Motu Kaikoura rat management programme
Progress report - December 2024

Michael Lee & Clint Stannard

Summary

The Motu Kaikoura Trust has been undertaking a manual rat control operation (baiting and trapping) on Motu Kaikōura (564 ha) since March 2014 using an approximately 100m x 100m grid, with the objective of managing rodent numbers at or below 5% index level and thence by adaptive management to zero density.

Fig.1

Two species of rodents were recorded on Motu Kaikōura when the operation began, ship rat (*Rattus rattus*), present at very high levels, and Pacific rat or kiore (*Rattus exulans*) in comparatively low numbers. As the result of persistent ground-based control, since 2020 ship rats have been effectively eliminated from the island. The few occasionally detected in traps are likely swimmers from the nearby mainland. Kiore, previously subordinate and almost invisible, have increased in numbers and are now the predominant species.

The Trust's original goal of a 5% 'rodent' index level was first achieved in the Spring, (August and November) quarters of 2015 and regularly achieved since 2019. However, in 2023, for the first time since the beginning of the programme, summer index levels increased, reversing the trend of steady decline. This year 2024 was similar to 2023 and despite a two-month winter

pause, the year ended with the November quarter index level of 4%, which though is encouraging is in line with kiore population dynamics. This would suggest the Trust's strategy of long-term attrition, employing our existing bait/trap station network, given the population replacement of ship rats by kiore, has finally reached stalemate.

Introduction

Motu Kaikōura or Kaikoura Island (36°10' S, 175°19' E), situated in a large embayment on the western coast of Aotea / Great Barrier helps form Port FitzRoy harbour. It was purchased in 2004 by the N.Z. Government after a campaign to secure the island in public ownership. Its purchase was funded by contributions from the Nature Heritage Fund, the former Auckland Regional Council, former Auckland Territorial Local Authorities and the ASB Community Trust (now Foundation North).

The island is a scenic reserve administered by the Motu Kaikoura Trust, which was established in 2004. It was appointed under section 29 of the Reserves Act (1977) as the Administering Body of the reserve which was opened to the public by the Prime Minister, Helen Clark in May 2005. The Motu Kaikoura Trust administers the island under the terms of a Heads of Agreement with the Minister of Conservation signed in 2008. A management plan, the Motu Kaikoura Scenic Reserve Management Plan became operative in 2020.

Geologically, the island is comprised of volcanic andesite and breccia, part of the eroded remnants of an andesite stratovolcano of Miocene age (Hayward 2023). The island's topography is rugged with much of the coastline, especially on the northern side in steep cliffs. The highest point of the island, Mitre Peak is 184m asl. Several-hundred-years of anthropogenic impacts, repeated burn-offs and pastoral farming resulted in the island's natural values becoming severely degraded. In parts of the island even the topsoil has been eroded away. The island's natural ecological processes therefore have long since been disrupted or destroyed.

In 2005 when the Motu Kaikoura Trust assumed management, the island was essentially a reverting farm in the early stages of regeneration. Reverting pasture, secondary successional manuka and kanuka shrubland, linked pockets of mature coastal broadleaf forest of taraire, kohekohe, and puriri in several east and south facing valleys, with some stands of exotic pines (maritime and radiata) mainly in the southeast. At that time the forest understory was heavily browsed by fallow deer (*Dama dama*), feral pigs (*Sus scrofa*), and rabbits (*Oryctolagus cuniculus cuniculus*). Goats (*Capra hircus*) had been removed in 1993. Like neighbouring Great Barrier Island, Motu Kaikōura was also infested with feral cats (*Felis catus*), ship rats and kiore.

Fallow deer, pigs, feral cats and rabbits were progressively eradicated by the Trust in the period up to and including 2008. The removal of deer mainly by shooting, notably accelerated the process of forest regeneration.

In August 2008 an attempt was made to eradicate rats from the island with two aerial applications of 'Pestoff 20R' (brodifacoum based) (Ritchie 2008). Unfortunately, seven months later, both rat species *R. rattus* and *R. exulans* were detected on the island. The adjacent mainland at its closest point, the Stellin peninsula (Bunker Point) separated by the 80m wide Man of War Passage, is well within the swimming range of ship rats, which are known to reach the island from this location (Hamilton 2011; Bagasra *et al.* 2016). However, the presence of kiore known to be weak swimmers, as well as ship rats, identified by DNA testing to be from the island's original ship rat population (Fewster *et al.* 2011), provided conclusive evidence the aerial operation was a failure. An aerial drop undertaken the following year on neighbouring Glenfern Sanctuary evidently also failed to eradicate kiore. This would suggest

that two applications of bait are insufficient for aerial operations with multiple rodent species present, especially in northern New Zealand.

In the wake of the failure of the aerial operation, after seeking expert advice (not all of it consistent) and undertaking a period of review and analysis, the Motu Kaikoura Trust resolved to manage the island as a 'mainland island', treating the water barrier as a 'fence' and relying on ground-based methods to control rats on a permanent basis. This honours a key condition of the Heads of Agreement between the Minister of Conservation and the Motu Kaikoura Trust:

> 3 *(e) keep and maintain the Reserve free of litter and work towards the eradication of all plants and animals (including the eradication of fallow deer, pigs and rats) identified in the operative Auckland Regional Pest Management Strategy and the Biosecurity Act 1993;*

This is reflected in a key objective of the Motu Kaikoura Biodiversity Management Plan (2012):

Animal pest control recommendations. Method of control. Target all rodent species (ship rats, kiore) and aim to contain <5% relative abundance (as measured by rodent monitoring…) by establishing a 100 x 100m grid of bait stations.

This objective has also been included as a policy in the Motu Kaikoura Scenic Reserve Management Plan (2020):

C.4.6 Policies for Animal Pest Management and Control: *The Trust will work towards the eradication of rodents from Motu Kaikoura with an initial goal of achieving ≤5% relative abundance density and monitor progress by having an independent rat tracking monitor undertaken and reported on the outcomes every two years.*

In 2012/13 with the objective of facilitating rodent management and also to create public amenity, a 14.5 km perimeter walking track encircling the island was constructed. For operational purposes, the perimeter track known as 'East Track' & 'West Track', forms the main framework of our rat control network.

A plan based on an island-wide network of bait stations to be progressively expanded to form a 100m x 100m grid, with the objective of reducing rodent population levels to 5% was approved by the Trust in February 2014. Island-wide baiting using 4 blocks of brodifacoum based rodenticide ('Pestoff' 30 grams, 20 ppm and 'Brigand' 21 grams, 50 ppm) per station on a fortnightly basis, commenced in March 2014, as the network was progressively expanded.

At the start of the manual operation, rat numbers were recorded at irruptive levels with initial bait-take at over 90% (see fig.4). Monitored index levels during this period peaked at nearly 80% (see fig.6 & table 2). However, within seven months rat numbers declined to the stage where it was feasible to introduce snap traps into the system. Ship rats were the overwhelmingly predominant species detected in traps. Servicing was reduced from fortnightly to monthly. Bait placement was reduced to 2 blocks per station early in 2018 while stations have been progressively added.

Motu Kaikōura rat control network

The Motu Kaikōura rat control network is operated by island ranger Clint Stannard (contracted as 'Island Care'). Bait stations and traps are normally serviced monthly. This year for the first

time since beginning the programme, operations were paused in July and August mainly to undertake extensive track maintenance. Index monitoring takes place four times per year. The programme has been overseen from the beginning by trustee Mike Lee who reports to the Motu Kaikoura Trust Board.

The island rat control network for 2024 (up until mid-December) comprises, (adjusting for losses in vulnerably located stations in the coastal line due to storm damage), 713 stations, in 17 separate lines, made up variously of 366 motels, (2 traps and 2 bait blocks), and combinations of 330 bait hoppers (2 bait blocks) and 239 covered single trap units, the latter usually ganged with bait hoppers. This includes the experimental 'Intensified Management Area'.

During the two-month winter pause, old and worn snap traps were replaced with 290 x new D snap-traps which we find superior to the T-Rex models used up until now. After the December monthly status report, the full perimeter track (East Track & West Track) was intensified with an extra 141 x Philproof bait hoppers, placed every 50 metres between the existing 100m spaced rat motels, thereby creating a 14.5 km long 100m x 50m intensified zone encircling the islands. 210 new D traps and 119 bait hoppers are still on hand to be deployed in the network over the coming weeks. This new equipment was funded by a grant from the Lottery Grants Board. This is the first step in a comprehensive island-wide intensification in 2025, beginning with the Intensified Management Area.

Adaptive management – the Intensified Management Area (IMA)

In 2021 a pilot intensified grid, 4 km in length, covering 30ha, comprising mostly newly-cut tracks with segments of older refurbished tracks was launched, specifically aimed at experimentally targeting kiore. This intensified management area (IMA) is located in the Settlement Valley area, the island's logistical centre including the Lodge, accommodation and utility sheds and wharf, on the island's southern side. The IMA initially comprised 191 stations (motels, Philproof hoppers and covered trap units) armed with 234 snaptraps and 450 baits. Originally laid out in a 100m x 50m grid It became operational in January 2021, (Fig. 2). Early in 2022 it was further intensified by adding 52 more stations (Philproof hoppers), without cutting new tracks, thereby increasing the number of stations to 243. This presently forms an unconventional 100m x 25m grid. Over the first weeks of 2025 the IMA is to be further intensified to 50 x 50m grid, to be fully operational in February 2025. This work has been funded by a grant from Auckland Council Biosecurity.

Fig.2. The intensified management area (IMA) experimentally targeting kiore within the Settlement Valley

Off Island Protective Zone

There are 10 bait stations which form the off-island protective zone on the Great Barrier mainland and on Nelson Island. This is made up of:

Stellin Peninsula (80m from Motu Kaikōura)
Located on the nearest part of the Great Barrier mainland, Bunker Point (Stellin Peninsula) across the Man of War Passage. It comprises 8 x bait stations, each loaded with 4 bait blocks. This is designed reduce numbers of potential invading ship rats. These and the 10 x tracking tunnels deployed 750 metres to the south of Bunker Point line (see Fig. 3 RM6) also provide a statistical control providing useful comparative data.

Nelson Island (130m to the west of Motu Kaikōura)
Nelson Island (12 ha) is managed by the Trust by agreement with the owner Bryan King. Difficult to land on and steep-sided, the Trust maintains 2 x motels located just above the shoreline, each loaded with 16 bait blocks which are serviced on a monthly basis. The island is 330m from Motu Hāku where ship rats are also present. Experimental trapping by CS confirmed Nelson Island is inhabited by ship rats. In November the authors visited Nelson Island, reloaded the bait stations plus two more on the summit and hand-cast baits over the summit and slopes. It is likely the ship rats on Nelson are periodically reinforced by swimmers from Motu Hāku.

Motu Kaikōura trap and bait station inventory - January to mid-December 2024*

	stations	motels	philproofs	trap units	bait blocks	traps
Coast	72	72	0	0	144	144
East	83	83	0	0	166	166
West	62	62	0	0	124	124
Overlook	54	27	27	0	108	54
Ridge	51	26	25	0	102	52
Road	17	17	0	0	34	34
House	30	11	12	7	46	29
Badlands	27	0	27	27	54	27
Intensified (IMA)	225	43	182	148	450	234
Pohutukawa	20	0	20	20	40	20
Vodafone	5	5		4	10	14
Gecko area	10	0	10	0	20	0
Midline	12	0	12	12	24	12
Airstrip	12	12	0	0	24	24
Bradshaws	10	0	10	10	20	10
Fence End of Airstrip	8 11	8 0	0 5	0 11	16 10	16 11
Island Total	**713**	**366**	**330**	**239**	**1392**	**971**
Stellin Pen.	8	0	8	0	16	0
Nelson Isd.	2	0	2	0	32	0
Grand Total	**723**	**366**	**340**	**239**	**1440**	**971**

Table 1
*The Island perimeter track (East & West tracks) was intensified in late December with the addition of a further 141 bait hoppers over and above those reported here.

Motu Kaikōura Index monitoring system

There are 50 x footprint tracking tunnels, grouped in five lines of 10, with one control line of 10 stations on the nearby mainland. This monitoring network was installed by Auckland Council Biosecurity officers in late 2010 (Mitchell 2010) and has not been altered since, except for the addition of a control line on the mainland which was installed in April 2015 (see Fig.3). The coreflute tunnels ('Black Trakka') have an inked tracking card which is baited with peanut butter, left overnight, then collected the next day. (Brown *et al.* 1996). Standard one-night footprint tracking monitoring is undertaken every quarter

Monitoring Lines on Motu Kaikōura and on nearby Great Barrier Island

Fig. 3 Monitoring lines each comprised of 10 tracking tunnels (RM1to 5) on island, (RM6) is mainland control

Bait rotation

The Trust has a policy of rotating use of bait. We are currently using 'Double-Tap' which is the first non 2nd generation anti-coagulant bait that we have found to be effective – rats readily consume it. There are two active ingredients to 'Double Tap' as the name suggests: diphacinone and cholecalciferol. It is sold by Connovation Ltd. 'Double Tap' was recommended to us by Brett Butland of Predator-Free NZ Ltd.

Motu Kaikōura Track system

Total length of formed operational tracks and roads: **31.7 km**
Perimeter track: **14.5 km**
Total length of coastline network**: 16.8 km**

Over the past year to facilitate the efficiency of rat management, with the additional benefit of improving the quality of access for recreational walkers, major tracks have been comprehensively upgraded and the balance of the tracks given basic maintenance. Track maintenance is a major part of our ranger work programme.

Results

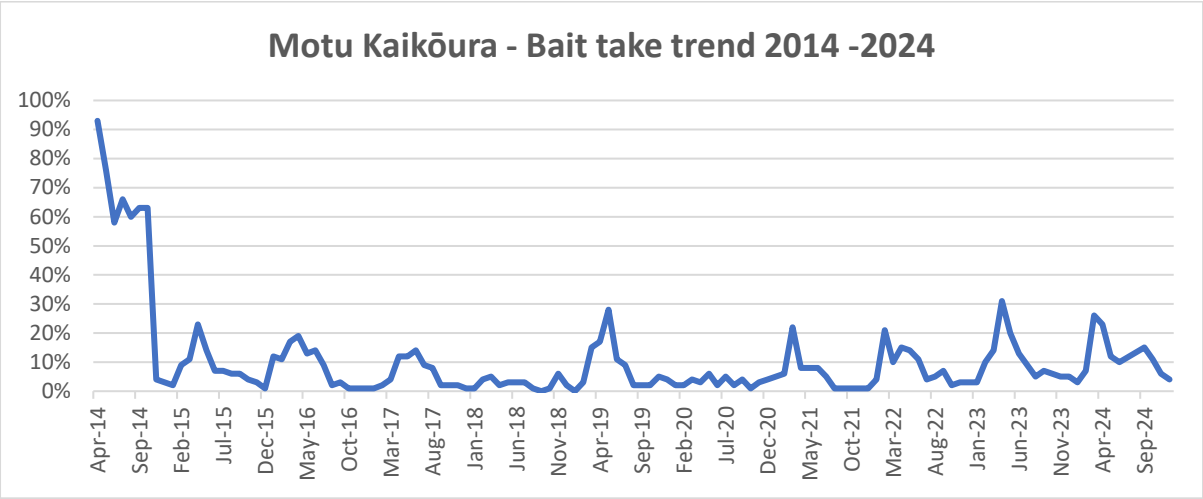

Fig. 4. Bait take trend beginning in April 2014 when rats were at irruptive levels. Spikes indicate peaks in rat numbers after the summer breeding season. The late summer peak of 2023 was the highest since 2014 and coincided with extremely wet weather and rising kiore numbers.

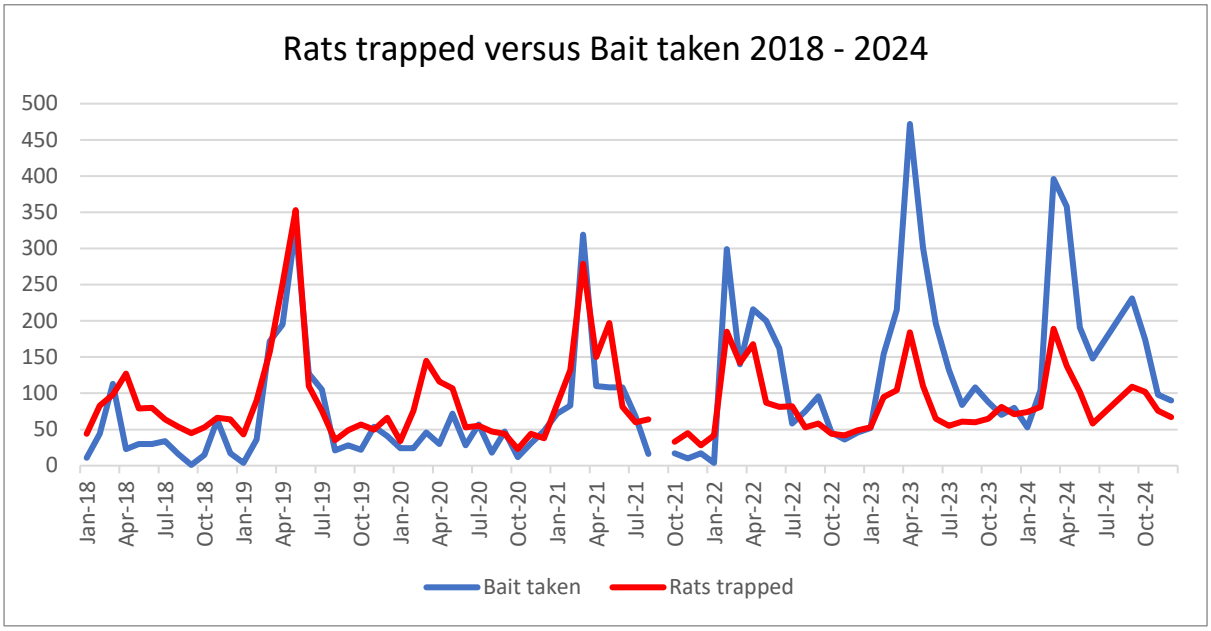

Fig.5. Trapping and baiting show a trend indicating late summer rat population peaks and springtime lows. Note record peak in the summer of 2023 & spike in Sept 2024 after pausing operations in July & August, Since the 'near eradication' of ships rats from 2020, kiore have become the predominant rat species on Motu Kaikōura.

Results summary
January to December 2024

Number of rats trapped **996** (971) traps). **18** carcasses identified as ship rats (1.8%).
Number of bait blocks consumed **1843** (1464 available monthly). Estimated number of rats killed by rodenticide c **922.**[1]
Total number of rats killed in 2024: c**1918**

[1] a conservative estimate – baits taken divided by 2.

Quarterly monitoring index average **11%.** Mainland control **35%**
Summary of results from previous years:

January to December 2023
Number of rats trapped **1004** (971 traps). **21** carcasses identified as ship rats (2%).
Number of bait blocks consumed **1952** (1464 available monthly). Estimated number of rats killed by rodenticide **976.**
Number of rats killed in 2023: c**1980.**
Quarterly monitoring average **10%.** Mainland control **60%**

January to December 2022
Number of rats trapped **1033** (1043 traps). **32** carcasses identified as ship rats (3%).
Number of bait blocks consumed **1378** (1464 available monthly) Estimated number of rats killed by rodenticide **689.**
Percentage of rats killed by traps **65%,** by bait **35%.**
Total number of rats killed in 2022: c**1722.**
Quarterly monitoring average **4.5%.** Mainland control **20%**

January to December 2021
Number of rats trapped **1154** (1043 traps). Six carcasses identified as ship rats (0.5%).
Number of bait blocks consumed **928** (1450 available) Estimated number of rats killed by rodenticide **464**.
Percentage of rats killed by traps **72%,** by bait **28%.**
Total number of rats killed in 2021: c**1618**
Quarterly monitoring average **5%.** Mainland control **30%**

January to December 2020
Number of rats trapped: **437** (959 traps). Seven carcasses identified as ship rats. (1.6%).
Number of bait blocks consumed: **782 (**1192 available) Estimated number of rats killed by rodenticide **391.**
Percentage of rats killed by traps **53%,** by bait **47%.**
Total number of rats killed in 2020: c**828.**
Quarterly monitoring average **6%.** Mainland control **17.5%**

January to December 2019
Number of rats trapped: **1337** (959 traps). 10 carcasses identified as ship rats (0.7%).
Number of bait blocks consumed: **1135** (1152 available). Estimated number of rats killed by rodenticide **567.**
Percentage of rats killed by traps **66%,** by bait **33%.**
Total number of rats killed in 2019: c**1702.**

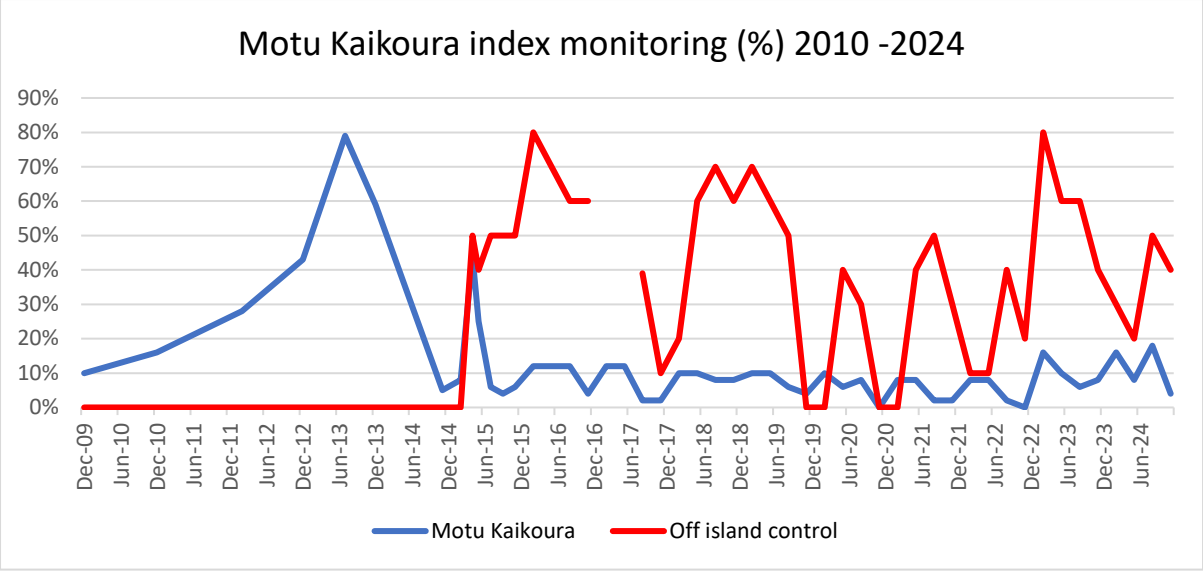

Fig.6 Index monitoring on Motu Kaikōura compared to the mainland (Great Barrier) control site. This indicates rat numbers on Motu Kaikōura generally to be an order in magnitude below that on the mainland. Note also the major spike in rat numbers evident on the island early in 2023 indicating the post ship-rat release of kiore.

Table of Monitoring Results 2010 – 2023

	island	control		island	control		island	control
Dec-10	16%	-	May-17	12%	-	Aug-21	2%	50%
Feb-12	28%		Aug-17	2%	-	Nov-21	2%	30%
Dec-12	43%		Nov-17	2%	-	Feb-22	8%	10%
Jul-13	79%		Feb-18	10%	20%	May-22	8%	10%
Dec-13	59%		May-18	10%	80%	Aug-22	2%	40%
Nov-14	5%		Aug-18	8%	70%	Nov-22	0%	20%
Feb-15	8%		Nov-18	8%	60%	Feb-23	16%	80%
Apr-15	44%*	50% *	Feb-19	10%	70%	May-23	10%	60%
May-15	25% **	40%**	May-19	10%	60%	Aug-23	6%	60%
July-15	6%	50%	Aug-19	6%	50%	Nov-23	8%	40%
Sep-15	4%	50%	Nov-19	4%	0%	Feb-24	16%	30%
Nov-15	6%	50%	Feb-20	10%	0%	May-24	8%	20%
Feb-16	12%	80%	May-20	6%	40%	Aug-24	18%	50%
May-16	12%	70%	Aug-20	8%	30%	Nov-24	4%	40%
Aug-16	12%	60%	Nov-20	0%	0%			
Nov-16	4%	60%	Feb-21	8%	0%			
Feb-17	12%	-	May-21	8%	40%			

Table 2.
N.B. Manual operation commenced April 2014.
* Mitchell et al. 2015.
** Sambell et al. 2015

Intensified management area (IMA)

The 30ha intensified grid covers just 5% of the island and despite its inherent limitations i.e. small size and vulnerability to incursion across its long boundary, it has proven to be effective at reaching kiore previously unaffected by the standard 100m x 100m grid. The experimental 100m x 25m grid albeit unconventional, is reducing kiore numbers within this area. Of the 996 rats trapped on the 564ha island in 2024, 177, all kiore, were accounted for in the 30 ha IMA. This is 18% of the total number of rats trapped on the island, down from 241 (24%) in 2022, and 334 (29%) in 2021 when we began the experiment, (see Fig.7).

Of the 1843 baits taken across the island in 2024, 610 were taken within the IMA (33%). This compares to 44% in 2023 50% in 2022 and a remarkable 61% in 2021.

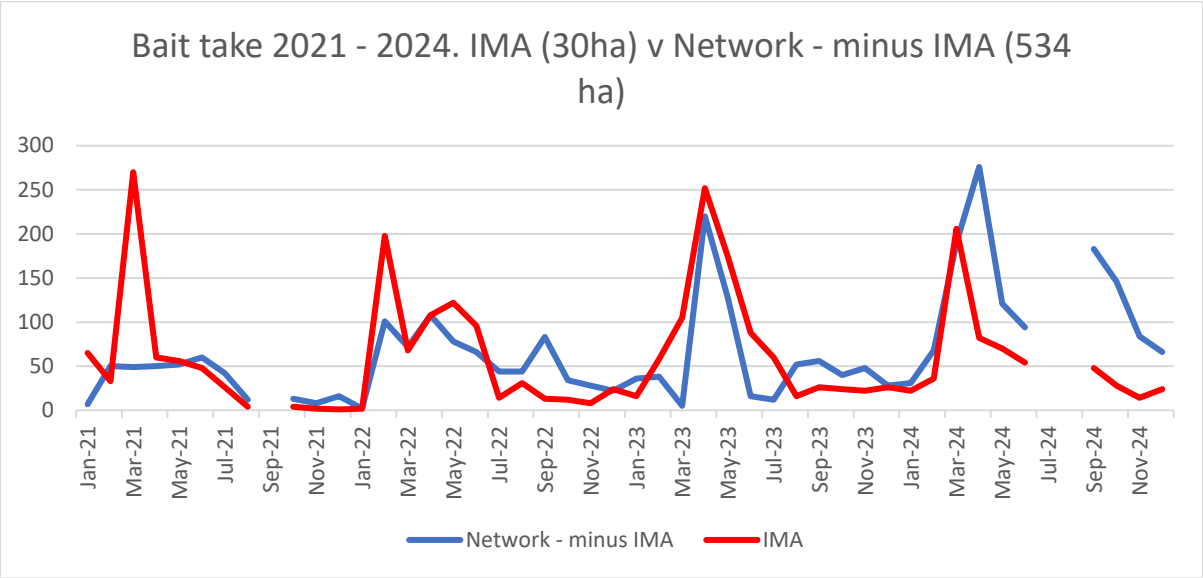

Fig 7. Efficacy of the 100m x 25m grid compared to the 100m x 100m network grid indicated here. Note late summer peaks and also a spike in Sept 2024 after the winter pause in operations. The initial bait take in the IMA in 2021 exceeded that of the rest of the network but Kiore numbers are gradually declining within the Intensified Management Area.

Discussion

Ground-based rat control on Motu Kaikōura has now been underway for ten years. Ship rats which were the predominant species on this island, and on nearly all islands and mainland forests where rats are present, continue to be suppressed at a level of termed 'near eradication' (Innes & Saunders 2011). Individual ship rats still swim to the island, from the nearby Great Barrier mainland and presumably from Motu Hāku and Nelson islands – especially in late summer. 18 ship rat carcasses were identified in traps this year, 14 from January to June, and 10 of these in January and February. The percentage of trapped ship rat carcasses identified this year was 1.8%, compared to 21 out of 1004, i.e. 2% in 2023, and 34 out of 1022 carcasses in 2022 (3%). This is in line with the results of the last live-trapping exercise by Thomas Bodey (unpubl.) early in 2019. Out of the 34 rats caught, Bodey found 1 x ship rat (3%) and 33 x kiore (97%).

It is worth noting live-trapping exercises at southern Great Barrier Island undertaken by Bodey in the same period indicated ship rats at 96% and kiore at 4% of the sample – almost the exact reverse to that found on Motu Kaikōura. These Great Barrier figures align with the normal population ratio of ship rats (dominant) and kiore (subordinate) on northern New Zealand islands, for instance, Rakitu in 2016. (See also Russell & Clout 2004; Harper 2006); and more broadly on tropical islands where the two rat species coexist, Russell *et. al* 2015. Such ship

rat dominance was the previous situation on Motu Kaikōura as reported by Fewster *et al.* (2011), and Bagasra *et al.* (2016). The latter in January and February 2013, trapped 41 rats, 39 of which were ship rats and 2 kiore (5%). As noted, as the result of persistent control this ratio has been more than reversed. However, ship rats can be expected to attempt to re-establish as long as there are ship rats on the Great Barrier mainland.

That being said, our experience over the last five years indicates we have the infrastructure in place to prevent ship rats re-establishing – as long as our present operation is maintained.

Last year 2023, the steady long-term decline of the island's overall 'rodent' population, evident since we began the operation in 2014, ended with a sharp increase in numbers in the late summer of that year. In 2023 this co-related with the unprecedented weather events, notably prolonged heavy rain over the summer which is likely to have resulted in an abundance of wild food (see Bunn & Craig 1989). However, a similar spike occurred this year and therefore we conclude this to be a manifestation of a differential response to our management regime by the two rat species. This differential response has resulted in the population replacement, to our knowledge unprecedented on this scale, of ship rats with kiore. This has facilitated a phenomenon ecologists term 'meso-predator release'.

While the successful 'near eradication' of ship rats has doubtlessly assisted ecosystem recovery, we have found that kiore due to their smaller foraging range, are less impacted by the existing bait/station network that proved to be effective in eliminating ship rats. While ship rats are known to out compete and directly prey on kiore, as Harper & Bunbury (2015) noted '*When predators and competitors are absent, Pacific rats appear to reach higher densities than their conspecifics, possibly related to their smaller size*.'

Therefore it appears that kiore are attempting to fill the habitat void left by ship rats and though the full manifestation of this is being blocked by our existing control network, (approximately 2000 kiore were trapped and poisoned this year), nevertheless the present biomass of kiore must be acting as a major impediment to ecosystem recovery (Towns 2023).

As regards targeting kiore, our adaptively managed Intensified Management Area (IMA) currently configured in a grid of 100m x 25m (despite the obvious limitations already referred to) has confirmed assumptions that given the smaller foraging range of this species (Atkinson & Moller in King 1990; Moller & Craig 1987; Bunn & Craig 1994; Bramley 2014; Harper & Bunbury 2015) more intensively designed control grid (ideally 50m) across the island would be needed to collapse their numbers in the same way as occurred with ship rats. (See Atkinson 1990; Harper 2006). This means given the limited swimming range of kiore it would be theoretically possible to completely eradicate this species from the island. Such a 50m grid based on what the NZ Wildlife service and DOC successfully employed to remove rats from islands in the Mercury group (Towns 2023), would entail approximately four times the numbers of stations presently deployed. This would be a major logistic challenge for the Trust especially given our limited resources. Never-the-less it is the approach we are now planning and for which we are seeking support from the DOC Conservation Community Fund. In the meantime, on the principle of adaptive management we are making a start on intensifying the present island-wide network to 100m x 50m. First along the full length of the 14.5km perimeter track, thereby creating an intensified band encircling the island and at the same time intensifying the experimental IMA down to a 50m grid.

As noted in the **Results** section, it is encouraging that the proportion of rats trapped and bait taken within the IMA and its 100m x 25 m grid compared to the rest of the island has declined steadily over the four years of its operation. We can conclude the IMA would be even more effective with a 50m grid.

While mindful that ground-based rat eradications in the past have generally succeeded on islands much smaller than Motu Kaikōura, the same principles must apply. What the Trust has achieved in the last ten years proves that long term attrition was a viable strategy to effectively eradicate ship rats. But attrition will require significant intensification if we are to repeat our success with ship rats by eradicating kiore. Shifting our focus to target kiore is essential if we are to progress the Motu Kaikoura Trust's long-term mission to eradicate rats from Motu Kaikōura.

Acknowledgement and thanks

The Motu Kaikoura Trust would like to acknowledge the dedicated work of scenic reserve ranger Clint Stannard (Island Care). We also record our thanks to DOC, Foundation North, Lottery Grants Board and Auckland Council Biosecurity for vital support for our rat and ecosystem management work, and to the Aotea-Great Barrier Local Board for funding in support of the island's essential infrastructure. We also wish to thank Cat Boyes and Colin Heng of Auckland Council Bio Information for producing the GPS waypoint image at the head of this report. Finally, we express thanks to our neighbours Sven & Trish Stellin of Port FitzRoy, Aotea for their support for our programme and to Bryan King of Motu Hāku.

References

Atkinson, I.A.E., Moller, H. 1990. Kiore. In King, C.M. (ed.) *The Handbook of New Zealand Mammals*, pp 175-192. Oxford University Press. Auckland,

Bagasra, A., Nathan H.W., Mitchell, M.S. & Russell, J.C. 2016. Tracking invasive rate movements with a systemic biomarker. *New Zealand Journal of Ecology* (2016) 40(2): 267-272.

Bramley, G.N. 2014. Home ranges and interactions of kiore (*Rattus exulans*) and Norway rats (R. norvegicus) on Kapiti Island. New Zealand Journal of Ecology. 38:2. 328-334.

Brown, K.P., Moller, H., Innes, J. & Alterio, N. 1996. Calibration of tunnel tracking rate to estimate relative abundance of ship rats (Rattus rats) and mice (Mus Musculus) in a New Zealand forest. *New Zealand Journal of Ecology*, Vol.20. No.2.

Bunn, T.J. & Craig, J.L. 1989. Population cycles of *Rattus exulans*: Population changes, diet, and food availability, New Zealand Journal of Zoology, 16:3, 409-418, DOI: 10.1080/03014223.1989.10422907

Fewster, R.M., S.D. Miller & Ritchie, J. 2011. DNA profiling - a management tool for rat eradication. Pp 426-431 In: Veitch, C. R. Clout, M.N. & Towns, D.R. (eds.) *Island invasives: eradication and management*. IUCN, Gland & Auckland.

Hamilton, O. 2011. *Distribution and density of ship rat (Rattus rattus) on Motu Kaikoura, Hauraki Gulf, following reinvasion after eradication*. University of Auckland, School of Biological Sciences (unpublished report).

Harper, G. 2006. Habitat use by three rat species on an island without other mammalian predators *NZ Journal of Ecology*. 30 (3) 321-333.

Harper G. & Bunbury N. 2015. Invasive rats on tropical islands: their population biology and impacts on native species. *Global Ecology and Conservation*. 3: 607-627.

Hayward, B. W. 2023. Geology of Motu Kaikoura, Aotea/Great Barrier. *Geocene,* 33:14-17.

Innes, J & Saunders, A. 2011. Eradicating multiple pests: an overview. Pp 177-181 in: Veitch, C.R; Clout, M.N. & Towns D.R. (eds.) 2011. *Island invasives: eradication and management* IUCN, Gland & Auckland.

Lee, M. & Stannard, C. 2023. *Motu Kaikoura rat management programme – Progress Report*.

Mitchell, M. 2010. *Report on Motu Kaikoura rat monitoring*. Auckland Council. Unpublished report to Motu Kaikoura Trust.

Mitchell, M. Warden, J. Shields, B. 2015. *Motu Kaikoura Rodent Monitor April 2015*. Unpublished report to Motu Kaikoura Trust.

Moller, H. & Craig, J.L. 1987. The population ecology of *Rattus exulans* on Tiritiri Matangi Island, and a model of comparative population dynamics in New Zealand. *New Zealand Journal of Zoylogu*, 14: 3, 305-328.

Motu Kaikoura Trust. 2012. *Motu Kaikoura Biodiversity Management Plan,* Motu Kaikoura Trust, Auckland.

Motu Kaikoura Trust. 2020. *Motu Kaikoura Scenic Reserve Management Plan*. Motu Kaikoura Trust, Auckland.

Ritchie. J. 2008. *Kaikoura Island Eradication Plan*. Natural Logic Environmental Management. Unpublished report to Motu Kaikoura Trust.

Russell J.C. & Clout, M. 2004. Modelling the distribution and interaction of introduced rodents on New Zealand offshore islands. *Global Ecology and Biogeography,* **13**, 497–507.

Russell, J.C., Caut, S., Anderson, S.H. & Lee, M. 2015. Invasive rat interactions and over-invasion on a coral atoll *Biological Conservation* 185 59–65.

Towns. D. 2023. *Ahuahu – a conservation journey in Aotearoa New Zealand*. Canterbury University Press. Christchurch.