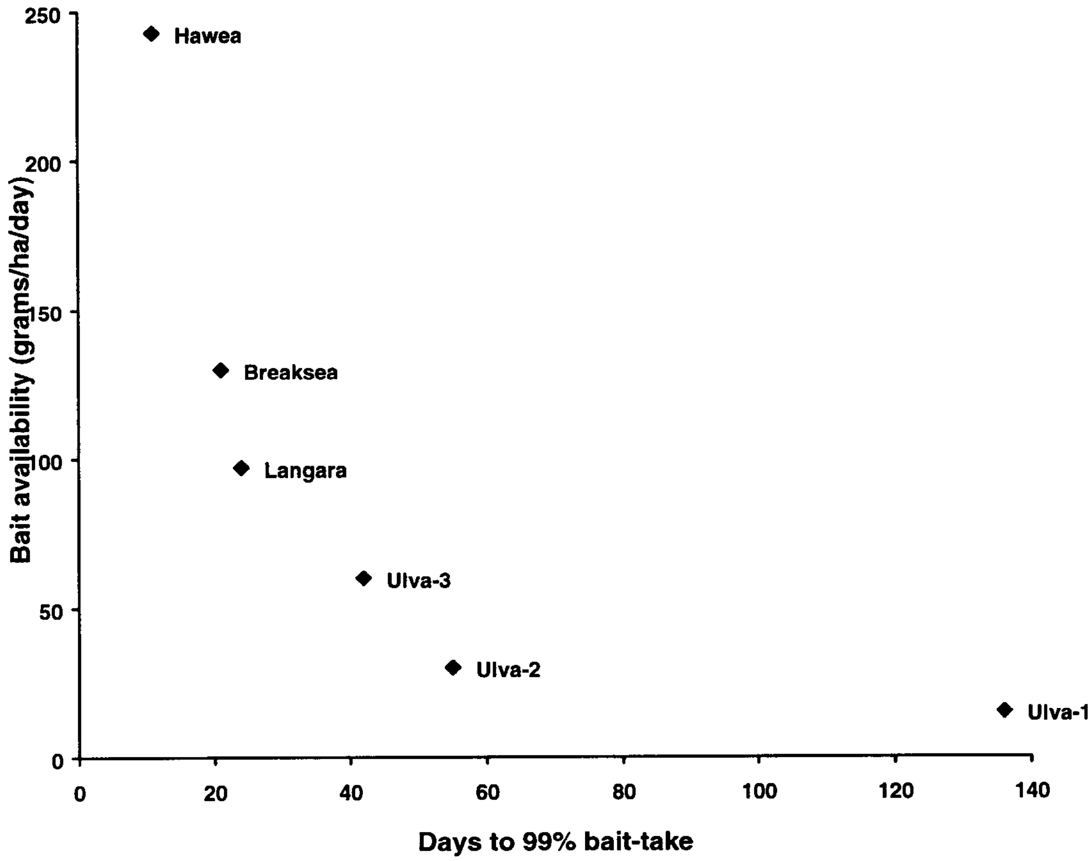

Figure 5: Relationship between bait availability and the duration of the rat-eradication campaign (after Taylor *et al.* in prep.).

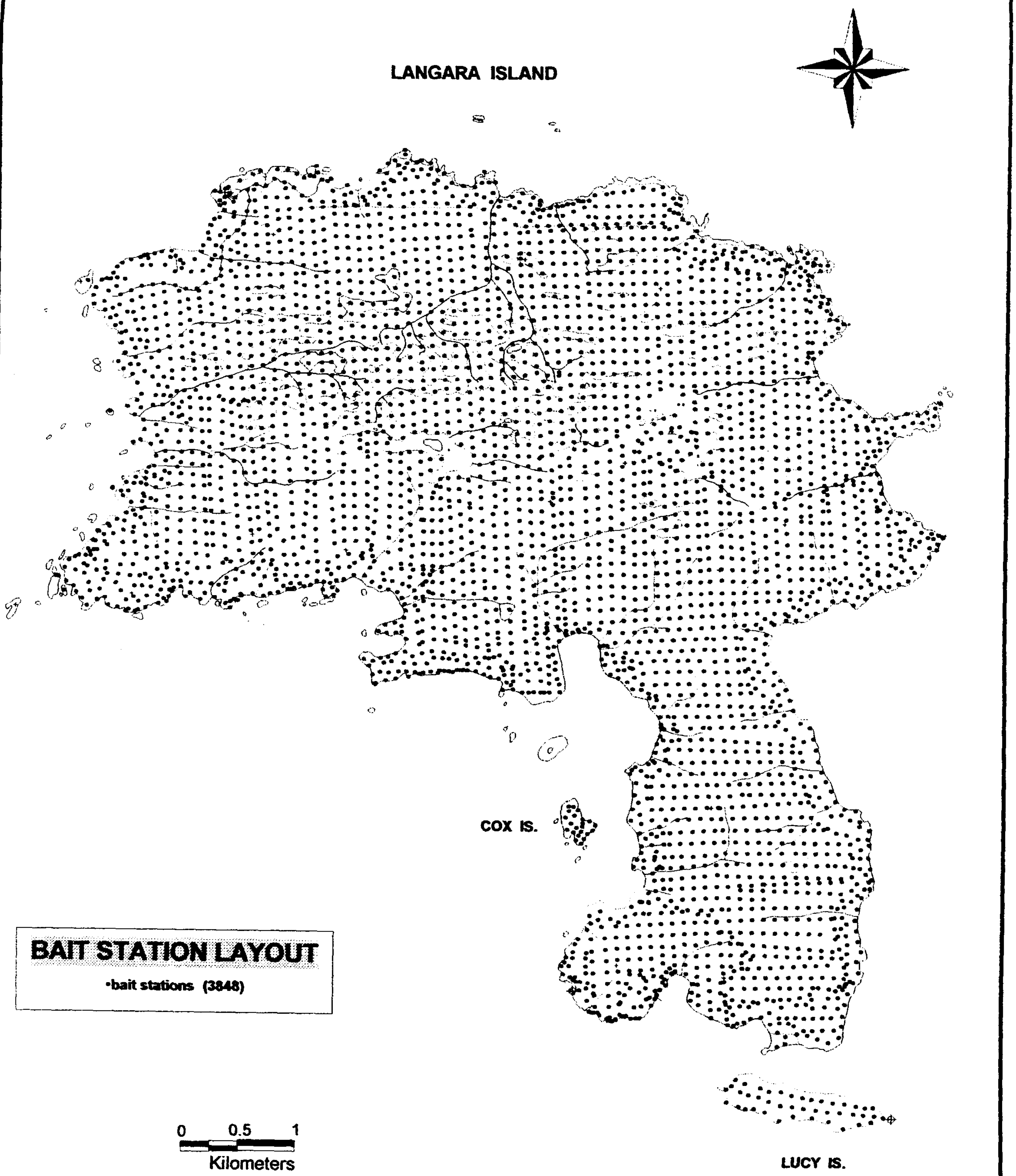

Figure 6: The array of 3,848 bait stations on Kiisgwaii for the rat-eradication campaign of July and August 1995.

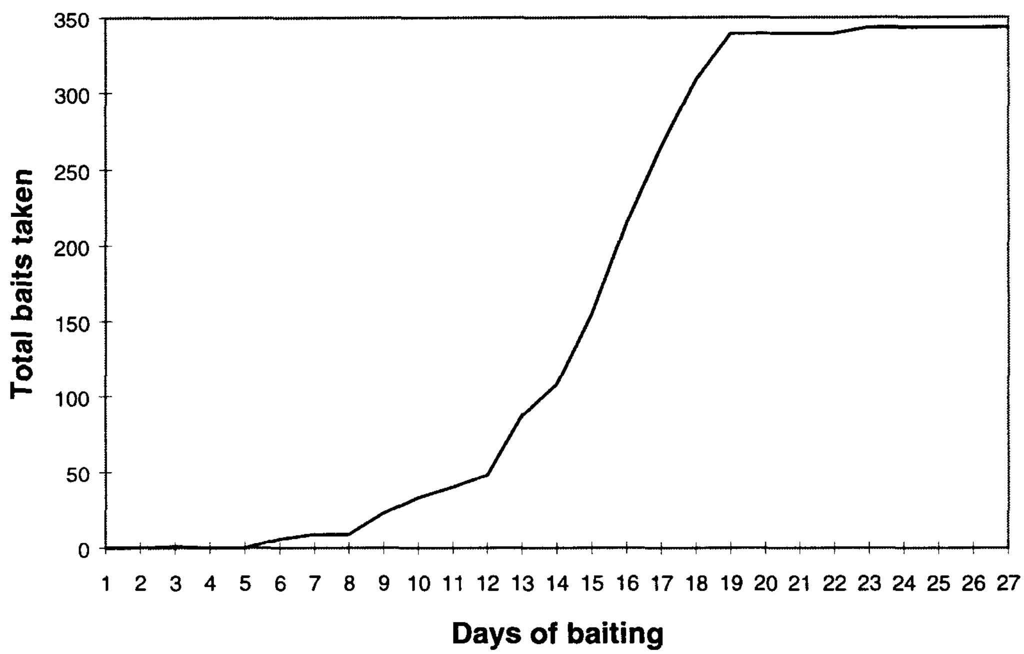

Figure 7: Progress of bait consumption during the Lucy Island pilot project, 1994. Baiting began on 12 July 1994.

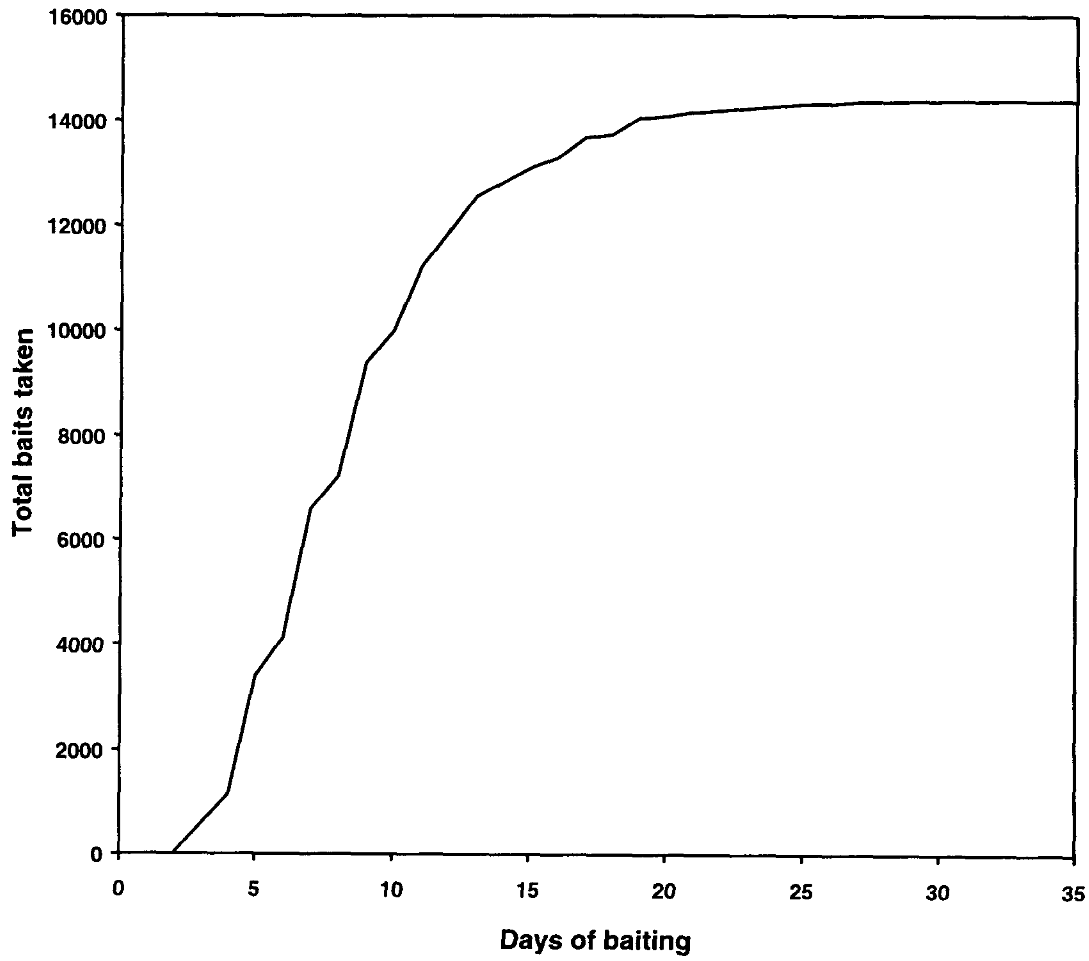

Figure 8: Progress of bait consumption on Kiisgwaii during the eradication campaign, 1995. Baiting began on 10 July 1995.

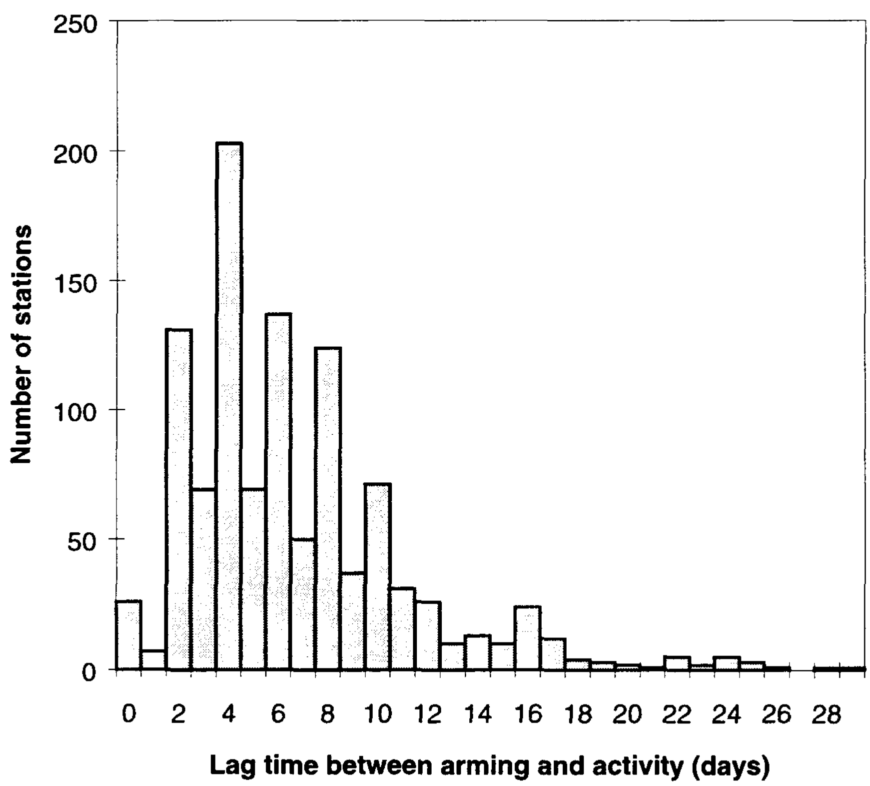

Figure 9: Lag time between date of arming and first activity by rats at a station in July 1995.

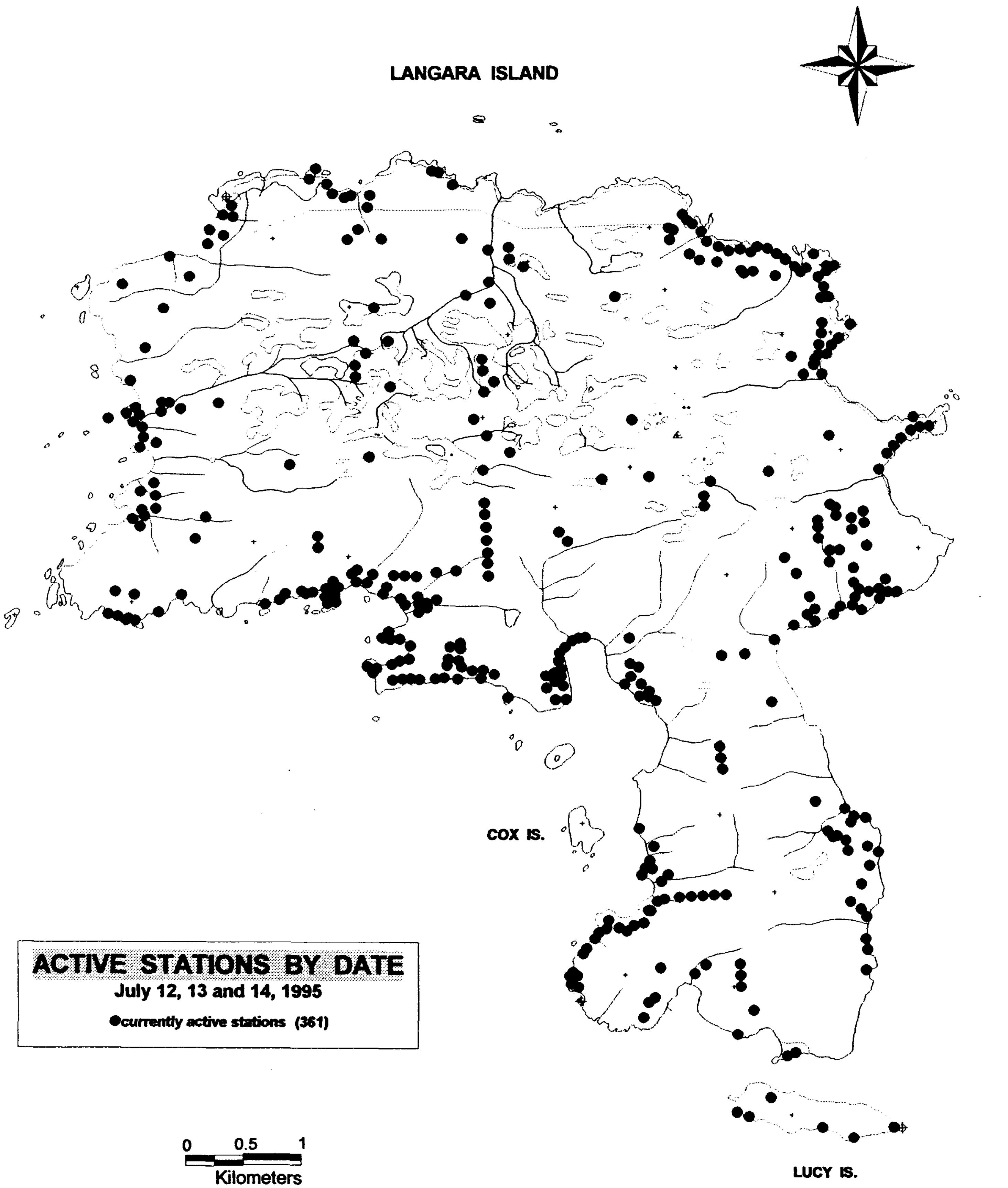

Figure 10: Bait station activity on Kiisgwaii during the first round of inspections (12 to 14 July 1995). Most stations had been armed on 10 or 11 July 1995.

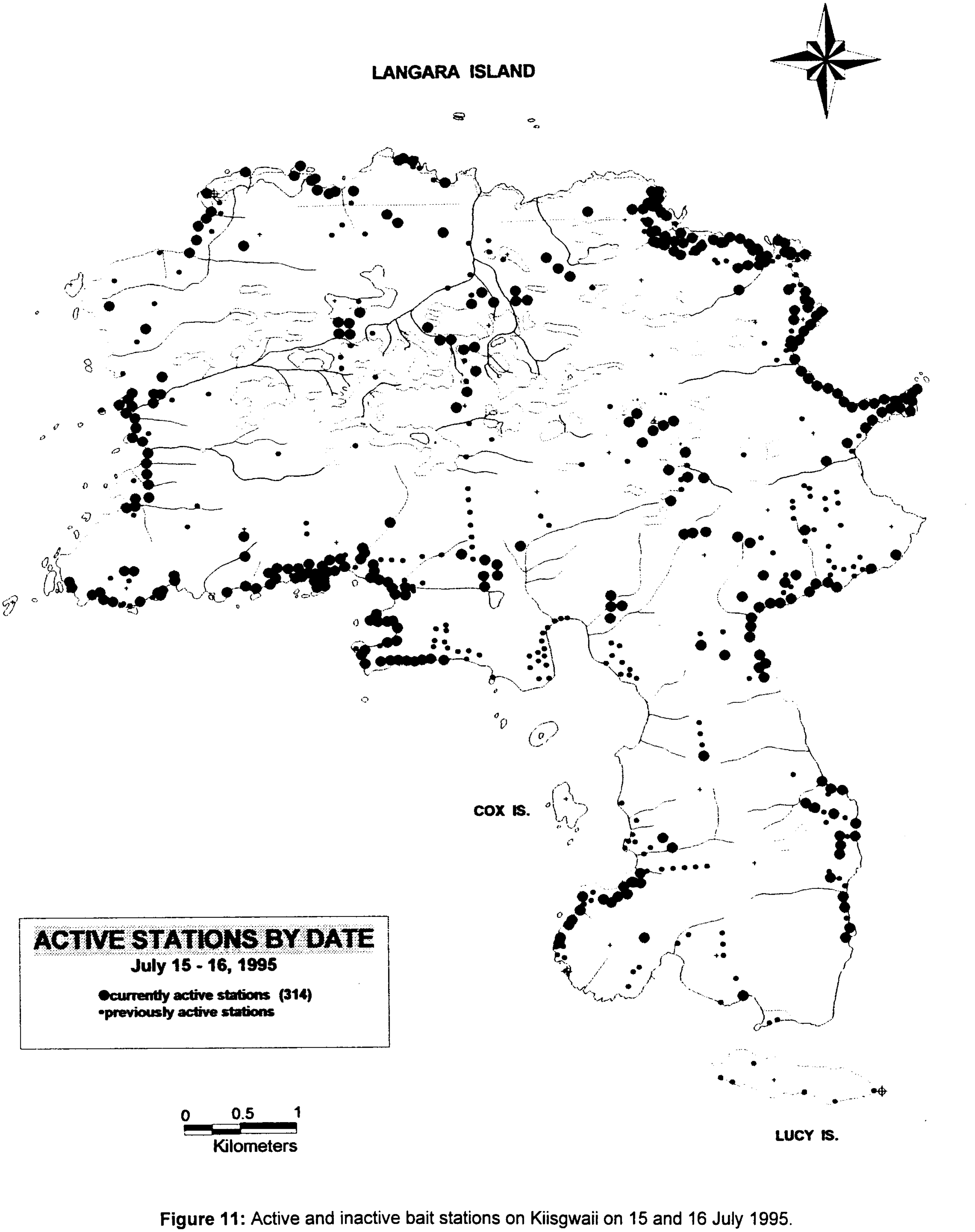

Figure 11: Active and inactive bait stations on Kiisgwaii on 15 and 16 July 1995.

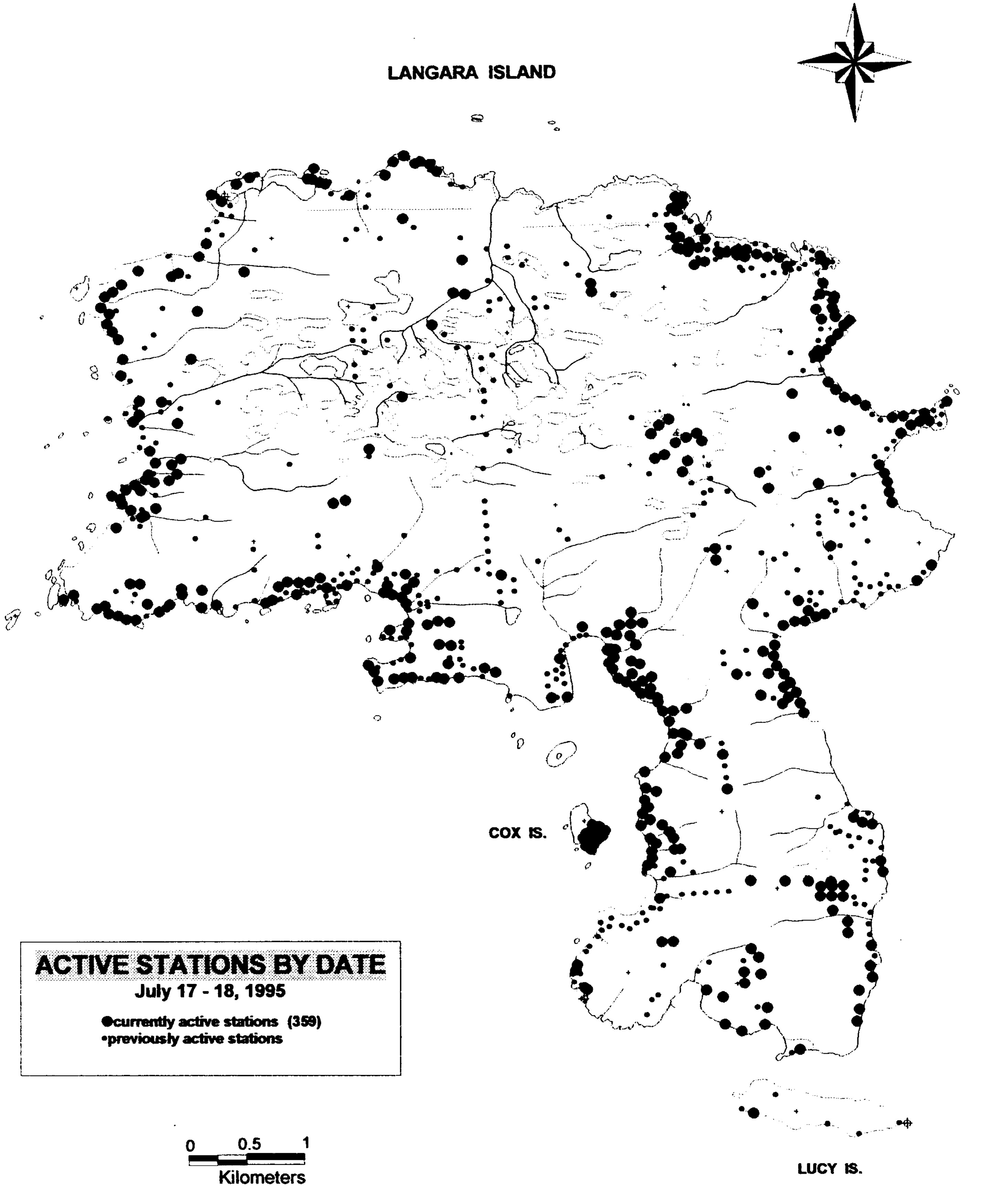

Figure 12: Active and inactive bait stations on Kiisgwaii on 17 and 18 July 1995.

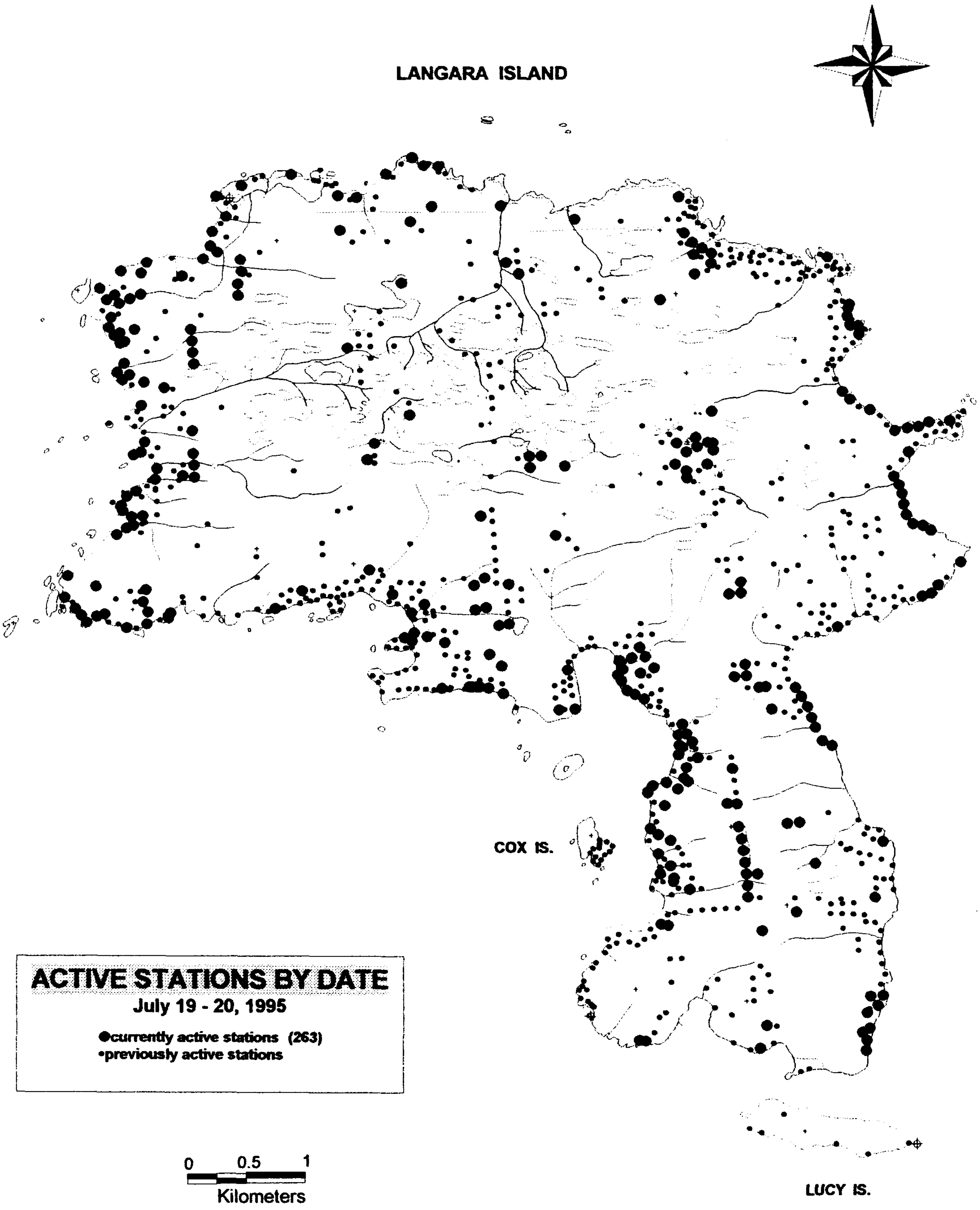

Figure 13: Active and inactive bait stations on Kiisgwaii on 19 and 20 July 1995.

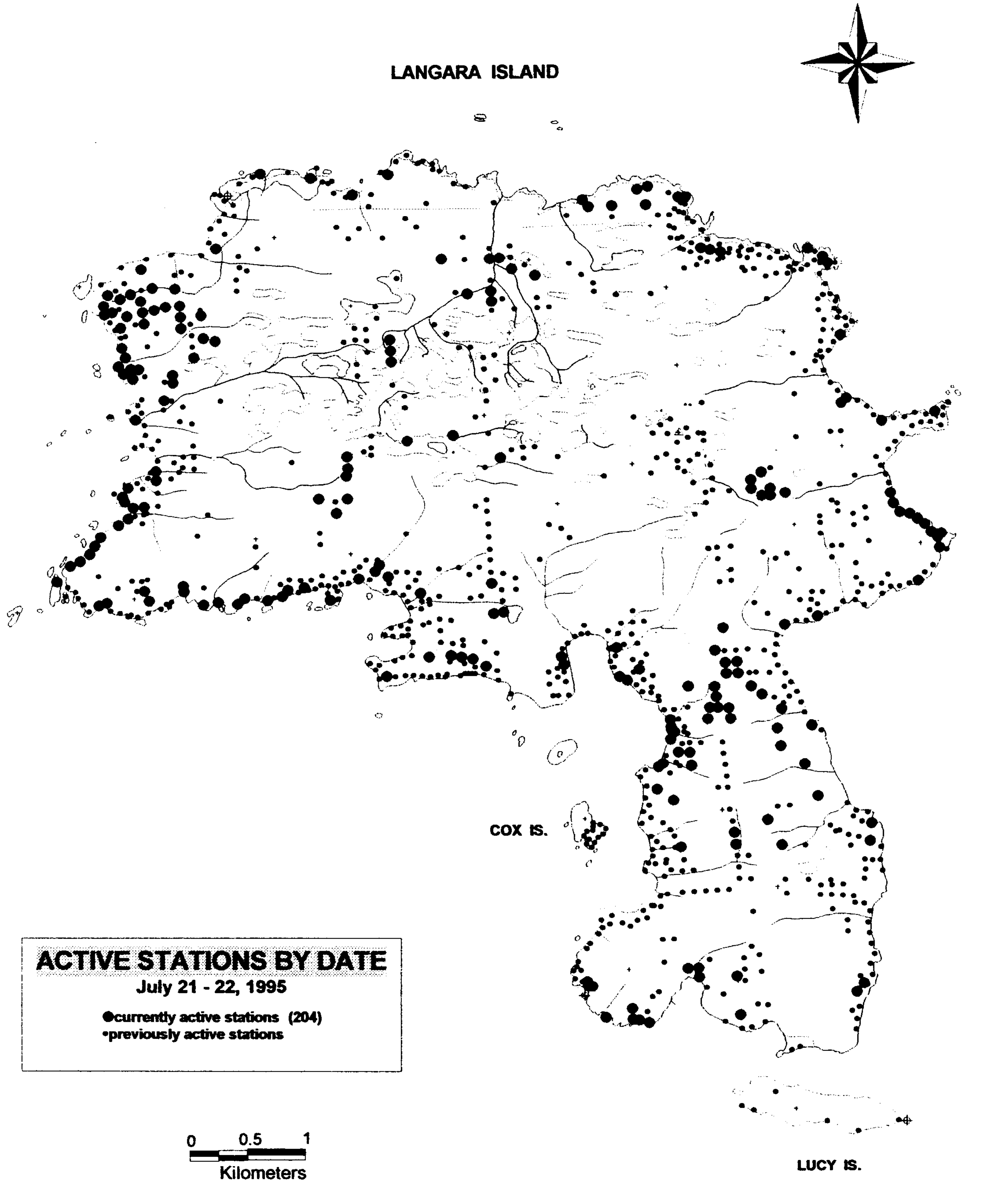

Figure 14: Active and inactive bait stations on Kiisgwaii on 21 and 22 July 1995.

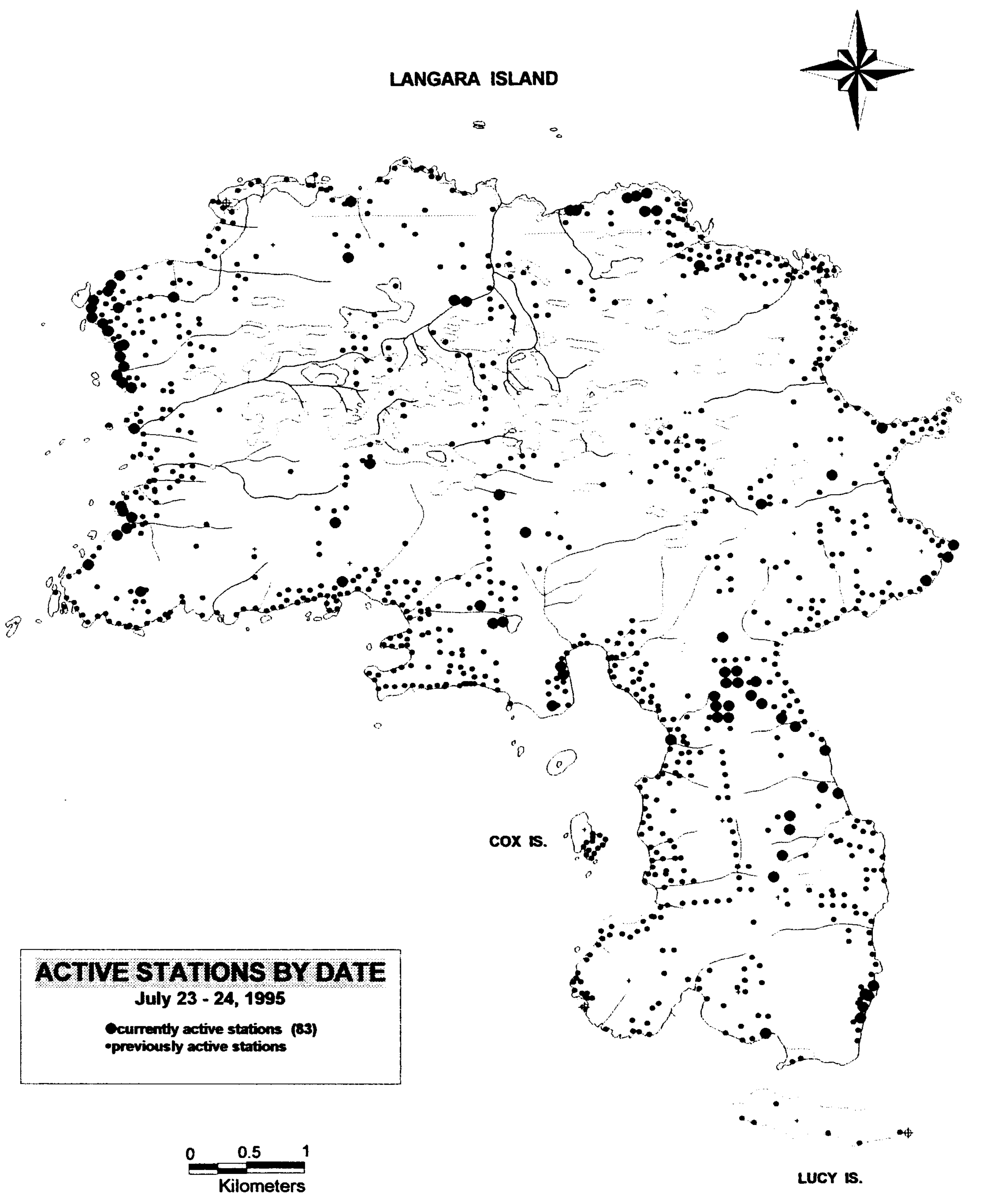

Figure 15: Active and inactive bait stations on Kiisgwaii on 23 and 24 July 1995.

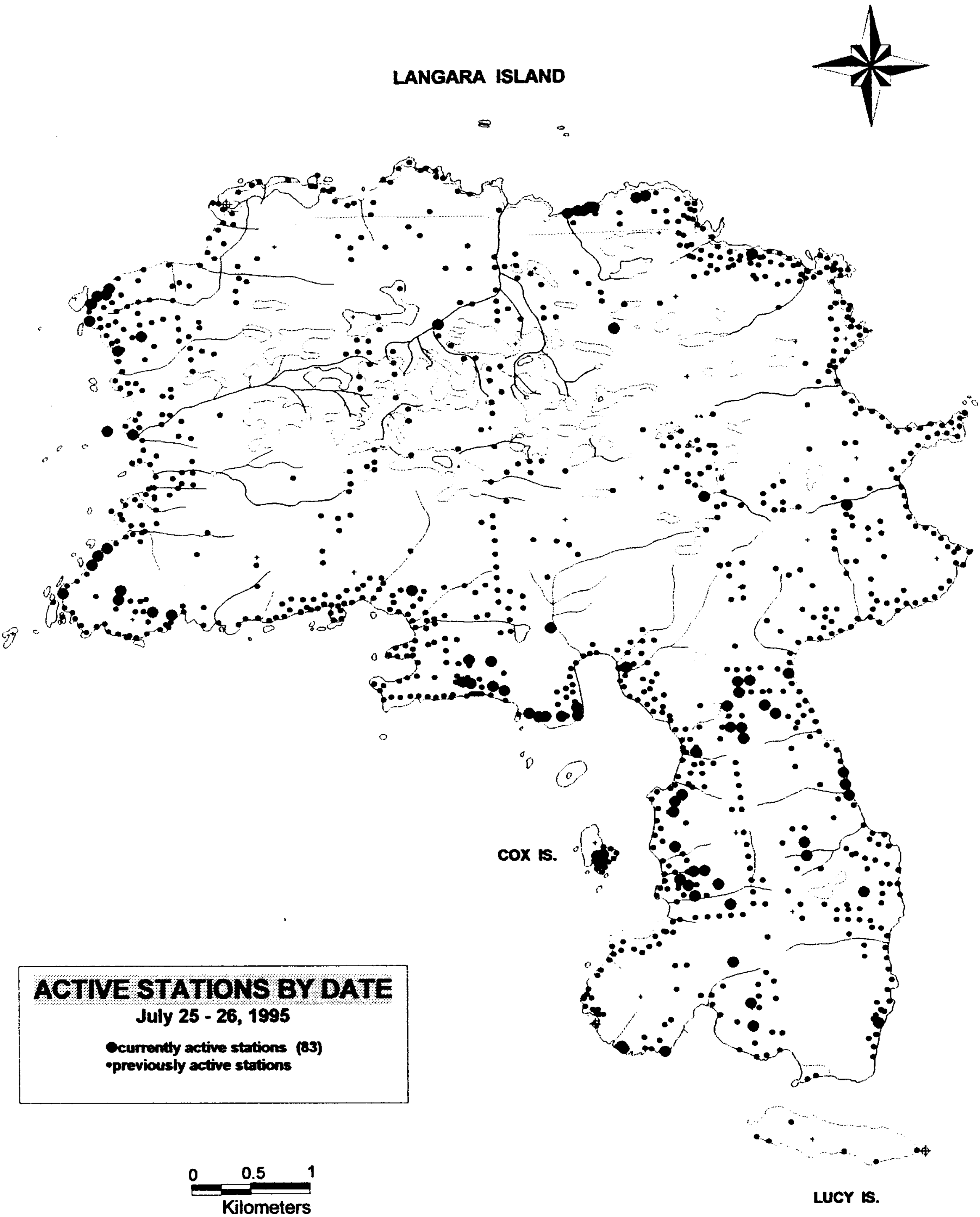

Figure 16: Active and inactive bait stations on Kiisgwaii on 25 and 26 July 1995.

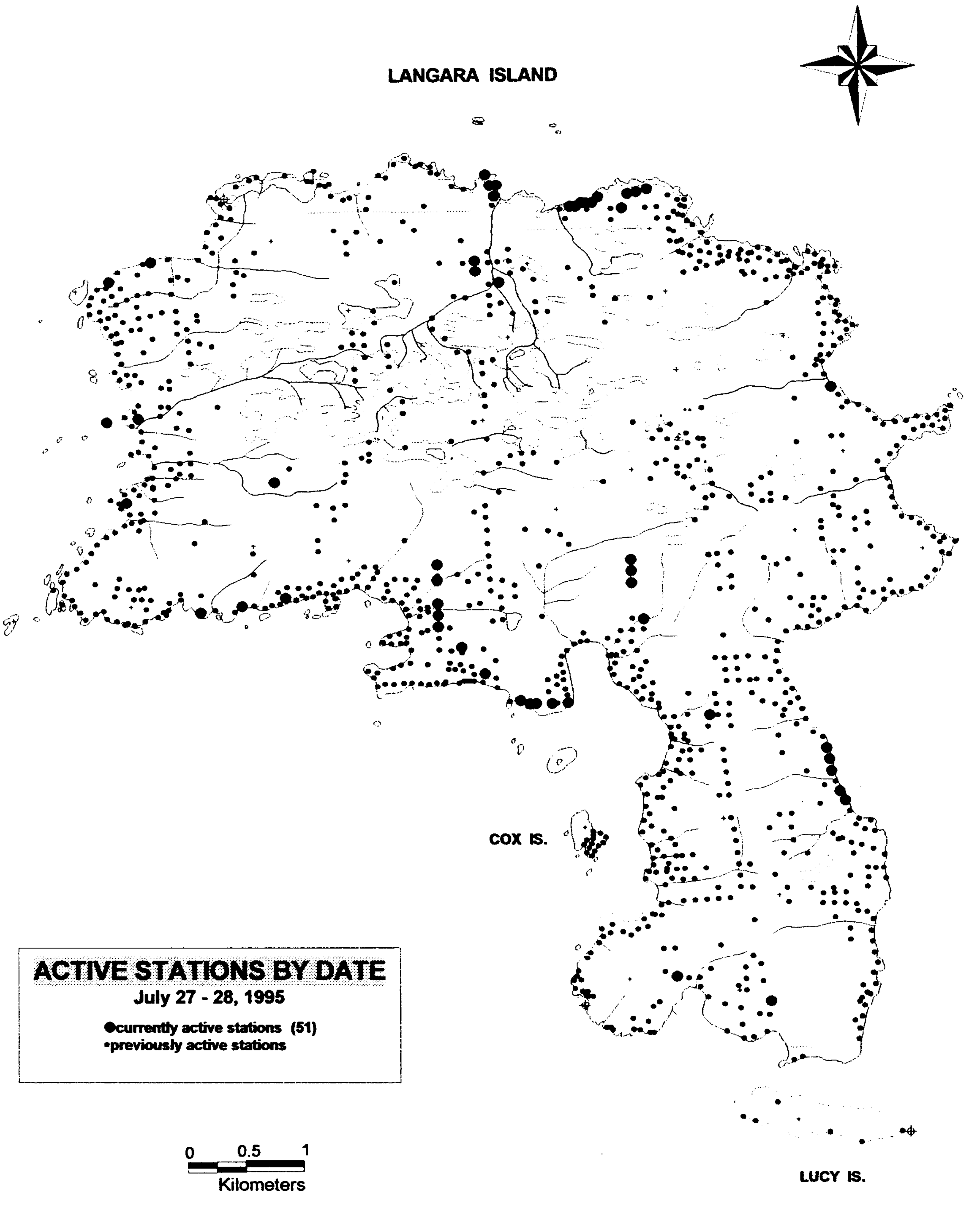

Figure 17: Active and inactive bait stations on Kiisgwaii on 27 and 28 July 1995.

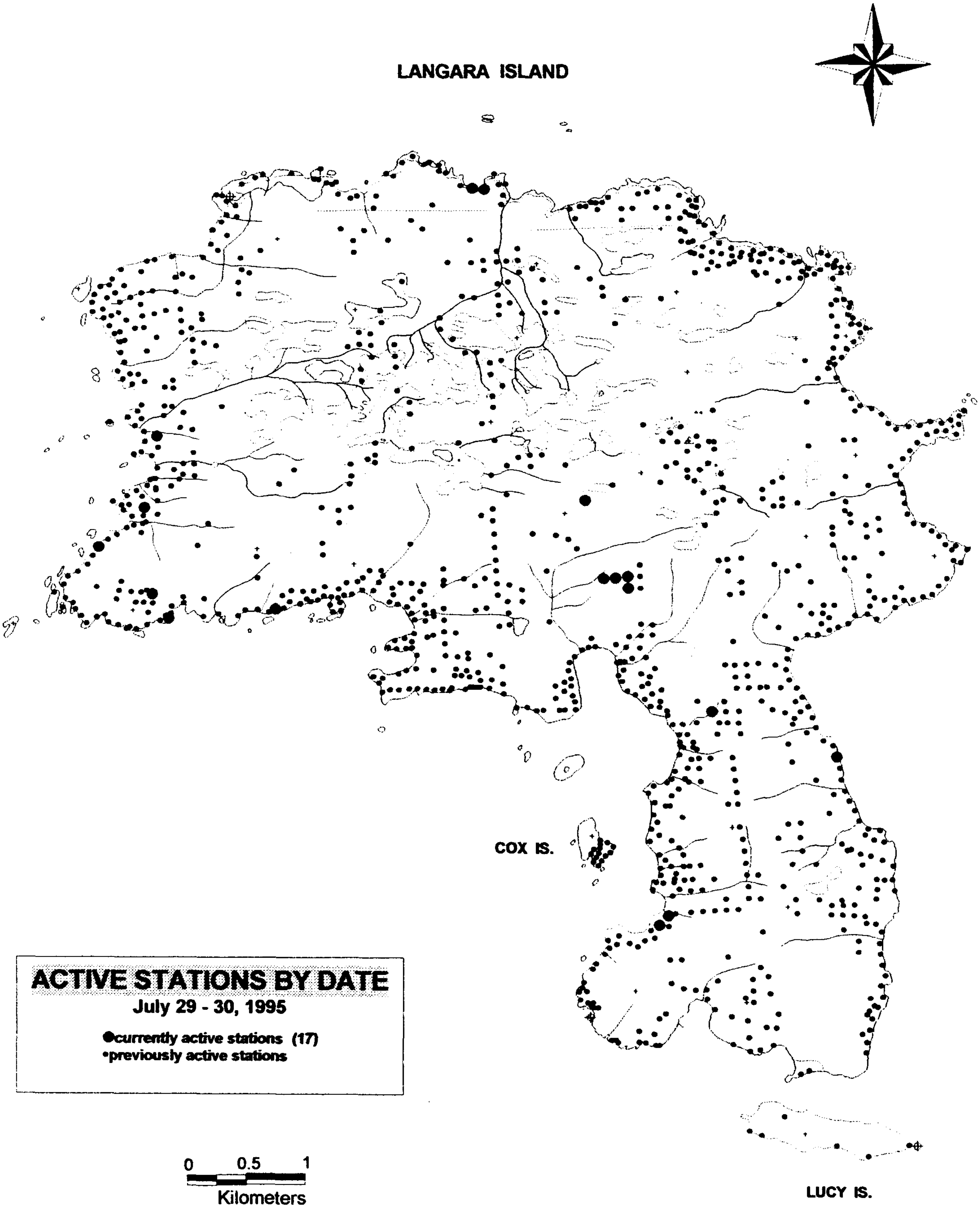

Figure 18: Active and inactive bait stations on Kiisgwaii on 29 and 30 July 1995.

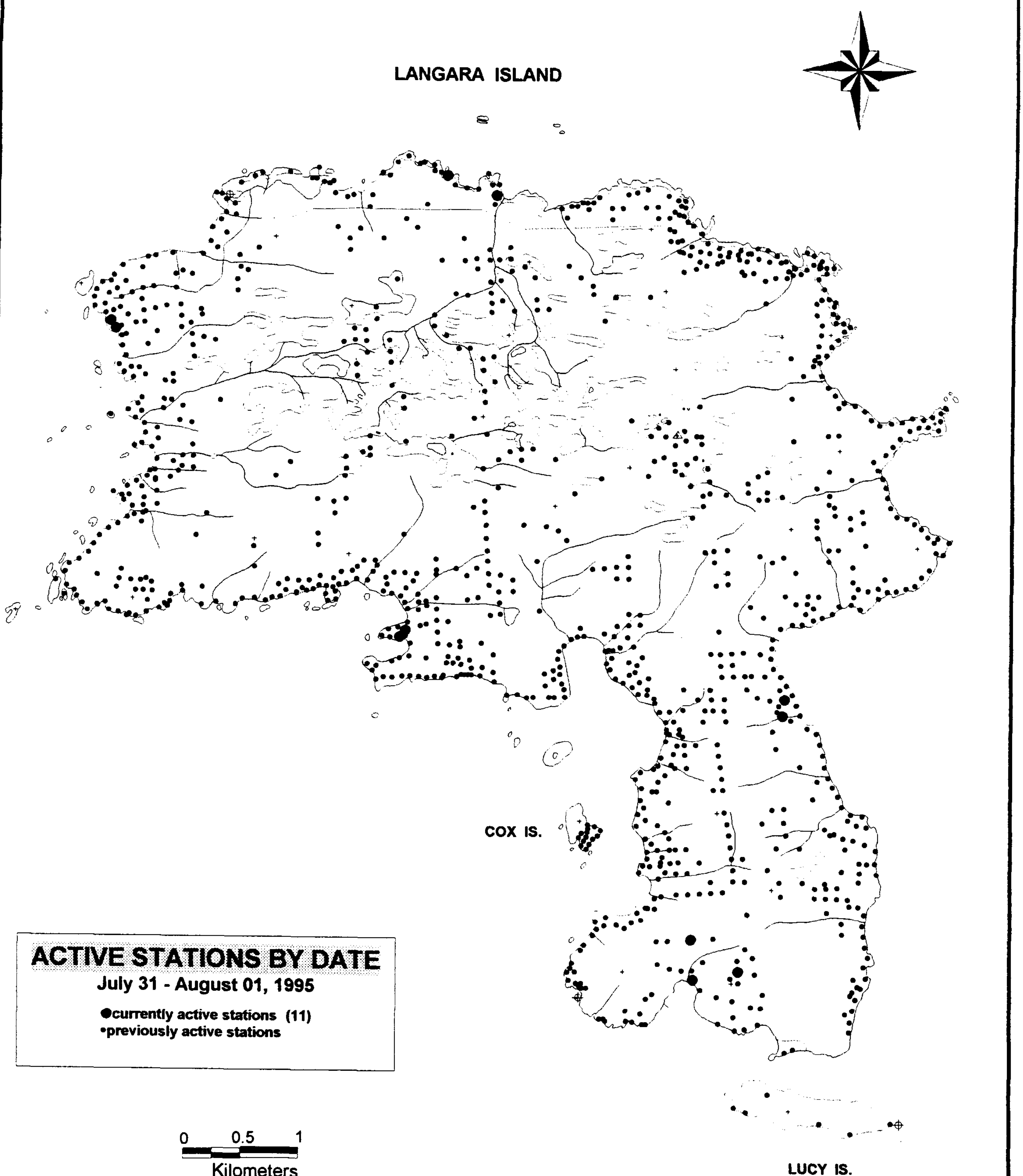

Figure 19: Active and inactive bait stations on Kiisgwaii on 31 July and 1 August 1995.

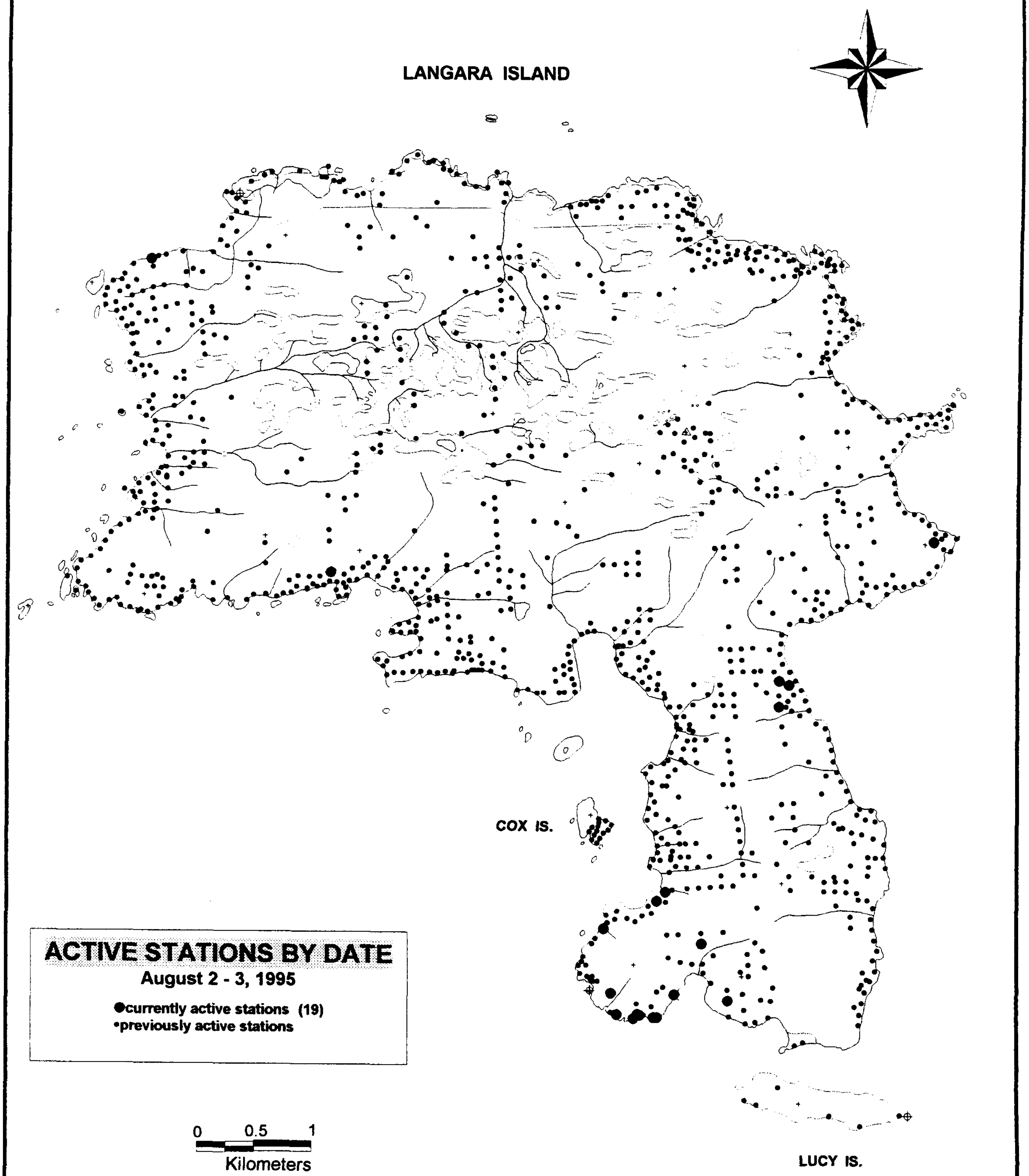

Figure 20: Active and inactive bait stations on Kiisgwaii on 2 and 3 August 1995.

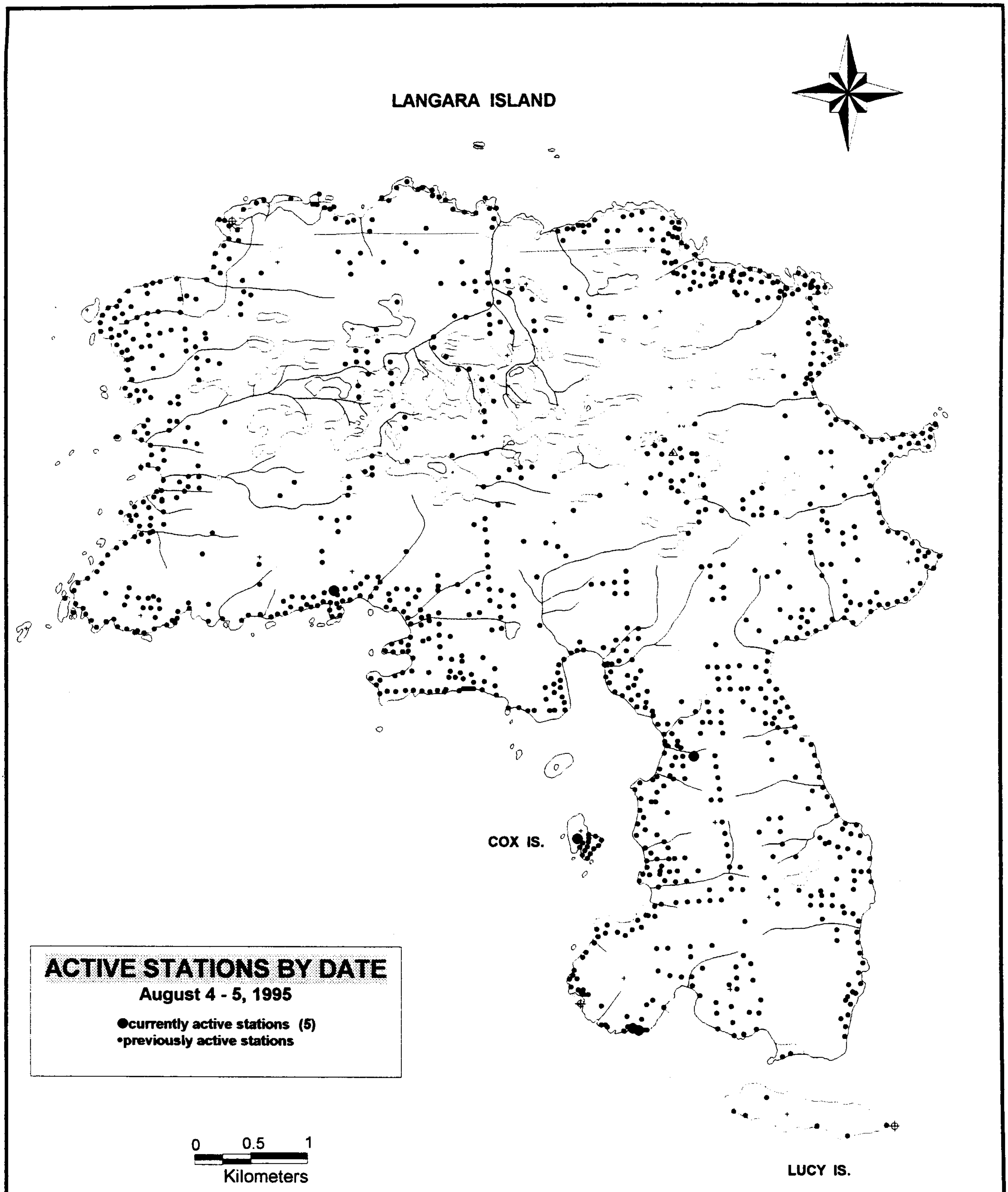

Figure 21: Active and inactive bait stations on Kiisgwaii on 4 and 5 August 1995.

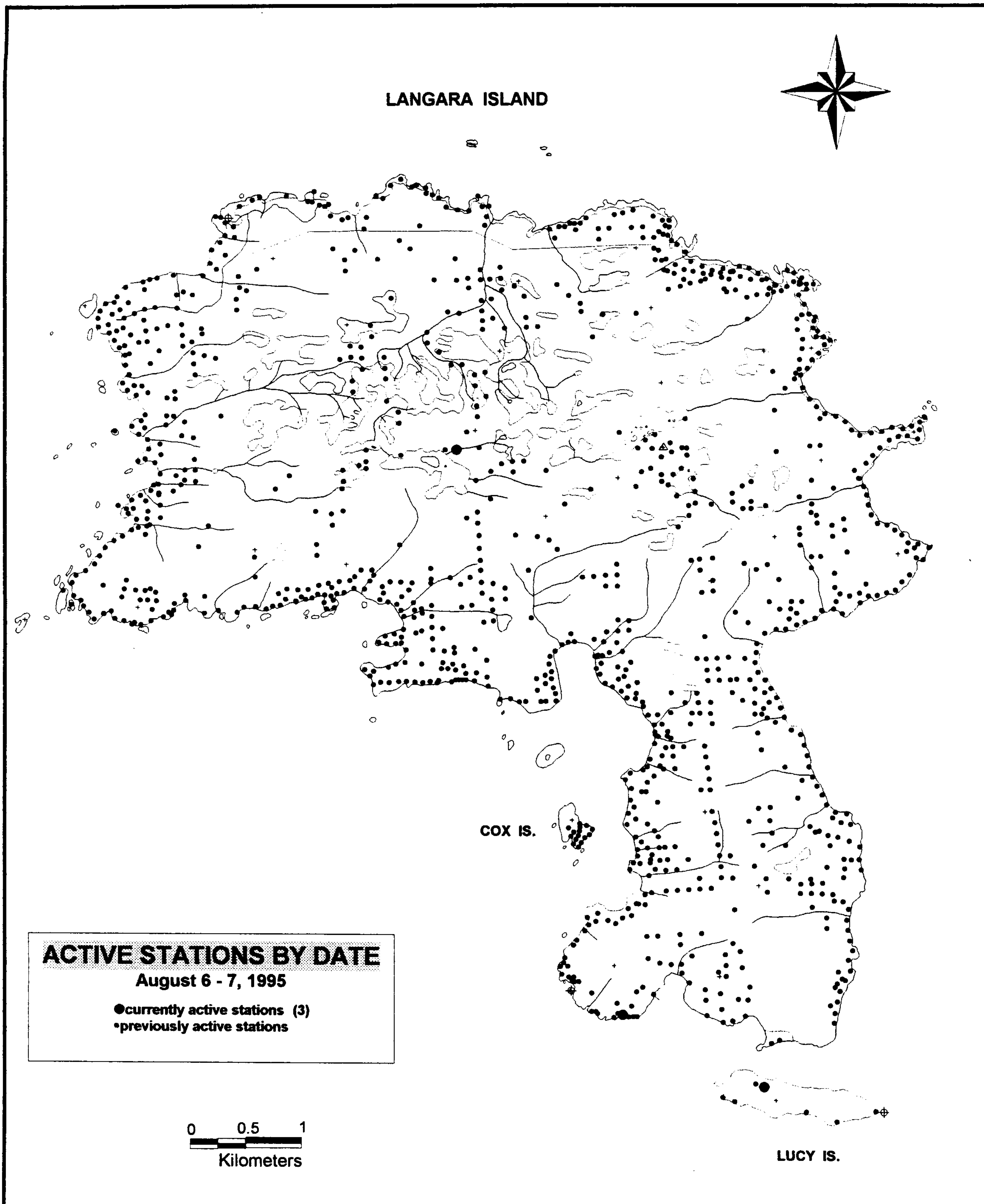

Figure 22: Active and inactive bait stations on Kiisgwaii on 6 and 7 August 1995.

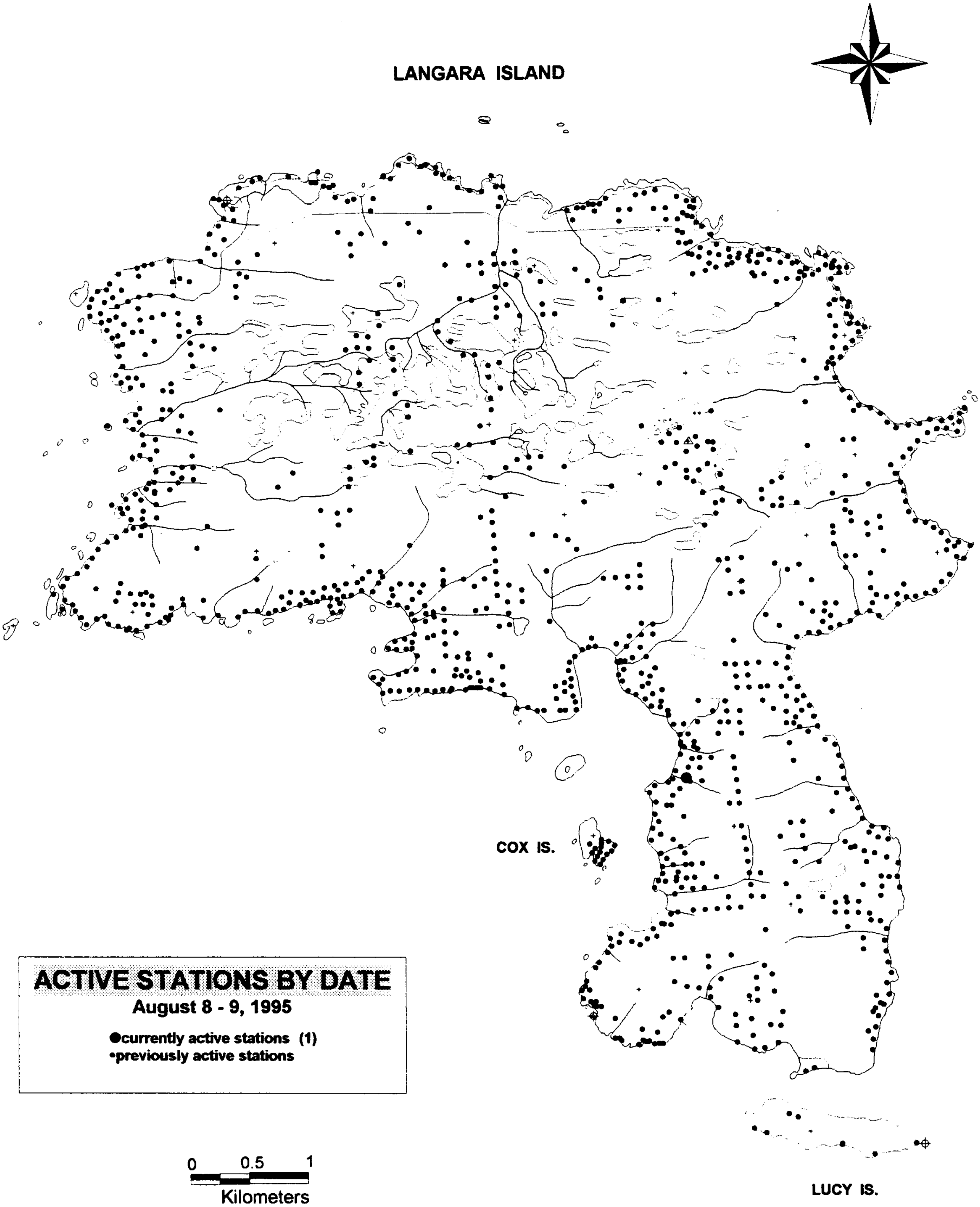

Figure 23: Active and inactive bait stations on Kiisgwaii on 8 and 9 August 1995.

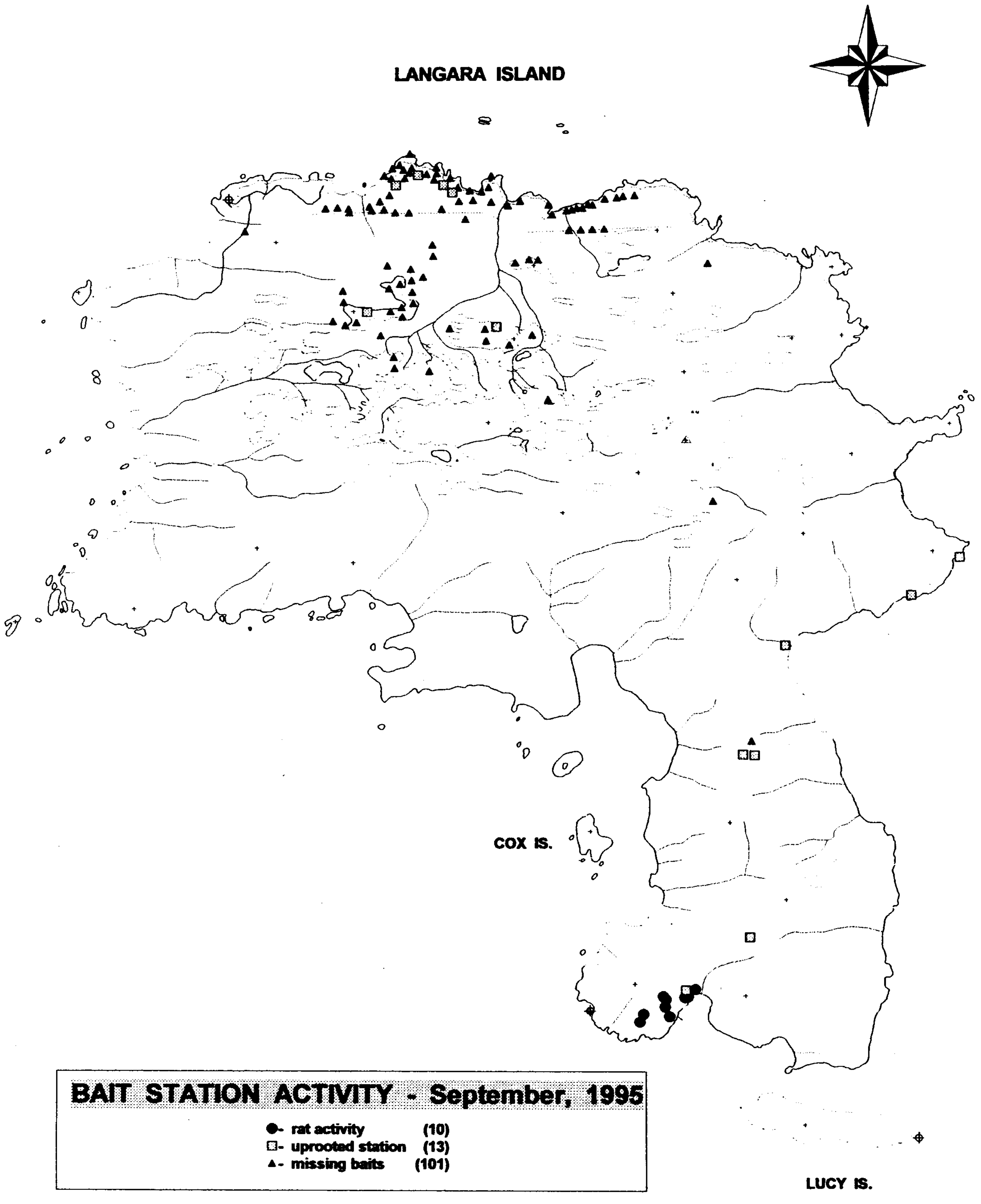

Figure 24: Activity observed on Langara Island during the comprehensive bait station check in September 1995 and the suppression of surviving rats in Henslung Cove.

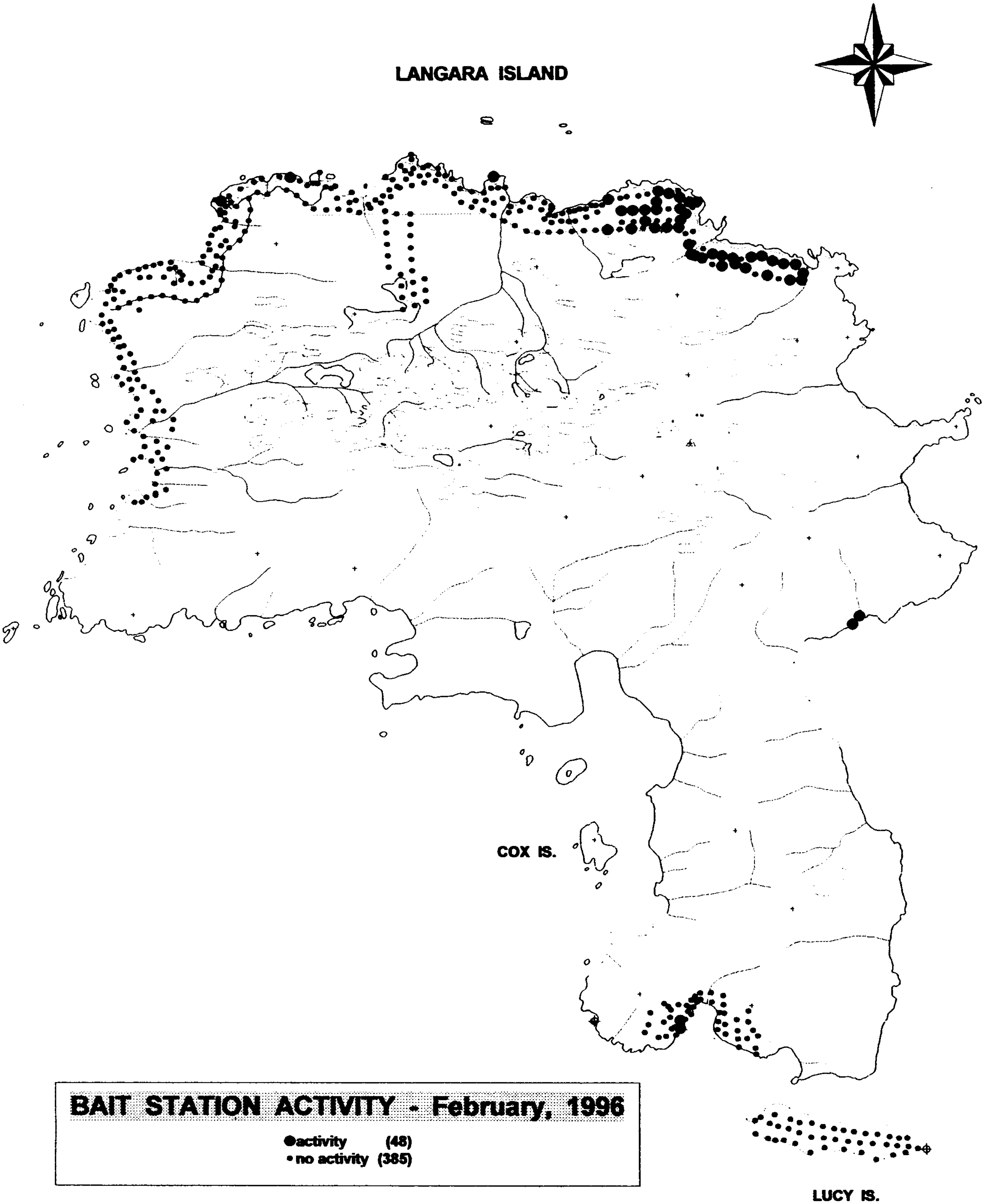

Figure 25: Active and inactive stations observed on Langara Island and Lucy Island during the effort to eradicate rats at the light station, 7 to 11 February 1996.

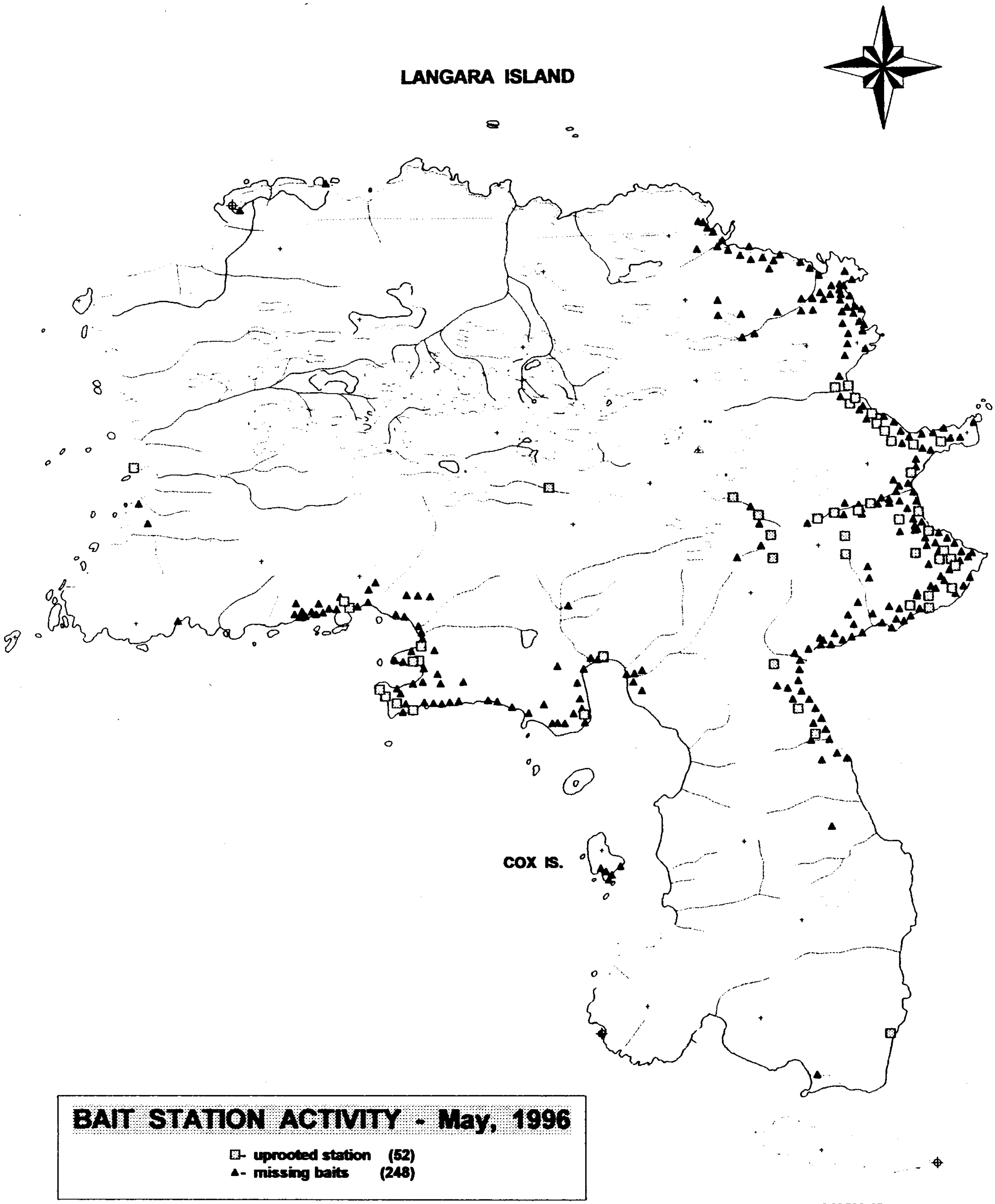

Figure 26: Activity at bait stations on Kiisgwaii found during the partial check in May or the check of coastal stations in May and June 1996.

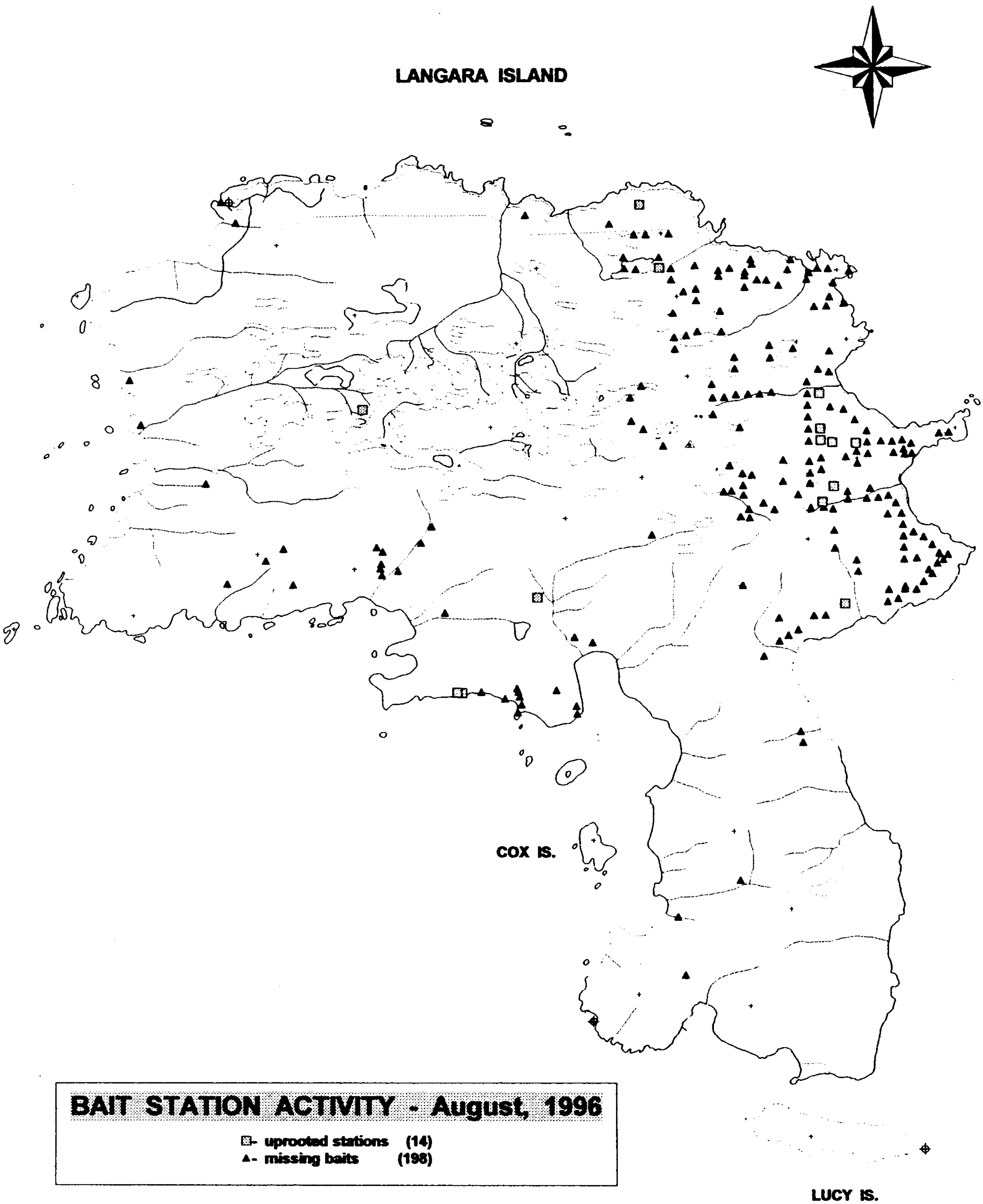

Figure 27: Activity at bait stations on Kiisgwaii found during the partial check in May or the complete check in July and August 1996.

APPENDICES

RESTRICTED 10 kg (500 x 20g Block)

Weather Blok® Bait

Containing **Ratak+®** Rodenticide
Water-Proof Wax Formulation

WARNING POISON

READ THE LABEL BEFORE USING

KEEP OUT OF THE REACH OF CHILDREN

GUARANTEE: brodifacoum 0.005%

REGISTRATION NUMBER 24057
PEST CONTROL PRODUCTS ACT

CANADIAN WILDLIFE SERVICE
ENVIRONMENT CANADA
RR #1, 5421 Robertson Road,
Delta, British Columbia
V4K 3N2

PRODUCT INFORMATION

Weather Blok Bait containing RATAK+ rodenticide is exceptionally effective against the Norway Rat (*Rattus norvegicus*) and the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*). It differs from other indirect anticoagulant rodenticides such as warfarin in that the formulated product kills after a single feeding for many species. Laboratory results indicate that as little as 2 grams of the bait will kill a Norway rat and 0.5 grams will kill a house mouse. Weather Blok Bait is effective on rodents which are resistant to conventional anticoagulants.

NOTICE TO USER

This control product is to be used only in accordance with the directions on this label. It is an offence under the **Pest Control Products Act** to use a control product under unsafe conditions:

1) For use only by or under the supervision of the Canadian Wildlife Service.
2) For use only in compliance with recommendations of the required environmental impact assessment and any other provincial or territorial requirement.
3) For use only where alien rodents threaten nesting seabirds.

DIRECTIONS FOR USE

Eradication or control of rats and house mice around seabird colonies must follow protocols established and approved by the Canadian Wildlife Service following a site-specific environmental impact assessment.

NORWAY AND BLACK RATS: Weather Blok bait rodenticide is to be placed in specially designed bait stations such as 0.5-m lengths of plastic pipe (15 cm dia.) or automatic dispensing silos. Bait stations are to be distributed in a regular grid pattern and their locations flagged or otherwise mapped or marked to ensure retrieval. During intensive eradication programs, baits should be checked and replaced daily, if possible, but at least every few days for a period calculated to provide complete eradication. To monitor the success of the operation and guard against survivors, bait stations can be left in position and monitored less frequently, preferably every 3-4 months but at least spring and fall for up to 12 months. Further monitoring with non-toxic indicator baits is recommended.

HOUSE MICE: Mouse eradication should precede rat eradication programs. This will ensure that house mice do not spread and colonize new areas once predation by rats has been stopped. Apply 1 Weather Blok bait at intervals of 2.5-4.0 metres in buildings and other areas known to be infested. Larger placements (2 baits) may be necessary at points of very high mouse activity. Maintain an uninterrupted supply of fresh baits for 15 days or until house mouse activity has ceased.

Do not place bait in areas where there is the possibility of contaminating food or surfaces that come into direct contact with food.

Collect all un-used product and rodent carcasses and dispose in compliance with municipal or provincial requirements.

NOTE: The operational requirements for rodent eradication programs on islands with seabird colonies are stringent. Weather Blok bait is significantly more potent than warfarin formulations and can potentially result in direct risk to native mammals and secondary poisoning of mammalian or avian predators and scavengers. Programs for seabird conservation purposes require complete eradication of the rats. **Follow directions of use and placement exactly.** If there are non-target impacts, ensure that they are fully recorded and reported to the Canadian Wildlife Service representative and other competent agencies.

LIMITATIONS OF USE

1) Baits left un-taken must be collected and properly disposed when the program is terminated.
2) Site-specific operational procedures, approved by the Canadian Wildlife Service, must be adhered to.

PRECAUTIONS FOR HANDLING BROKEN CARTONS

1. **Prevent inhalation or skin and eye contact:** wear rubber gloves, boots, goggles, and an NIOSH-approved pesticide respirator.

2. Place damaged unit so further leakage is minimized. Cover spilled material and are around damaged unit with heavy absorbent and plastic sheeting to prevent dusting and blowing.

3. **EMERGENCY TELEPHONE NUMBER:** 1-800-263-0984 at all hours but ONLY for health or environmental information.

RATAK+ is a registered trademark of Zeneca Ltd., England.
Weather Blok is a registered trademark of Zeneca Inc.

PRECAUTIONS

KEEP OUT OF REACH OF CHILDREN
May be harmful or fatal if swallowed. Keep away from humans, domestic fowl, domestic animals (especially dogs), or pets. Wash hands after handling bait. This product is toxic to fish, birds, and wildlife. Keep out of lakes, streams, or ponds. Do not store near food, eating utensils, potable water supplies or stock feed.

NOTE: Dogs poisoned by Weather Blok will exhibit loss of appetite and listlessness. Any suspicion of poisoning should be reported to a veterinarian immediately for treatment.

FIRST AID

If ingested, do not induce vomiting. Seek medical attention immediately. Transfer to nearest hospital as soon as possible. For dogs and cats contact a veterinarian at once.

TOXICOLOGICAL INFORMATION

Vitamin K_1 in the form of intravenous, intramuscular, or subcutaneous injection, or by oral ingestion is the suggested remedial treatment for anticoagulant poisoning. The severity of the case, as measured by establishing the prolonged prothrombin times (P.T.) will determine the appropriate therapy. Monitoring P.T. will indicate any necessity of repeated treatments.

Antidote - Vitamin K_1 - Phytomenadione BP

Adult dosage -	40mg/day in divided doses
Child dosage -	20mg/day in divided doses
Dog dosage -	2mg/kg once or twice daily for at least 4 days.

Antidote must be administered under medical supervision. It is advisable to monitor haemoglobin levels. Patients should be kept under medical supervision until prothrombin times return to and remain normal and/or bleeding has ceased.

Supportive Measures: Blood should be grouped and cross matched as soon as possible. Transfusions of compatible blood may be necessary if severe or persistent bleeding occurs.

EMERGENCY TELEPHONE NUMBER

All hours, 1-800-263-0984 ONLY for health and environmental information.

DISPOSAL

- Do not re-use container.
- Make the empty container unsuitable for further use.
- Dispose of the container, unused product, and rodent bodies in accordance with municipal or provincial requirements.
- For information on the disposal of unused or unwanted product and the clean-up of spills, contact the regional office of Environmental Protection, Environment Canada.

Province of British Columbia
MINISTRY OF ENVIRONMENT, LANDS AND PARKS

BC Environment

Skeena Region
Box 5000
Smithers, British Columbia
V0J 2N0
Telephone: (604) 847-7260
FAX: (604) 847-7591/7728/7709

PESTICIDE USE PERMIT

June 6, 1995

Permit No. 253-102-95/96*RES

Minister of Environment
Migratory Birds Conservation
Canadian Wildlife Service
Environment Canada
PO Box 340
Delta, British Columbia
V4K 3Y3

Attention: G.W. Kaiser, Head, Migratory Birds Conservation

The pesticide use as applied for on Pesticide Use Permit Application 253-102-95/96*RES, received January 31, 1995 may be carried out in accordance with the Pesticide Control Act and Regulation subject to the additional conditions listed below. Please note that the application number is 253-102 rather than 253-101 as advertised. The "253-101" is the number utilized for the research trial conducted on Lucy Island in 1994. As well, the Pest Control Products Act Registration No. of 21084 has been changed to 24057. The use of Weather Blok Bait for the control of rats and house mice around sea bird colonies has now been registered by the Federal Government. This product (Reg. No. 24057) can only be used by or under the supervision of the Canadian Wildlife Service and is the same as the product with Reg. No. 21084.

Public Notification

A. The permittee shall without delay:
post a copy of the permit with relevant maps at the premises of the permittee to allow inspection by the public. The posted permit and maps shall remain for at least 30 days.

B. The pesticide use may not be carried out before 31 days following the date that the permit and maps are posted.

C. A copy of the permit and information package shall be provided to the Lighthouse Keeper on Langara Island, lodges and tourist facilities prior to the start of the baiting program. In particular, the Kumdis River Lodge Ltd. Which has a permanent on-shoare lodge, is to be notified (C.G. Schroeder, 873-4228).

C. Signs shall be posted at visible access points to the treatment areas advising of the treatment and such signs shall be maintained for a period of 60 days. The signs shall contain the following information:
(a) name of permit holder
(b) purpose of pesticide use
(c) trade name of pesticide used, and
(d) date(s) of pesticide application

Authorized Pesticide(s):

E. The pesticide listed below is approved for use under the terms of this permit. The application rate and quantities indicated are maximums. These quantities are based on the results obtained from the 1994 Lucy Island trial. A constant level of 4 to 12 baits will be maintained in each station (3600 for Langara, Lucy, Cox Islands combined) for the period from July 7, 1995 to May 30, 1996. Each bait weighs 20 grams and contains .001 g of the active ingredient, brodifacoum. To calculate the total quantity of active ingredient to be used, an average of 50 changes per station is expected to be required.

4. a. Trade Name	b. Common Name	a.i. code	c. P.C.P. No.	d. Application Rate (kg a.i./ha)	e. Treatment Area (ha)	f. Quantity (kg a.i.)
Weather Blok Bait	brodifacoum	BRF	24057	.0006	3900	2.34

Target Pest Species

F. The purpose of these large-scale research trials is to field test the use of this baiting tactic to eliminate the Norway rate from Lucy, Cox and Langara Islands to assist in the recovery of seabird habitat. The research will also focus on establishing monitoring techniques that will be used to assess risks to other species concurrent with carrying the baiting program over the winter through to May 30, 1996.

Treatment Sites and Application Method

G. The following sites are approved for treatment in accordance with the application method indicated:

TREATMENT SITES	METHOD
1. Lucy Island (51°11'N, 132°59'W) 40.7 ha 2. Langara Island (54°15'N, 132° 59'W) 3549 ha 3. Cox Island (51°12'20'N, 133°00'45'W) 10.6 ha	Baits placed inside plastic tubes (0.5 m x 10 cm) secured in place. Stations checked daily until rat populations cease feeding. Afterwards, regular inspections until May 30, 1996.

Treatment Dates

H. Subject to product label limitations, the project described herein may be conducted between the following time periods.

July 7, 1995 to May 30, 1996

Licensing and Certification

I. Each contracting firm hired to conduct the project shall possess a current British Columbia Pest Control Service Licence, and the Regional Pesticide Management Program, Ministry of Environment, Lands and Parks shall be notified in writing of the name and licence number of the contractor prior to any pesticide use.

..../3

All rodenticide use shall be carried out by or under the direct supervision of an individual with a valid British Columbia Pesticide Applicator Certificate in the rodenticide-special application category.

Restrictions

J. Bait stations to be deployed in a manner that provides for a 10 metre pesticide-free-zone on all waterbodies. Applicators shall provide adequate buffers to ensure that the 10 metre pesticide-free zone is maintained. We suggest a 5 to 25 metre buffer zone on all fishery sensitive zones. A 50 metre pesticide-free-zone shall be maintained at domestic wells located at Henslung Cove and the lighthouse.

K. Bait stations shall be clearly marked and their surroundings will be checked on a regular schedule for the presence of baits that have not been taken to rat burrows. A public notification program is to be formulated so that unrecovered baits are returned safely to the project team.

L. Baits are to be bagged following collapse of bait-taking by rat population. The baits shall remain bagged through the winter and until such time as they are removed before May 30, 1996.

M. A detailed map giving precise locations of bait locations shall be provided to the Pesticide Management Program, and the Haida Tribal Society within two weeks of deployment.

N. All rodent carcasses are to be collected to reduce the potential of secondary poisoning of mammalian and avian predators and other species.

O. All unused product shall be collected and held in appropriate storage at Canadian Wildlife Service facilities.

P. The ratio of non-certified pesticide applicators to certified applicators shall not exceed 4:1.

Q. All personnel involved in the project shall be notified of the terms and conditions of the permit.

R. **Agency notification** shall be provided to the following, in writing, at least 3 weeks prior to commencement of the project.
   1) M. Wan, Environment Canada, Environmental Projection Service, 224 West Esplanade, North Vancouver, BC V7M 3H7 (G. Mitchell) 666-3111 FAX 666-9059.
   2) E. Collison, Haida Tribal Society, Box 589, Masset, BC V0T 1M0.
   3) A. Cober, Forest Ecosystem Specialist, Ministry of Environment, Lands and Parks, BC Environment, 1229 Cemetery Road, Box 39, Queen Charlotte City, BC V0T 1S0 (FAX 559-8342).

S. **Follow-up Reports** shall be provided to the appropriate regional office of the Ministry of Environment, Lands and Parks, Pesticide Management Program, prior to December

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31 of each year during which the permit is in effect. The report shall include the quantities of pesticide used (kg), the area treated (ha), and maps and/or a description of the treatment area. Forms are provided for this purpose.

T. Three copies of the research report shall be provided to the Pesticide Management Program, Box 5000, Smithers, BC V0J 2N0 prior to December 31, 1995.

The above pesticide use is hereby authorized in accordance with Section 8. of the Pesticide Control Act. (Permit is not valid unless signed by the Deputy Administrator).

Jerry M. Vakenti

J.M. Vakenti, P. Ag.
Deputy Administrator, Pesticide Control Act

Date: June 6, 1995

Appeal Procedures A notice of appeal of this permit shall be sent by registered mail or left during business hours at the office of the chairman of the Environmental Appeal Board, 125-911 Yates Street, Victoria, BC V8V 4X3 within 30 days of the issuance date. A fee of $25, payable to the Minister of Finance and Corporate Relations, must accompany the appeal.

The notice shall contain the name and address of the appellant, the name of the counsel or agent, if any, for the appellant, the address for service upon the appellant, grounds for appeal, particulars relative to the appeal and a statement of the nature of the order requested, and shall be signed by the appellant, or on his behalf, by his counsel or agent.

JMV/bs

cc: D.E.Cronin
RPRC
E. Collison, Haida Tribal Society, Box 589, Masset, BC V0T 1M0
M. Richardson, President, Council of the Haida Nation, PO Box 98, Skidegate, Haida Gwaii V0T 1S0
I. Smythe, BC Lands
A. Cober/R. Smith, BC Environment, Queen Charlotte City

AGREEMENT TO COMPLETE THE LANGARA ISLAND SEABIRD HABITAT

Whereas the goal of the seabird habitat recovery project, administered by the Canadian Wildlife Service, is to remove all of the rats from Langara, Lucy, and Cox Islands and recreate, as far as possible conditions for the re-establishment of seabird colonies and this goal is consistent with the policy of the Old Massett Village Council to maintain the cultural and natural values of those islands; it is agreed that:

a) The Canadian Wildlife Service will conduct the project in an environmentally safe and responsible manner as described in the 1993 feasibility study and that all activities and reports will be communicated to the Old Massett Village Council or its delegated representatives.

b) Wherever possible, the project will seek to employ members of the Haida community and where persons of equal qualifications apply, precedence will be given to members of the Haida community. In particular, the employment process will seek to place members of the Haida community among the supervisory staff and seek ways of providing training opportunities for any students employed on the project.

c) The managers of the project will consult with the Old Massett Village Council as employment or business opportunities arise.

d) The Canadian Wildlife Service accepts the principle that it will conclude the project in May 1996 to the satisfaction of the Old Massett Village Council:

i) Campsites and trails will be cleared of plastic flagging and other refuse.

ii) Only trails designated by the Old Massett Village Council will remain marked.

e) In all publications and public information, the Old Massett Village Council will be recognized as one of the four major co-operators; the others being the Canadian Wildlife Service, Nestucca Environmental Recovery Trust Fund, and the British Columbia Conservation Foundation. Publications and public information sponsored by the project that extend beyond technical material shall be submitted to the council for review.

In return,

a) The Old Massett Village Council will permit project operations to occur on reserves and historic village sites provided there is no significant or permanent impact on those reserves or sites or within such guidelines as the council deems necessary.

b) The council will designate a representative to participate in employment interviews and selections and provide communication with the community through the Outreach Program.

c) The council will assist the managers of the project in mediating such problems as might arise through misunderstanding or miscommunication with members of the Haida community.

In addition, Environment Canada and the Old Massett Village Council are both interested in improved infrastructure and communication in the area between Old Massett and Langara Island, along the north shore of Graham Island. Environment Canada views the area as "a wilderness are at-risk from oil soils in which clean up and recovery would be very difficult" and the Old Massett Village Council has stewardship interests in the area's cultural and natural values. It is agreed, therefore, that at least sufficient equipment for the establishment of two base camps (2 portable buildings, 2 water pumps, a water filter, wood stoves, cook stoves, and miscellaneous kitchenware) be placed on loan to the Old Massett Village Council for potential use in the event of an oil-spill emergency and for other council activities for the expected useful life of the portable buildings (4 years). The project manager will also provide a list of surplus equipment or supplies that might be of use to the community.

....	....
Gary Kaiser, Project Manager Langara Island Seabird Project	Wilson Brown, Chief Councillor Old Massett Village Council
5/1/5 1995 Date	June 27 95 Date