Assessment of Chatham Island as a location for liberation of black stilts

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Summary

At the high water level that we encountered, Te Whanga Lagoon and its immediate environs are largely unsuited to black stilts. Nevertheless, the area of shallow-water foraging habitat that does exist at this water level would be sufficient to maintain a population of them. At low water levels, large areas of shallows would be available to black stilts.

Suitable nesting sites are generally small and scattered away from the main lagoon. The lagoon edge would be unsuitable for nesting because it is susceptible to flooding by wind-generated water level fluctuations.

Biomass of aquatic invertebrates in the shallows at high water level are relatively low compared to biomass in shallows in the Mackenzie Basin but would be adequate for black stilts. The types of prey species present would be easily caught and eaten by them. The type and quantity of food supplies at low water levels is unknown.

The inland waters on Chatham Island are generally brown, saline, alkaline, and high in dissolved oxygen. They are warmer in winter than waters of the Mackenzie Basin. The warmer conditions are likely to result in higher winter food production in Chatham Island shallow waters than in shallow waters of the Upper Waitaki Basin.

Twenty seven pied stilts were seen on Chatham Island. This was probably the entire population, or close to it.

Although pied stilts may regularly move to and from mainland New Zealand, the presence of two juveniles indicates that they also breed on the island. The small population size, and high adult to juvenile ratio suggest that breeding success is low.

Pied stilt feeding and searching rates were similar to feeding and searching rates of black stilts in winter. This similarity provides further support for the conclusion that food supplies on Chatham Island would be adequate for black stilts.

Wekas appear to be present in high numbers everywhere. Cats, rats and possums are present but their density and distribution are unknown. Kahu *(Circus approximans)* are present but at much lower density than in the Mackenzie Basin. The potential effects on black stilts of these predators, particularly wekas, may be just as serious as the present effects of predators in the Mackenzie Basin.

There is good potential to enhance the habitat for black stilts by creating better nesting areas and by erecting barriers to exclude predators from the eastern spit area, or around individual ponds.

1. Introduction

There are presently fewer than 100 black stilts *(Himantopus novaezelandiae* Gould, 1841) in the wild, and the species is one of the world's rarest wading birds. The black stilt breeding population is confined to the Upper Waitaki Basin in the eastern central South Island, but formerly black stilts were found in wetlands throughout New Zealand (Pierce 1984). They inhabit braided rivers, small streams, ponds, tarns, swamps and lake deltas throughout the year.Around 10% of the population migrate to coastal estuaries and northern harbours (Reed et al. 1993).

To reduce the risk of the black stilt population becoming extinct in its single breeding location, the Department of Conservation aims to identify and establish a second population in a different geographical area. One management option is to establish a population of them on a predator-free island (Black Stilt Recovery Plan, Section 9.5, Reed et al. 1993). The Black Stilt Recovery Plan recommends that a suitable island would be one that:

1. contains no nesting pied stilts *(H. himantopus)* (to eliminate potential hybridisation problems), i.e. is outside their natural range;

2. provides suitable nesting and feeding habitat to support at least 5-10 pairs of black stilts; and

3. is free of ground predators (the presence of kiore may be considered acceptable if no alternatives exist).

Enquiries made of several people familiar with New Zealand offshore islands failed to locate any island that met all of the above criteria. The island with the greatest potential appeared to be Chatham Island (Fig. 1), which has an extensive shallow lagoon, but is not predator-free, and is inhabited by pied stilts.

The Black Stilt Recovery Group recommended, at its 30 May 1994 meeting, that a preliminary investigation of Chatham Island be made. We (DPM & MDS) formulated the following eight objectives and investigated them during a site visit from 19 to 24 June 1994

2. Objectives

1. To describe the extent and nature (including stability over time) of potential black stilt foraging habitat.

2. To describe the extent and nature (including stability over time) of potential black stilt nesting habitat.

3. To describe the taxonomic composition, and measure biomass and density, of aquatic invertebrate food supplies at potential black stilt foraging habitats.

4. To measure basic physicochemical parameters at potential black stilt foraging habitats. (Relevant to aquatic invertebrate food supplies.)

5. To estimate pied stilt abundance.

6. To determine whether pied stilts may breed on the island.

7. To describe and measure foraging behaviour of pied stilts.

8. To gauge the likely effect of potential predators of black stilts.

3. Methods

Discussions with DOC Chatham Island staff and inspection of part of the island revealed that the majority of wading habitat was likely to be located on the shores of Te Whanga Lagoon, but that other smaller lakes and ponds might also be used by waders. Therefore, we concentrated on investigating the above objectives at Te Whanga Lagoon and as many lakes and ponds as possible in the limited time available.

The entire shoreline of Te Whanga Lagoon, parts of several islands in the lagoon, and 16 lakes and ponds were surveyed by boat, or vehicle or on foot. Lakes and ponds visited are listed in Table 1. Shorelines were divided into areas with broadly similar vegetation, substrate type, shore steepness, presence of spits or islands, and overall suitability for black stilts. These areas were described and mapped.

Seventeen sites (A-R, but not I, Fig. 1) that represented several main types of shoreline habitat apparent to us were investigated in greater detail. These sites included two sites where pied stilts were observed foraging. At fifteen sites (not A and I), five 0.1 m^2 substrate and water column samples were taken. Aquatic invertebrates from these samples were identified, counted and weighed in the laboratory. Water temperature, pH, dissolved oxygen concentration, and salinity were also measured at these sites.

Black stilts forage in water less than 18 cm deep, usually with gently sloping edges, and away from high banks or tall vegetation or debris (Pierce 1982; pers. obs.; pers. comm. from many field workers). Therefore, to indicate the extent of potential foraging habitat at each site, we estimated mean distance from water's edge to 'maximum foraging depth' (18 cm). Distance to any vegetation or debris that we considered could provide cover for ground predators was also estimated, as were distances to stable vegetation, to banks over 0.3 m high, and to banks over 1 m high. These distance estimates are compared with similar estimates made in the Mackenzie Basin.

Pied stilts were counted and observed wherever encountered. Foraging behaviour may reflect quality of foraging habitat. Therefore, pecking and stepping rates of pied stilts were recorded for comparison with pecking and stepping rates of black stilts.

Sightings of potential predators of black stilts were noted, and a count of kahu *(Circus approximans)* was made while driving.

Photographs were taken of representative areas of shoreline around Te Whanga Lagoon, including pied stilt foraging sites, and of several of the smaller ponds and lakes. Discussions with local DOC staff and other Chatham Island residents provided information on wader foraging and nesting sites, predators and lagoon water level fluctuations.

4. Results and discussion

4.1 FORAGING HABITAT

Te Whanga Lagoon has an area of 16 000 ha (Hay et al. 1970). The most suitable wader habitat is found on the northern and northeastern shorelines, where extensive areas of mud and sand flats are exposed when water levels are low. Figure 2 shows bottom contours of the lagoon and indicates a 2 ft depth, in places 2.5 km and more offshore. The slope is very gentle along these northern shores and shallows would be available at all water levels. Water levels fluctuate when the lagoon outlet at Hikurangi Channel is open but are also affected far more rapidly by wind intensity and direction which can push the water to one end of the lagoon or the other. During the survey the outlet was closed and water levels high. There were no exposed mud or sand flats but waders, including pied stilts were observed foraging and roosting along the north and north-east shoreline.

Pied stilts were seen in three areas along the north and northeastern shoreline of Te Whanga Lagoon; `Ocean Mail Roadside' (Fig. 4), `Hapupu Salt Marsh' (Fig. 5) and `Northeastern Shore' (Fig. 6). These areas have the most potential as black stilt foraging habitat and are therefore discussed in the most detail. Six sites (B, E, J, K, Q & R) within these three areas were described in detail; aquatic invertebrates and water chemistry were sampled at five sites (13, E, J, K, & Q).

All site descriptions, including water chemistry, are summarised in Table 2. Mean invertebrate biomasses in samples from 15 sites are presented in Figure 8, and total numbers of different invertebrate taxa found in the five samples from each site are listed in Table 3. Figure 9 compares the range and mean of mean invertebrate biomasses in samples taken on Chatham Island to the ranges and means of mean invertebrate biomasses in samples taken from the Tasman and Godley Deltas in winter.

The three areas where pied stilts were seen had large areas of open, flat space (80 - 400 m to banks over 0.3 m high), and only limited vegetation or debris suitable for predator cover (see Fig. 4 - 6). Spot water temperatures were higher than spot water temperatures taken in the Mackenzie Basin and it is extremely unlikely that foraging habitat would freeze up and become unavailable to black stilts. Water of foraging depth (< 18 cm) extended 2 to 5 m from the water edge. Shallows of this extent are also typical of black stilt foraging sites in the Mackenzie Basin. Thus, Ocean Mail Roadside, Hapupu Salt Marsh and North-eastern Shore would be physically suitable as black stilt foraging habitat.

Hay et al. (1970) and discussions with locals indicate that the lagoon outlet is more often closed than open. Closure occurs as a result of sand-bar build up and water levels may remain high for about five years (Hay et al., 1970). If water levels encroach on grazing land before the outlet opens naturally it may be mechanically opened by the local council but it often closes again within two years. The high water level at the time of the survey could therefore be regarded as normal. Extensive exposed flats, that would provide more extensive foraging habitat (but with unknown food supplies) can only be expected about a third of the time.

The remainder of the lagoon has limited foraging habitat (Fig. 3). The islands off Kahupiri Point have some exposed flats during low water levels as do the islands by Hikurangi Channel. The northwestern shoreline from Waikato Point to Mikitoroa Point has occasional shallow bays with a sandy substrate where marginal habitat exists and some foraging could occur. Otherwise the shoreline is relatively steep and in most places is heavily vegetated by rushes or bush to the waters edge (e.g. Fig. 7).

Several small freshwater lakes were surveyed along the eastern and northern shoreline. No waders were seen in these areas and they were generally heavily vegetated to the waters edge. Most however, had gently sloping pasture shores at one end which could attract waders if conditions on the main lagoon were unsuitable. A large number of temporary and semi-permanent small wetlands were evident between Te Whanga Lagoon and the north and east coasts. Most were on open pasture lands and would provide foraging habitat of unknown quality.

4.2 FOOD SUPPLIES

Aquatic invertebrate samples from the five sites sampled within these three areas were numerically dominated by amphipods, oligochaete worms and fly larvae, as were samples from most other sites (Table 3). Other invertebrate taxa (beetle, damselfly and moth larvae, molluscs, crabs, centipedes, millipedes, mites, spiders and isopods) occurred rarely and in low numbers. Oligochaete worms and fly larvae occur at similar densities at black stilt foraging sites in the Mackenzie Basin (Sanders 1996) to those found on Chatham Island. Oligochaete worms and fly larvae are undoubtedly taken by black stilts in the Mackenzie Basin. Although amphipods are very fast swimmers, black stilts would probably have no difficulty preying upon them, as they can easily capture fast swimming waterboatmen *(Sigara arguta)* (Sanders 1997).

Mean invertebrate biomass (± SEM), in samples from areas at which pied stilts had been observed foraging, ranged from 0.15 ± 0.06 to 0.36 ± 0.09 g/m 2 dry weight. These values are within the lower range of biomass in winter samples from the Mackenzie Basin (Fig. 9). However, black stilts forage at sites with similar invertebrate biomass (Sanders 1996). We consider that the type and quantity of aquatic invertebrate food supplies present, in June 1994, at sites B, E, J, K, & Q would be adequate for black stilts. When Te Whanga Lagoon is lower, extensive mudflats and sandbars are exposed. The nature of food supplies on such mudflats and sandbars is unknown.

Invertebrate samples from eight of the other ten sites were also dominated by amphipods, oligochaete worms and fly larvae, and most contained, on average, greater numbers and biomasses (Fig. 8) than samples from the three areas above. For example, samples from Kahupiri Point (site H) contained an average of 2.6 ± 0.67 g/m2 dry weight of invertebrates. Although food supplies were generally more abundant at these other sites, the physical habitat was always less suitable than at the above three areas: Shores were usually steep, shallows less extensive, and dense vegetation or steep banks were usually close to the water edge. Samples from six sites (B, C, D, M, N, Q) contained very low of invertebrate biomass (Fig. 8).

The high salinity at most sites sampled (Table 2) would exclude freshwater invertebrates with low salt tolerances, but at the same time is clearly suited to amphipods. Dissolved oxygen concentration was high, pH was well within the range encountered in the Mackenzie Basin, and spot temperatures were higher than those taken in the Mackenzie Basin in winter. These factors are unlikely to limit invertebrate production on Chatham Island.

4.3 FORAGING BEHAVIOUR OF PIED STILTS

The feeding rate of pied stilts at Ocean Mail Roadside (sites B, K & Q) ranged from 10 to 47 pecks/min, and averaged 28 pecks/min (three birds observed, five observations). Two searching rates of 40 and 82 steps/min were recorded at this site. These rates recorded fall within ranges of rates recorded for black stilts at various sites in the Mackenzie Basin during winter (e.g. from 4 to 60 pecks/min and 23 to 130 steps/min on the Tasman Delta). Foraging behaviour was observed but not measured at Hapupu Salt Marsh. Most foraging occurred in water less than about 10 cm deep, and pecks were directed mainly at the substrate. The foraging behaviour of pied stilts that we observed was similar to that of black stilts. This similarity suggests that black stilts would have no difficulty foraging on Chatham Island.

4.4 NESTING HABITAT

In our opinion the majority of the shoreline of Te Whanga Lagoon is unlikely to be attractive to black stilts for nesting. During low lagoon levels wind-generated water level fluctuations would flood nests situated on the exposed flats on a regular basis in the vicinity of the major foraging areas. There would be little or no nest building material available.

The following three areas, which are immediately behind the northern and eastern shores, appear suitable for black stilt nesting. They are the places where the greatest numbers of waders (including pied stilts) were seen.

a) Hapupu Saltmarsh (Sites E & J, Fig. 5)
This is a large flat area (500 m x 150 m) between the lagoon and vegetated sand dunes. It is covered with short saltmarsh vegetation close to the lagoon and short grazed pasture behind. There are scattered clumps of rushes but the area is largely open. It has a large number of shallow interconnected and isolated ponds. It appears to be permanently wet and above all but the highest of lagoon water levels.

b) Northeastern Shore (Site R, Fig. 6)
A developed pasture edge between Hapupu Saltmarsh and Ocean Mail Roadside. Similar to Hapupu Saltmarsh but slightly steeper with ponds on short grazed pasture closer to the lagoon edge. Very open with hardly any clumps of rushes. Twenty seven Pied Stilts were seen roosting in this area.About 2 km long.

c) Ocean Mail Roadside (Site B, Fig. 4)
A narrow strip of saline ponds between the road and main lagoon. Short pasture grass. Most of the freshwater lakes where marginal foraging habitat was recorded would have some potential for nesting. However straight-edged shorelines with a lack of spits/islands would probably not make them very attractive for nesting.

In addition to the above areas numerous small temporary and semi-permanent wetlands scattered about rough and developed pasture around the northern end of Te Whanga Lagoon would probably provide attractive nest sites for black stilts. The species' tendency to nest as isolated pairs could contribute to their decision to seek out such places. Many have small islands, spits and irregular shorelines.

4.5 PIED STILT NUMBERS

A total of 27 pied stilts, including two juveniles, were located. This was a greater number than expected. The 27 were all in one flock found roosting on the northeastern shore (site L) of Te Whanga Lagoon. Four adult pied stilts seen at Ocean Mail Roadside (sites B, K & Q) and four seen Hapupu Salt Marsh (sites E & J) on different occasions are believed to have come from the flock of 27. Local information suggests pied stilts are infrequently seen and most sightings are on the north and northeastern shores. A local farmer reports one sighting of 6 - 8 pied stilts at Lake Taia on the east coast during summer which may indicate that nesting occurs there.

The pied stilt observations have significance for any proposal to introduce black stilts to the island.

a) Their presence in greater numbers than expected and observations of feeding rates indicates that foraging habitat would be suitable for black stilts.

b) Pied stilts would have to be eliminated from the area to avoid hybridisation.

c) The presence of two pied stilt juveniles indicates that nesting probably occurs on Chatham Island.

4.6 PREDATORS

a) Cats *(Felis catus):* No wild cats were seen during the survey but they are present and widely distributed.

b) Rats *(Rattus* spp.): Norway and ship rats are present but we have no information on their numbers or distribution.

c) Kahu: Compared to the Mackenzie Basin, hawks are relatively low in numbers. Three were seen in 58 km of road travel in one day. They were observed hunting in wader areas and scavenging on road-killed weka.

d) Buff Weka *(Gallirallus australis hectori):* Weka were evident in all areas and local information suggests numbers are very high. They were seen in wet rush-covered areas close to wader foraging sites and we believe they would be a major threat to nesting stilts.

5. Potential for habitat enhancement

The physical habitat and food supply, at the time of our samples, are probably not limiting for black stilts. However, the lack of flood-free nest sites and the presence of cats, weka and kahu make the island unsuitable for black stilt releases. Nevertheless, with appropriate management, it should be possible to mitigate the effects of both of these limiting factors. Black stilt habitat could be enhanced by:

(1) creating raised or floating nesting areas, that have shallow gradients and are free from tall vegetation. These nest areas could be sited throughout the best stilt feeding areas and would provide areas for nesting and roosting that were always above the high water mark.

(2) management of predators by trapping and exclusion. The eastern side of Te Whanga Lagoon is a narrow sand spit and is geographically well suited to the construction of fences and trapping grids to reduce the movement and density of ground predators. Predators could also be excluded from individual lakes and ponds by constructing an enclosing predator-proof fence.

(3) mechanically working areas of edge that are presently unsuitable at high water levels (too steep, dense vegetation) to reduce gradients and clear vegetation. This technique would be best suited to lake and pond areas from which predators could be effectively removed.

6. Conclusions

The main Chatham Island is not a suitable location for the establishment of a black stilt population at this time, because of potential limitations in safe nest sites, and the presence of predators. Enhancement of key sites to increase nesting and feeding areas, and reduce predator abundance needs further investigation.

Following the success of releases of black stilt juveniles reared in captivity in the Mackenzie Basin, a similar method of liberation on Chatham Island could be considered after a careful study to investigate:

a) the breeding success of pied stilts on the island, and limitations to pied stilt population recruitment,

b) whether all pied stilts remain resident on the island,

c) whether landowners on Chatham Island would allow access and management activities on private land,

d) the attitude of islanders to elimination of the pied stilt population,

e) the attitude of islanders to the establishment of a new species on the island,

f) the potential to eliminate/control predators, including weka in some areas of the island.

The department should advocate/assist detailed research of predator biology on the island with emphasis on predatory behaviour of ground-nesting species.

7. References

Hay, R.F, Mutch, A.R.,Watters, W.A. 1970. *Geology of the Chatham Islands.* Geological Survey division of the Department of Scientific and Industrial Research.

Pierce, R.J. 1982.A comparative ecological study of Pied and Black Stilts in South Canterbury. PhD thesis, Zoology Department, University of Otago.

Pierce, R. J. 1984.The changed distributions of stilts in New Zealand. *Notornis 31:* 7-18.

Reed, C.E.M., Murray, D.P, Butler, D. 1993. *Black Stilt Recovery Plan.* Threatened Species Recovery Plan Series, Department of Conservation, Wellington.

Sanders, M. D. 1996. Effects of fluctuating lake levels and habitat enhancement on black stilts *(Himantopus novaezelandiae* Gould, 1841). Zoology Department. University of Canterbury, Christchurch, New Zealand. 223 pp.

Sanders, M. D. 1997. Food supplies at black stilt nest sites. *Science for Conservation 58:16.*

Table 1. Lakes and ponds, other than Te Whanga Lagoon, that were investigated during June 1994.

Lake or pond	Comments
L. Rangitai	No suitable edges - rushes. Invertebrates sampled at site D.
L. Pateriki	No suitable edge.
L. Te Wapu	Very minimal suitable edge.
L. Rotorua	Some suitable edge. Invertebrates sampled at site F.
L. Kaingarahu	No suitable edge.
L. Makuku	No suitable edge .
L. Kairae	Minimal suitable edge.
L. Taia	Minimal suitable edge.
Long Pond	Adjacent wet pasture with potential foraging areas.
L. Kaimoumi	No suitable edge.
L. Wharemani	No suitable edge.
L. Koomatu	No suitable edge.
Pakauwera Pond	No suitable edge.
L. Wharo	No suitable edge.
Tennants Lake	Minimal suitable edge.
L. Huro	Minimal suitable edge.
Numerous small ponds between Ocean Mail Beach and Te Whanga Lagoon	Ephemeral and semi-permanent wetlands. Variable size and edge types. Scattered small areas of potential feeding and nesting sites.

Table 2. Descriptions of physicochemical parameters and physical habitat at fifteen sites on Chatham Island. Sites at which pied stilts were observed foraging are indicated by *. Physical suitability of foraging and nesting habitat was judged as S = suitable, M = marginal, or U = unsuitable.

Site		Map reference (all NZMS 260 1:50 000)	Distance to bank > 0.3 m (m)	Distance to bank > 1.0 m (m)	Distance to 18 cm depth (m)	pH	Dissolved Oxygen conc. (mg/l)	Temp. (°C)	Salinity (‰)	Foraging suitability	Nesting suitability	Comments
A	Blind Jims Creek	456744	-	-	0.5	7.8	-	8.6	22	U	U	Grassy banks.
B*	Ocean Mail roadside	549775	80	100	5	8.4	11.6	11.6	15	S	M	Flooded shallow ponds back from lagoon edge. See site 'K', also.
C	Hapupu causeway pond	628736	5	10	1.5	7.6	11.1	10.7	3	S	U	Ephemeral wetland.
D	Lake Rangitai	640748	5	20	1	8.4	11.0	9.4	4	U	U	Dense rushes to water edge.
E*	Hapupu salt marsh	612720	150	150	4	7.6	10.2	9.8	4	S	S	Shallow muddy ponds back from lagoon edge. Many waders. See J.
F	Lake Rotorua	670767	150	150	1.5	7.8	11.0	9.4	4	S	U	Pasture to water edge.
G	Island near Titihaukai island	550695	6	1500	4	8.1	-	-	28	M	U	Dense rushes 3 m from water edge.
H	Kahupiri Point	557680	2	1500	0.5	8.1	-	-	25	M	U	Narrow spit.
I	Te Awainanga River mouth	547547	-	-	-	7.6	-	-	17	U	U	Water chemistry only measured, in deep water at mouth.
J*	Hapupu salt marsh	609718	400	400	2	7.9	11.6	10.0	18	S	S	Lagoon edge, hard sand/silt. See K.
K*	Ocean Mail roadside	545777	80	100	5	7.6	-	-	21	S	M	Lagoon edge adjacent to site 'B'.
L	Cemetery Point Roadside	452766	10	10	2	7.9	-	-	25	M	U	Probably too steep for black stilts
M	By airport road	496685	4	20	0.5	7.9	-	-	29	U	U	Too steep and not open enough.
N	Oringi Creek mouth	510697	0	20	-	8.1	-	-	6	U	U	Freshwater creek mouth. Sandy.
O	Airport end, old ford	521697	30	30	0.5	8.0	-	-	28	M	M	Open space but steep shore.
P	Matanginui Creek	463736	25	25	0.5	7.8	-	-	25	M	U	Probably too steep for black stilts.
Q*	Ocean Mail roadside	552775	50	70	2	8.0	-	-	26	S	M	Bays near Site 'B'.
R	Northeastern Shore	595745	500+	500+	-	-	-	-	-	S	S	27 pied stilts seen roosting here.

Table 3. Total numbers of aquatic invertebrates in five samples taken from fifteen sites on Chatham Island during June 1994. Samples were taken from 0.1 m2 areas of substrate in waters less than 18 cm deep. Cockle *(Chione stutchburyi)* abundances are shown in parentheses because the specimens found in samples were too large to be taken by black stilts. Cockles were therefore excluded from biomass measurements. Sites at which pied stilts were observed foraging are indicated by *.

Taxon			Site														
			B*	C	D	E*	F	G	H	J*	K*	L	M	N	O	P	Q*
INSECTA: Diptera	Ephydridae	?*Brachydeutera* sp.	42			1		5			8						6
	Ephydridae	unident. pupa	1			1		3	1								
	Stratiomyidae	Sp. 1	8	1			8				15	10			15	2	14
	"	Sp. 2						1									
	"	Sp. 3						2	1	14							
	Dolichopodidae	1 sp.	10			2			11				1	1			
	Psychodidae	1 sp.	1														
	Chironomidae	*Camptocladius* sp.		1		19	3		1								
	Muscidae	Sp. 1			3					1		11					
	"	Sp. 2				4	1	2	1	1	1	7			2	2	3
	Tipulidae	*Limonia* sp.					1										
	"	*Eriopterini* sp.				7				7							
	"	*Molophilus* sp.						1									
	Sarcophagidae	1 sp.												1			
INSECTA: Coleoptera	Curculionidae	*Deslantha ascita*						4		2	1						
	Hydrophiloidea	1 sp.									1						
INSECTA: Lepidoptera	unident. terr. larva	Sp. 1		2			18			2	2	1					
	"	Sp. 2									1						3
INSECTA: Odonata	Coenagrionidae	*Xanthocnemis tuanuii*															
ARACHNIDA: Araneae	Linyphiidae	?*Erigone* sp.		3			1				13	2					6
ARACHNIDA: Acarina		Sp. 1									1						5
DIPLOPODA		1 sp.													1		
CHILOPODA		1 sp.							1								
CRUSTACEA: Amphipoda	Talitridae	1 sp?	35		45	90	19	1746	1163	311	95	3888	56	1	1937	2006	130
CRUSTACEA: Isopoda	Sphaeromatidae	Sp. 1											1				
		Sp. 2						2									
		Sp. 3			2												
CRUSTACEA: Decapoda	Hymenosomatidae	*Halicarcinus varius*							1				2				
MOLLUSCA: Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum*					1										
MOLLUSCA: Pulmonata		1 sp.					3										
MOLLUSCA: Bivalvia	Veneridae	*Chione stutchburyi*	(1)								(18)				(1)		
OLIGOCHAETA: Lumbriculida	Lumbriculidae	?*Stylodrilus* sp.		4													
OLIGOCHAETA: Haplotaxida	Haplotaxidae	?*Haplotaxis* sp.			1				2					2	63	36	
	Lumbricidae	*Eiseniella tetraedra*		2			35										
	Naidae	?*Pristina idrensis*	2	15	1	233	1		583								
	Tubificidae	?*Telmatodrilus multiprostatus*				22	114	122		18	54	62	4	1	5		12

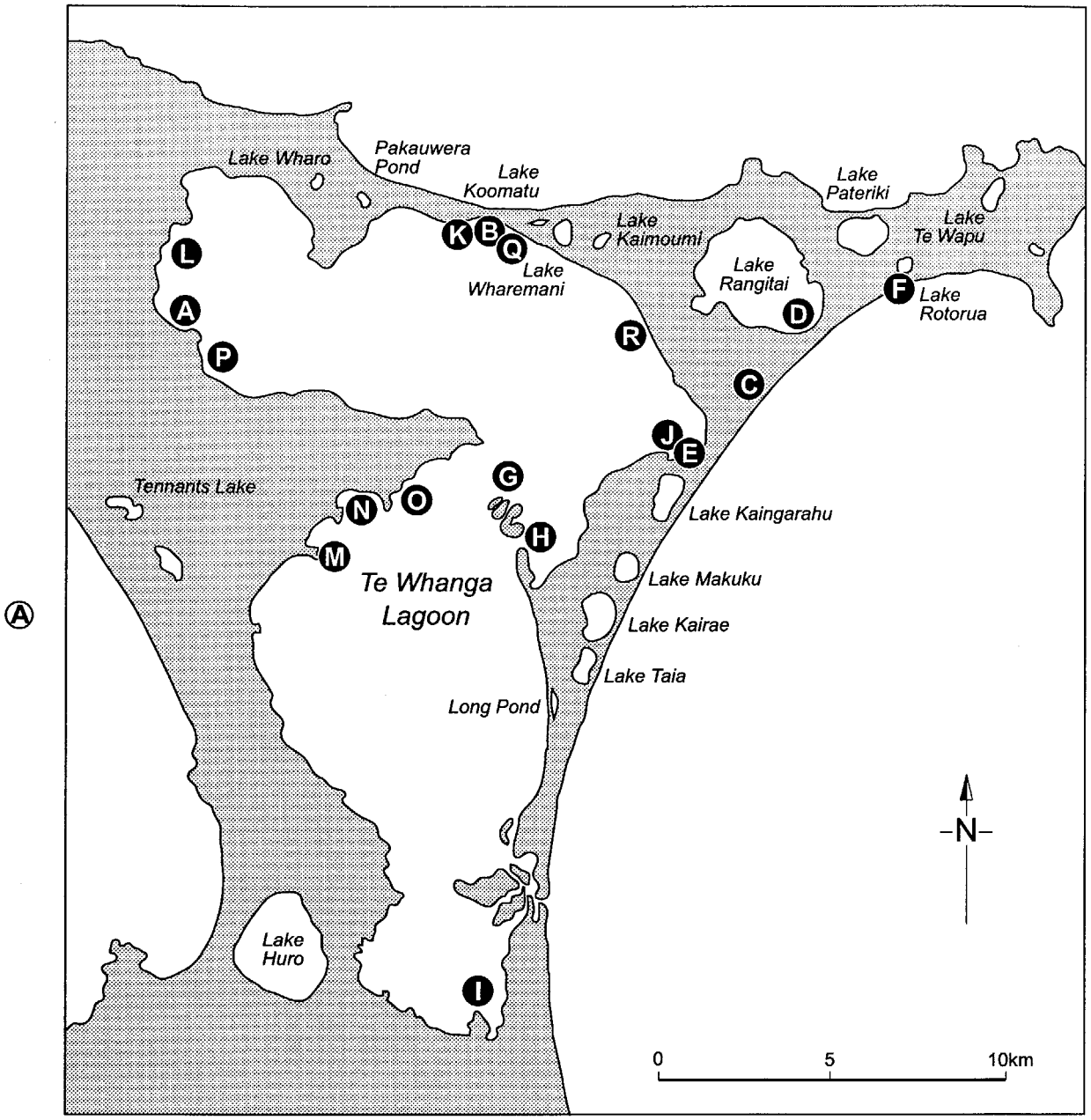

Figure 1. Chatham Island. Letters indicate sites that were described and/or sampled. See Table 2 for site descriptions.

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