

Records of the Auckland Museum

Volume 51 | 2016



TAMAKI PAENGA HIRA
AUCKLAND WAR MEMORIAL MUSEUM

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Hemideina gigantea !
Deinacrida heteracantha
Trans. N.Z. XXVII p. 144.
Colenso 355/31.

Captured 1838.
Described 1880.



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Cover image: Holotype of *Hemideina gigantea* Colenso, AMNZ21862. Photo: Peter Quin.

Table of Contents

Foreword	iv
Articles	
Fossil and Recent molluscan types in the Auckland War Memorial Museum. Part 1: Bivalvia Wilma M. Blom	1
Provenance of the type specimen of William Colenso's giant weta <i>Hemideina gigantea</i> . John W. Early	49
Biogeography and biodiversity of intertidal micromollusca of northern New Zealand Margaret S. Morley & Bruce W. Hayward	55
Ostracoda of the Cavalli Islands, Northland, New Zealand Margaret S. Morley & Bruce W. Hayward	79



Biogeography and biodiversity of intertidal micromollusca of northern New Zealand

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Abstract

Three hundred and sixty-seven species (91% endemic to New Zealand) of micromollusc (greatest dimension of adult shell <10 mm) are recorded from the intertidal zone of northern New Zealand. Many of these shells have been washed up dead from deeper water and thus the total diversity is more representative of the inner shelf (0-50 m), but at least 154 species have been found living in our intertidal surveys. Eleven of our species' records are provincial range extensions, two for the Aupourian Province (northeast coast) and nine for the Cookian Province (west coast). More than twice the number of micromolluscs live in the warmer Aupourian Province (361 spp.) than the west coast Cookian Province (157 spp.). Cluster analysis of 162 spring low-tidal survey localities based on presence/absence data (Jaccard coefficient) of 257 micromollusc species allows the recognition of nine associations that reflect increasing diversity from sheltered inner harbour localities (0-10 species per locality) out to partly sheltered-fully exposed localities around the entrance to the Hauraki Gulf (61-140 species per locality). The cluster subdivision also reflects the lower biodiversity on the open west coast shores compared to the east coast, partly a result of the greater range of habitats present on open east coast shores. The two inner and middle harbour associations occur in both the Waitemata and Manukau harbours on each coast. Two other associations that occur around the entrance to the Manukau Harbour also occur on the coast around the middle reaches of the Hauraki Gulf. One association is restricted to the exposed west coast of the Waitakere Ranges and Awhitu Peninsula and the remaining four associations are restricted to the coast of the inner, middle and outer Hauraki Gulf and Whangarei Harbour on the east coast..

Keywords

Auckland; Hauraki Gulf; intertidal micromolluscs; biogeography; biodiversity.

INTRODUCTION

Most ecological and conchological marine studies restrict their attention to the larger, more easily seen organisms, many of which belong to the phylum Mollusca. There is, however, a sizeable group of smaller molluscs (micromolluscs) that receive far less attention, largely because they require a hand lens or microscope to view them in sufficient detail to identify. Micromolluscs are defined as molluscs with the greatest dimension of their shell being less than 10 mm (Beu and Maxwell 1990). In fact many are considerably smaller than 5 mm. They are aesthetically rewarding as they include some of the most elegant and most beautifully sculptured shells of all molluscs. Although some micromolluscs belong to families in which large species predominate, the majority occur in relatively few families that are composed more or less exclusively of small species (Beu and Maxwell 1990). In most cases micromolluscs and juveniles of larger adult species can

be distinguished by differences such as the relative size or orientation of the protoconch (Morley 2000).

In this paper we provide results from the most extensive study so far undertaken in New Zealand of the geographic distribution of micromolluscs that either live intertidally or that get washed up intertidally as dead shells. We provide an assessment of the biodiversity of intertidal micromolluscs of northern New Zealand and the factors that influence the faunal differences between the east and west coasts and the sheltered to exposed parts of the Hauraki Gulf.

Previous Work

Suter (1913, 1915) was the first to provide a summary of the state of knowledge of the New Zealand molluscan fauna giving both descriptions and illustrations of over 1000 shells, many of them micromolluscs. Laws (1937-1940) published extensively on the Pyramidellidae. Ponder (1965a-c, 1968) was the next to make a major contribution to our knowledge of New Zealand

micromolluscs by providing illustrations, localities and comprehensive descriptions of both the shell and live animal. He mainly documented the micromollusc families Cingulopsidae, Eatonellidae, Rastodontidae, Rissoellidae and Anabathridae (as Rissoidae). Morton and Miller (1968: 205–209) described the habitats and life style of intertidal micromolluscs both on seaweeds and under stones mostly from northern New Zealand. In Powell's monumental work (1979) micromollusc descriptions were expanded, some based on Suter, Ponder and other earlier records. Beu and Maxwell (1990) dedicated a whole chapter to micromolluscs in their monograph on New Zealand fossil Cenozoic Mollusca.

Members of the Auckland Museum Conchology Section have made numerous small studies on micromolluscs of northern New Zealand. Among these were: Norman Gardner (1966, 1968, 1977); Ken Hipkins (1950, 1951, 1955, 1956, 1958, 1959) who published on micromolluscs of the families Columbidae and Rissoidae and of seaweed and stones. First author, Margaret Morley (2000, 2009) published observations on *Turbonilla*, *Evalea* and those inhabiting shipworm tubes (Morley and Bain 2007). She also documented the distribution of micromolluscs in Whangapoua Estuary, Coromandel Peninsula (Morley and Hayward 2006) and compared the micromollusc faunas and their tidal zonation in intertidal *Corallina* pools of Auckland's east and west coast harbours (Morley and Hayward 2010). Conchology Section members surveyed the intertidal shores of the Manukau Harbour including micromolluscs (Morley *et al.* 2011).

METHODS

This study has two parts: the first presents a species list of the intertidal micromolluscs and their locality records from northern New Zealand; the second is the quantitative biogeographic and diversity analyses of micromolluscs around Auckland and the Hauraki Gulf.

Study area and sources of species records

For the purposes of the first part of this study we have defined northern New Zealand as extending northwards from the Manukau Harbour, Firth of Thames and Coromandel Peninsula and including Great Barrier Island, but not the Three Kings or Kermadec islands.

The majority of the species records reported here have been made by the authors since 1995 while undertaking the semi-quantitative intertidal surveys described below for the second part of the study. These have been supplemented with the records from major surveys where the total biota has already been documented and published by us. These are, from north to south: Parengarenga Harbour (Hayward *et al.* 2001), Ahipara (Hayward *et al.* 2004), Kawerua (Hayward *et al.* 1995), Bay of Islands (Morley and Hayward 1999), Whananaki (Hayward *et al.* 2012), Great Barrier Island (Morley and Hayward 2009), Whangapoua, Coromandel Peninsula (Hayward *et al.* 2014), Waitemata Harbour (Hayward *et al.* 1999), Tamaki Estuary (Hayward and Morley 2008), Bucklands Beach (Morley 2002), Howick

Beach (Morley *et al.* 2001), Te Matuku Bay, Waiheke Island (Hayward *et al.* 1997), and the Waitakere Ranges and northern Manukau Harbour (Hayward and Morley 2004). Ad-hoc historical locality records dating back to 1980 made by one of us (MSM, Appendix 1) have also been included, together with observations of species made during snorkelling at shallow subtidal depths down to 1–3 m. These unpublished records consist of drawings, photographs and notes. A number of additional locality records have been added from Ponder (1965a–c) and Powell (1979).

Field

The second part of this study, around Auckland and the Hauraki Gulf, is based on the results of 162 extensive intertidal surveys undertaken by the authors over the past 15 years. Each survey aimed to provide a qualitative assessment of the abundance and occurrence of the live macrobiota and micromolluscs of a 0.5–2 km stretch of coast that was typically surveyed over a 2–4 hr period either side of a spring low tide. Each survey also recorded all the species of washed-up dead molluscan shells. Only some of the larger microscopic molluscs can be seen in the field, so the micromollusc data for this study was acquired by collecting samples of shelly sediment from all likely habitats (low tidal sediment, shell wash-ups, intertidal pools and gullies, under moveable rocks), collecting clumps of oysters or tube worms to break apart, shaking samples of seaweed into large plastic bags, and washing clinging micromolluscs off the undersides of intertidal cobbles.

Identifications

The shell sand and other samples were taken back to the laboratory, examined under a microscope and the micromollusc species identified by MSM. Often with microscopic gastropod shells it is difficult to determine whether the animal is alive and withdrawn deeply into the shell or the shell is empty. Although qualitative assessments of abundance of live micromolluscs were attempted (Appendix 1), it was decided that these determinations were unlikely to be reliable enough to use in our analyses. We used therefore only data on the presence or absence of micromollusc species (live and dead) at each survey site in our analyses. Identifying micromollusc shells under the microscope was more reliable for live taken specimens as they usually retained all the features useful for positive identification, whereas dead shells were often abraded and faded making identification less certain. The seminal taxonomic works of Ponder (1965a–c) and Powell (1979) were the main tools used for identifications. These have been updated using Spencer *et al.* (2014). Illustrations in the figures in this paper are the work of the first author (MSM) unless stated otherwise.

While we were undertaking this study, DNA sequencing was used by Nakano *et al.* (2009) to study the limpets of the genus *Notoacmea*. This molecular work was used to clarify the taxonomy of the common tiny intertidal limpets, that up until then had been lumped by us into the species *N. elongata* and *N. helmsi*. Unfortunately some of the genetically-distinguished

species (e.g. *N. elongata*, *N. daedala*) are impossible or very difficult to distinguish on shell characters alone. Thus we have retained the taxon *N. elongata* s.l. for our pre-2009 identifications and many of those shells subsequently found to be indistinguishable. Wherever identifications were possible from shell and soft part morphologies we have subsequently recorded *N. daedala*, *N. elongata*, *N. potae*, *N. rapida* and *N. turbatrix* (Table 1 – over page).

Voucher specimens of the majority of the micromollusc species recorded here have been placed in the collections of the Marine Department of the Auckland War Memorial Museum (catalogue numbers prefixed by MA).

Statistical analysis

To investigate the geographic distribution of micromolluscs around northern New Zealand, we undertook a Q-mode cluster analysis (Jaccard similarity coefficient) on our 162 survey sites based on the presence or absence of 257 micromollusc species in each. The analysis was undertaken using the MVSP statistical package (Kovach 1993) and a dendrogram classification produced using the unweighted pair group method with arithmetic mean. From the dendrogram we recognise nine locality cluster associations with nine samples unclustered. To identify the most characterising species of each association we calculated the persistence and fidelity of each species with respect to each association, where:

Persistence (P) = percentage of sites within the association in which the species occurs;

Fidelity (F) = degree to which a species is restricted to an association expressed as the percentage of sites within the association in which the species occurs less its mean percentage in the other associations.

ECOLOGICAL DISTRIBUTION

In this study we have records of at least 154 micromollusc species as living in intertidal habitats (Table 1). The remainder have only been recorded dead, washed up by storms and concentrated in shell lines on beaches or trapped in the sediment on the bottom of intertidal pools or under cobbles. Intertidal micromolluscs have been found living in a wide variety of habitats. Characteristic and more abundant species of these various habitats are cited here:

Living in low tidal fine sediment in sheltered harbours and estuaries: *Theora lubrica*, *Linucula hartvigiana*, *Arthritica bifurca*, *Odostomia* spp., *Turbonilla errabunda*;

In trails in low tidal sandy sediment: *Turbonilla* spp.;

Living in sediment under stable cobbles: *Anabathron* spp., *Merelina* spp., *Pisinna* spp., *Rissoina* spp. and *Turbonilla* spp.;

Grazing microalgae on high tidal rocks: *Austrolittorina antipodum*;

Attached to underside of high tidal rocks resting on mud: *Caecum digitulum*;

Attached to underside of low tidal rocks: *Anabathron hedleyi*, *Austromitra rubiginosa*, *Borniola reniformis*,

Sinezona brevis, *Zemitrella choava*;

Living in high tidal crevices, feeding on wave-tossed detritus: *Lasaea hinemoa*, *Leuconopsis obsoleta*;

Attached to underside of dead shells: *Notoacmea* spp.;

Inside clumps and dead shells of rock oysters

(*Saccostrea glomerata* and *Crassostrea gigas*):

Leuconopsis obsoleta, *Risellopsis varia*, *Fossarina*

rimata, *Notoacmea* spp.;

Inside clumps of the oyster *Ostrea stentina*: *Evalea*

sabulosa (Morley 2009);

Inside clumps of the tube worm *Spirobranchus*

cariniferus: *Leuconopsis obsoleta*, *Risellopsis varia*;

Living among the branchlets of coralline turf: *Lasaea*

hinemoa, *L. maoria* (Morley and Hayward 2010);

Living in sediment in the bottoms of coralline

turf-lined pools and low-tidal gullies: *Anabathron*

hedleyi, *Eatonina* spp., *Eatoniella olivacea*, *Neolepton*

antipodum, *Tubbreva exigua*, *Zalipais lissa* (Morley

and Hayward 2010);

Attached to the red seaweed *Vidalia colensoi*:

Gaimardia finlayi;

Clinging to other larger seaweeds: *Eatoniella* spp.,

Rissoella spp.

Attached inside the holdfasts of larger seaweed:

Hiatella arctica;

Inside rotting wood and the empty tunnels of the

shipworm, *Bankia australis*: *Leuconopsis obsoleta*

(Morley and Bain 2007);

Inside the mantle of the rock borer, *Barnea similis*:

Arthritica crassiformis;

Parasitic or commensal on the holothurian *Trochodota*:

Scintillona zelandica;

Parasitic on polychaete worms: *Odostomia incidata*.

Commensal and attached by byssal threads to the anal spines of the heart urchin *Echinocardium cordatum*: *Montacuta semiradiata*.

SPECIES DIVERSITY

A total of 367 species of micromolluscs have been recorded here from the intertidal zone of northern New Zealand. Of these 154 have been found definitely alive in the intertidal. Of the remainder, some may live intertidally but probably the majority live subtidally and have been washed up dead. These dead washed-up shells are more diverse on more open coasts than inside harbours and the inner Hauraki Gulf.

To more objectively document geographic trends in species diversity, this section only uses diversity data derived from our study sites that were surveyed by consistent methods. There is a clear trend in increasing species diversity moving from the inner lower salinity parts (0-10 spp.) of harbours and estuaries (Manukau and Waitemata Harbours, Tamaki Estuary, Firth of Thames) out towards the more normal salinity outer parts (11-40 spp.) with more diverse habitats (particularly rocky shore habitats) (Fig. 1). On the east coast there is a clear trend of increasing micromollusc diversity from the more sheltered inner Hauraki Gulf and Firth of Thames (11-30 spp.) through the middle reaches (31-60 spp.) to the outer (50-140 spp.). On the west coast there is a

Table 1. List of intertidal micromolluscs (<10 mm greatest dimension) from northern New Zealand giving their distribution in terms of five subregions and in terms of New Zealand provinces (Powell, 1955). Province abbreviations are: A = Aupourian, C = Cookian, F = Forsterian, K = Kermadecian, M = Moriorian, An = Antipodian, with E = endemic to New Zealand. x = present. Species names have been updated to Spencer *et al.* (2014).

	Regions	NE coast Cape Maria - Whangarei 313 spp. 134 spp.	Hauraki Gulf - Whangarei- Miranda 234 spp. 146 spp.	Great Barrier and Coromandel 258 spp. 132 spp.	NW coast Ahipara- Hokianga 108 spp. 79 spp.	W coast Kaipara- Awhitu 115 spp. 73 spp.	Live
Number of species (total)							
Number of species (living intertidally)							154
Gastropoda							
<i>Aequispirella finlayi</i> (Powell, 1933)	A,C,M,E	x		x		x	x
<i>Agatha georgiana</i> (Hutton, 1885)	A,C,F,M,E	x	x	x			
<i>Alvania gallinacea</i> (Finlay, 1930)	A,E			x			
<i>Alvania pinguoides</i> (Powell, 1940)	A,E	x					
<i>Ammonicera</i> sp. 4 (Marshall sp. 2000)		x	x	x			x
<i>Ammonicera</i> spp.		x	x	x		x	x
<i>Amphithalamus falsestea</i> (Ponder, 1968)	A,C,E	x	x	x	x	x	x
<i>Amphithalamus incidatus maoria</i> (Ponder, 1968)	A,C,E	x	x				x
<i>Amphithalamus ornatus</i> (Powell, 1927)	A,E	x		x			
<i>Amphithalamus semen</i> (Odhner, 1924)	A,C,M,E	x	x	x		x	x
<i>Anabathron angulatum</i> (Powell, 1927)	A,E		x				
<i>Anabathron elongatum</i> (Powell, 1927)	A,E	x	x	x			x
<i>Anabathron excelsum</i> (Powell, 1933)	A,E	x	x	x			x
<i>Anabathron hedleyi</i> (Suter, 1908)	A,C,F,M,E	x	x	x	x	x	x
<i>Anabathron ovatum</i> (Powell, 1927)	A,C,E	x	x	x	x	x	x
<i>Anabathron rugulosum</i> (Powell, 1930)	A,E	x	x	x	x		x
<i>Anatoma</i> cf. <i>regia</i> (Mestayer, 1916)	A,C,F			x			
<i>Aoteadrillia wanganuiensis</i> (Hutton, 1873)	A,C,F,E			x			
<i>Argalista fluctuata</i> (Hutton, 1883)	A,C,F,M,An,E	x	x	x			x
<i>Argalista imperforata</i> Powell, 1940	A,C,F,E	x					
<i>Assimineia vulgaris</i> (Webster, 1905)	K,A,C	x	x	x		x	x
<i>Asteracmea suteri</i> (Iredale, 1915)	A,C,F,An,E	x	x	x	x	x	
<i>Ataxocerthium huttoni</i> (Cossmann, 1895)	A,C,F,E		x				
<i>Attenuata bollonsi</i> (Powell, 1930)	A,E	x		x			
<i>Attenuata manawatawhia</i> (Powell, 1937)	A,E	x		x			
<i>Austrodrillia rawitensis</i> Hedley, 1922	A,C,E	x	x	x			
<i>Austrodrillia secunda</i> Powell, 1965	A,E	x		x			
<i>Austrolittorina antipodum</i> (Philippi, 1847)	K,A,C,F,M,E	x	x	x	x	x	x
<i>Austromitra rubiginosa</i> (Hutton, 1873)	A,C,F,M,E	x	x	x	x	x	x
<i>Awanuia dilatata</i> Powell, 1927	A,E	x					
<i>Awanuia porcellana</i> Ponder, 1967	A,C,E	x					
<i>Bouchettriphora pallida</i> (Pease, 1870)	K,A,C	x	x	x	x		x
<i>Caecum digitulum</i> Hedley, 1904	A,C,F,M,An,E	x	x	x	x	x	x
<i>Cantharidus dilatatus</i> (G.B. Sowerby II, 1870)	A,C,F,M,E	x	x	x		x	x
<i>Cavolinia inflexa</i> (Lesueur, 1813)	A,C	x					
<i>Cerithiella stiria</i> (Webster, 1906)	A,E	x		x	x		
<i>Cerithiopsidae</i> indet.			x	x			
<i>Cerithiopsis powelli</i> B.A. Marshall, 1978	K,A,C,E			x			
<i>Cirsonella</i> aff. <i>consobrina</i> Powell, 1930	A,E			x			
<i>Cirsonella</i> aff. <i>laxa</i> Powell, 1937	A,C,An,E		x		x		x
<i>Cirsonella paradoxa</i> Powell, 1937	A,E	x	x				
<i>Cirsonella variegostata</i> Powell, 1940	A,F,E		x	x			
<i>Crassitiella carinata</i> Ponder, 1965	A,E	x	x	x	x		x
<i>Crosseola cuvieriana</i> (Mestayer, 1919)	A,E	x		x			
<i>Curveulima aupouria</i> (Powell, 1937)	A,C,E	x					
<i>Curveulima bollonsi</i> ? (Powell, 1937)	A,E	x					
<i>Curveulima titahica</i> (Suter, 1908)	A,C,E	x	x				
<i>Cylichna thetidis</i> Hedley, 1903	K,A	x	x	x			x
<i>Cylichna zealandica</i> Kirk, 1880	A,C,E	x					
<i>Cystiscus vidae</i> (Dell, 1956)	A,C,E	x		x			
<i>Dentimargo amoena</i> (Suter, 1908)	A,An,E	x			x		
<i>Dentimargo cairoma</i> (Brookes, 1924)	A,C,M,E	x	x	x	x	x	x
<i>Diaphana brazieri</i> Angas, 1877	A,F,An	x		x			
<i>Dolicrossea vesca</i> Finlay, 1926	A,C,M,E	x		x	x		
<i>Eatoniella albocolumella</i> Ponder, 1965	A,C,M,E	x	x	x	x	x	x

	Regions	NE coast Cape Maria - Whangarei	Hauraki Gulf Whangarei- Miranda	Great Barrier and Coromandel	NW coast Ahipara- Hokianga	W coast Kaipara- Awhitu	Live
<i>Eatoniella atervisceralis</i> Ponder, 1965	A,C,F,M,E	x	x		x	x	x
<i>Eatoniella atropurpurea</i> (Frauenfeld, 1867)	A,C,F,M	x	x	x			x
<i>Eatoniella delli</i> Ponder, 1965	A,C,E	x	x	x		x	x
<i>Eatoniella dilatata</i> (Powell, 1955)	A,C,F,M,An,E	x	x	x		x	x
<i>Eatoniella flammulata</i> (Hutton, 1878)	A,C,E	x	x	x	x		x
<i>Eatoniella globosa</i> Ponder, 1965	A,E		x	x		x	x
<i>Eatoniella latebricola</i> Ponder, 1965	A,C,E		x	x		x	
<i>Eatoniella limbata</i> (Hutton, 1883)	A,C,F,M,E	x	x	x	x	x	x
<i>Eatoniella lutea</i> (Suter, 1908)	A,C,E	x	x	x			x
<i>Eatoniella mortoni</i> Ponder, 1965	A,C,M,E	x	x	x	x	x	x
<i>Eatoniella notalabia</i> Ponder, 1965	A,C,F,M,An,E	x	x	x	x	x	x
<i>Eatoniella notata</i> Ponder & Yoo, 1978	A,C,E	x	x	x		x	x
<i>Eatoniella olivacea</i> (Hutton, 1882)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Eatoniella perforata</i> Ponder, 1965	A,E		x	x			x
<i>Eatoniella pfefferi</i> (Suter, 1909)	A,C,F,M,An,E		x	x	x	x	x
<i>Eatoniella pullmitra</i> Ponder, 1965	A,C,F,M,E	x	x				x
<i>Eatoniella puniceomacer</i> Ponder, 1965	A,E	x	x	x			
<i>Eatoniella roseocincta</i> (Suter, 1908)	A,C,E	x	x	x		x	
<i>Eatoniella roseola</i> (Iredale, 1915)	A,C,F,M,An,E	x	x	x		x	
<i>Eatoniella roseospira</i> (Powell, 1937)	A,C,E	x	x	x	x	x	x
<i>Eatoniella tenella</i> (Powell, 1937)	A,E	x	x	x			x
<i>Eatoniella varicolor</i> Ponder, 1965	A,C,F,E	x	x	x		x	x
<i>Eatonina atomaria</i> (Powell, 1933)	A,C,F,M,An,E	x	x	x		x	x
<i>Eatonina crassiscarinata</i> ? (Powell, 1937)	A,E				x		
<i>Eatonina maculosa</i> Ponder, 1965	A,E			x			
<i>Eatonina micans</i> (Webster, 1905)	A,C,An,E	x	x	x		x	x
<i>Eatonina subflavescens</i> (Iredale, 1915)	A,C,An,E	x	x	x	x	x	x
<i>Elachorbis subiatei</i> (Suter, 1907)	A,C,F,An,E	x	x	x			
<i>Eulima perspicua</i> (Oliver, 1915)	K,A,C,E	x	x	x		x	x
<i>Eulimella coena</i> Webster, 1905	A,E		x				
<i>Eulimella levilirata</i> Murdoch & Suter, 1906	A,C,F,M,E	x	x	x		x	x
<i>Evalea sabulosa</i> (Suter, 1908)	A,C,F,M,An,E		x	x			x
<i>Fictonoba carnosus carnosus</i> (Webster, 1905)	A,C,E	x	x	x			x
<i>Fictonoba rufolactea</i> (Suter, 1908)	A,C,E	x	x	x		x	x
<i>Fossarina rimata</i> (Hutton, 1884)	A,C,E	x	x	x	x	x	x
<i>Fusculima mangonui</i> (Powell, 1940)	A,E	x	x	x			x
<i>Gibberula ficula</i> (Murdoch & Suter, 1906)	A,C,F,E	x		x			
<i>Graphis blanda</i> (Finlay, 1924)	A,F,E		x	x			x
<i>Gumina dolichostoma</i> (Suter, 1908)	A,C,F,M,E	x	x	x			
<i>Gumina minor</i> Laws, 1940	A,E	x	x				
<i>Halopyrgus pupoides</i> (Hutton, 1882)	FW:N,S,E	x	x	x			x
<i>Heliconoides inflata</i> (d'Orbigny, 1836)	A,C	x		x			
<i>Herpetopoma bellum</i> (Hutton, 1873)	A,C,M,E	x	x	x	x	x	
<i>Herpetopoma larochei</i> (Powell, 1926)	A,C,E	x		x	x		
<i>Heterocithara mediocris</i> Odhner, 1924	A,E	x		x			
<i>Horologica dirempta</i> (Odhner, 1924)	A,E			x			
<i>Hypermastus bulbula</i> (Murdoch & Suter, 1906)	A,E	x		x	x		
<i>Incisura lytteltonensis</i> (E.A. Smith, 1894)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Incisura rosea</i> (Hedley, 1904)	A,C,F,M,An,E	x	x	x		x	x
<i>Iravadia inflata</i> (Ponder, 1967)	A,E	x		x			
<i>Ividella maoria</i> Powell, 1940	A,E	x					
<i>Laevitorina alta</i> (Powell, 1940)	A,E		x	x			x
<i>Larochea miranda</i> Finlay, 1927	A,E	x					
<i>Larochella alta</i> Powell, 1927	A,C,F,M,E	x	x	x	x		x
<i>Leuconopsis obsoleta</i> (Hutton, 1878)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Leucosyrinx eremita</i> (Murdoch & Suter, 1906)	A,E	x		x			
<i>Linopyrga rugata rugata</i> (Hutton, 1886)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Liotella indigena</i> Finlay, 1926	A,E	x					
<i>Liotella polypheura</i> (Hedley, 1904)	A,C,F,M,An,E	x	x	x		x	x
<i>Liratilia compta</i> Powell, 1930	A,C,E	x					
<i>Liratilia conquisita conquisita</i> (Suter, 1907)	A,C,F,An,E	x		x			
<i>Liratilia elegantula</i> Powell, 1937	A,E	x					
<i>Liratilia sinuata</i> Powell, 1937	A,E	x					

– Table 1 continued over page

	Regions	NE coast Cape Maria - Whangarei	Hauraki Gulf Whangarei- Miranda	Great Barrier and Coromandel	NW coast Ahipara- Hokianga	W coast Kaipara- Awhitu	Live
<i>Liratilia subnodosa</i> Powell, 1934	A,E	x					
<i>Lissotestella tryphenensis</i> (Powell, 1931)	A,E			x			
<i>Lodderena formosa</i> Powell, 1930	A,FE	x	x	x	x		
<i>Lodderia iota</i> Powell, 1940	A,C,E	x	x	x		x	x
<i>Lodderia waitemata</i> Powell, 1940	A,E	x	x	x			x
<i>Macrazafra enwrighti</i> Powell, 1940	A,E	x					
<i>Macrazafra mariae</i> Powell, 1940	A,E	x					
<i>Macrazafra nodicincta</i> (Suter, 1899)	A,C,FE	x		x			
<i>Macrazafra subabnormis</i> (Suter, 1899)	A,C,M,E	x	x	x	x		
<i>Manzonina gemmata</i> (Powell, 1927)	A,E	x	x				
<i>Maoritomella albula</i> (Hutton, 1873)	A,C,FE	x	x	x			x
<i>Melanella</i> sp.		x	x	x			
<i>Mendax ?trizonalis trizonalis</i> (Odhner, 1924)	A,E	x					
<i>Merelina compacta</i> Powell, 1927	A,E	x	x	x	x		
<i>Merelina coronata</i> (Powell, 1926)	A,E	x					
<i>Merelina crassissima</i> Powell, 1937	A,E	x					
<i>Merelina crosseiformis</i> (Powell, 1926)	A,E	x	x	x			
<i>Merelina foliata</i> (Suter, 1908)	A,F,M,An,E	x					
<i>Merelina lacunosa</i> (Powell, 1940)	A,E	x	x	x			
<i>Merelina lyalliana</i> (Suter, 1898)	A,C,E	x	x	x	x	x	x
<i>Merelina manawatawhia</i> Powell, 1937	A,E	x					
<i>Merelina superba</i> Powell, 1927	A,C,E	x	x	x			
<i>Merelina taupoensis</i> Powell, 1939	A,C,E	x	x	x	x		x
<i>Merelina tricarinata</i> (Powell, 1937)	A,E		x				
<i>Mesoginella koma</i> B.A. Marshall, 2004	A,C,E	x	x	x	x		x
<i>Mesoginella larochei</i> (Powell, 1932)	A,C,E	x			x		
<i>Mesoginella tryphenensis</i> (Powell, 1932)	A,E	x			x		
<i>Mesoginella vaiiei</i> (Powell, 1932)	A,E	x	x	x			
<i>Metaxia duplicarinata</i> (Powell, 1940)	A,E	x	x				
<i>Metaxia exaltata</i> (Powell, 1930)	K,A,C,E	x	x	x			
<i>Micrelenchus huttonii</i> (E.A. Smith, 1876)	A,C,FE	x	x		x	x	x
<i>Micrelenchus sanguineus</i> (Gray, 1843)	A,C,FE	x	x	x	x	x	x
<i>Microlenchus tenebrosus</i> (A. Adams, 1853)	A,C,FE				x	x	
<i>Micrelenchus tessellatus</i> (A. Adams, 1853)	A,C,FE	x	x	x	x	x	x
<i>Microcarina crenulata</i> (Powell, 1937)	A,E	x	x				
<i>Microdryas striatus</i> (Powell, 1927)	A,E	x					
<i>Microtralia insularis</i> (Powell, 1933)	A,C,E	x	x	x		x	
<i>Microvoluta marginata</i> (Hutton, 1885)	A,C,F,An,E	x		x			
<i>Monodilepas diemenensis</i> Finlay, 1930	A,E	x	x	x			
<i>Monophorus fascelinus</i> (Suter, 1908)	A,C,F,An,E	x	x	x			
<i>Munditia delicatula</i> Powell, 1940	A,E	x					
<i>Munditia serrata</i> (Suter, 1908)	A,E	x					
<i>Munditia tryphenensis</i> (Powell, 1926)	A,E	x		x			
<i>Naricava neozelanica</i> Powell, 1940	A,E	x	x				
<i>Nepotilla nitidula</i> Powell, 1940	A,E	x	x	x			
<i>Notoacmea daedala</i> (Suter, 1907)	A,C,FE	x	x	x	x	x	
<i>Notoacmea elongata</i> (Quoy & Gaimard, 1834) s.l.	A,C,FE	x	x	x	x	x	x
<i>Notoacmea parviconoidea</i> (Suter, 1907)	A,C,F,M,E	x	x	x	x	x	x
<i>Notoacmea potae</i> Nakano et al., 2009	A,C,FE	x				x	x
<i>Notoacmea rapida</i> Nakano et al., 2009	A,C,FE	x	x			x	x
<i>Notoacmea scapha</i> (Suter, 1907)	A,C,FE	x	x	x		x	
<i>Notoacmea scopulina</i> Oliver, 1926	A,C,E	x	x	x	x	x	x
<i>Notoacmea subtilis</i> (Suter, 1907)	A,C,FE	x	x	x	x	x	x
<i>Notoacmea turbatrix</i> Nakano et al., 2009	A,C,FE	x			x		x
<i>Nototriphora aupouria</i> (Powell, 1937)	K,A,C,E	x	x				
<i>Nozeba emarginata</i> (Hutton, 1885)	A,C,FE	x	x	x	x	x	x
<i>Odostomia chordata</i> Suter, 1908	A,E	x	x				
<i>Odostomia geoffreyi</i> ? Laws, 1939	A,C,E					x	
<i>Odostomia haurakiensis</i> Laws, 1939	A,E	x	x				
<i>Odostomia incidata</i> Suter, 1908	A,C,F,An,E	x	x	x	x	x	x
<i>Odostomia pudica</i> Suter, 1908	A,E	x	x				
<i>Odostomia takapunaensis</i> Suter, 1908	A,C,E		x	x	x	x	x
<i>Odostomia vaga</i> Laws, 1939	A,C,F,An,E			x			

	Regions	NE coast Cape Maria - Whangarei	Hauraki Gulf - Whangarei- Miranda	Great Barrier and Coromandel	NW coast Ahipara- Hokianga	W coast Kaipara- Awhitu	Live
<i>Odostomia vestalis</i> Murdoch, 1905	A,E	x	x	x			
<i>Omalogyra ammonitoides</i> (Powell, 1940)	A,C	x	x			x	x
<i>Omalogyra fusca</i> Suter, 1908	A,C,E		x				x
<i>Onoba aupouria</i> (Powell 1940)	A,E	x					
<i>Onoba candidissima</i> (Webster, 1905)	A,C,E	x	x	x			x
<i>Onoba elegans</i> (Ponder, 1965)	A,E	x					
<i>Onoba fumata</i> (Suter, 1898)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Onoba iredalei</i> (Powell, 1937)	A,E	x	x	x			
<i>Onoba obliquata</i> (Powell, 1940)	A,E	x					
<i>Orbitestella parva</i> (Finlay, 1924)	A,C,F,M,An,E	x	x	x		x	x
<i>Orbitestella toreuma</i> Powell, 1930	A,M,E	x	x	x			
<i>Paxula paxillus</i> (Murdoch, 1905)	A,C,F,E	x	x	x	x		x
<i>Peculator hedleyi</i> (Murdoch, 1905)	A,E	x		x			
<i>Philine powelli</i> Rudman, 1970	A,C,F,E	x	x	x			
<i>Pisinna rekohuana</i> (Powell, 1933)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Pisinna manawatawhia</i> (Powell, 1937)	A,E	x	x	x			x
<i>Pisinna olivacea impressa</i> (Hutton, 1885)	A,C,M,E	x	x	x	x	x	x
<i>Pisinna praecidecostata</i> (Ponder, 1965)	A,E	x					
<i>Pisinna semiplicata</i> (Powell, 1927)	A,E	x	x	x	x		x
<i>Pisinna semisulcata</i> (Hutton, 1885)	A,E	x		x			x
<i>Pisinna subrufa</i> (Powell, 1937)	A,E	x					
<i>Pisinna zosterophila</i> (Webster, 1905)	A,C,E	x	x	x	x	x	x
<i>Potamopyrgus estuarinus</i> Winterbourn, 1971	FW:N,S,E	x	x	x	x	x	x
<i>Powellisetia bilirata</i> Ponder, 1965	A,E			x			
<i>Powellisetia crassilabrum</i> (Powell, 1940)	A,E	x		x			
<i>Powellisetia subgradata</i> (Powell, 1937)	A,E			x			
<i>Powellisetia subtenuis</i> (Powell, 1937)	A,C,F,M,An,E	x	x	x			
<i>Powellisetia unicarinata</i> (Powell, 1930)	A,E	x		x			
<i>Proxiuber australe</i> (Hutton, 1878)	A,E	x	x	x			
<i>Pseudestea crassiconus</i> (Powell, 1933)	A,E		x	x			x
<i>Pseudotorinia amoena</i> (Murdoch & Suter, 1906)	A,C	x		x			
<i>Pseudovermis hancocki</i> Challis, 1969	A,E	x					
<i>Pusillina aupouria</i> (Powell, 1937)	A,E			x			
<i>Pusillina finlayi</i> (Powell, 1937)	A,E	x					
<i>Pusillina hamiltoni</i> (Suter, 1898)	A,C,F,M,E	x	x	x	x		x
<i>Pusillina infecta</i> (Suter, 1908)	A,C,F,M,E	x	x	x		x	x
<i>Pusillina latiambita</i> (Ponder, 1967)	A,E			x		x	x
<i>Pusillina mobilicosta</i> (Ponder, 1967)	A,C,E	x	x	x			x
<i>Pusillina semireticulata</i> (Murdoch & Suter, 1906)	A,E	x	x	x			
<i>Pusillina sinuastoma</i> (Ponder, 1967)	A,E		x	x			
Pyramidellidae indet.						x	
<i>Pyramidelloides pagoda</i> (Powell, 1926)	A,E	x		x			
<i>Radinista scalarina</i> Powell, 1940	A,E			x			
<i>Rastodens puerilis</i> Ponder, 1966	A,C,F,E	x	x				
<i>Retusa opima</i> (Finlay, 1926)	A,C,E	x					
<i>Retusa oruaensis</i> (Webster, 1908)	A,C,F,M,E	x	x	x	x	x	x
<i>Risellopsis varia</i> (Hutton, 1873)	A,C,F,M,E	x	x	x	x	x	x
<i>Rissoella cystophora</i> (Finlay, 1924)	A,C,F,M,E	x	x	x	x	x	x
<i>Rissoella elongatospira</i> Ponder, 1966	A,C,F,M,An,E	x	x	x	x		x
<i>Rissoella flemingi</i> Ponder, 1968	A,C,F,M,An,E	x	x	x		x	x
<i>Rissoella micra</i> (Finlay, 1924)	A,C,F,M,An,E	x	x	x		x	x
<i>Rissoella</i> n.sp.		x	x	x			x
<i>Rissoella rissoaformis</i> (Powell, 1939)	A,C,F,An,E	x	x	x	x	x	x
<i>Rissoina achatina</i> Odhner, 1924	A,E	x		x			x
<i>Rissoina achatinoides</i> Powell, 1937	A,E	x	x				
<i>Rissoina anguina</i> Finlay, 1926	A,C,E	x	x	x	x		x
<i>Rissoina chathamensis</i> (Hutton, 1873)	A,C,F,M,E	x	x	x	x	x	x
<i>Rissoina fictor</i> Finlay, 1930	A,E	x	x	x			
<i>Rissoina fucosa</i> Finlay, 1930	A,C,E	x	x	x		x	x
<i>Rissoina zonata</i> Suter, 1909	A,E	x		x	x		x
<i>Roseaplagis rufozona</i> (A. Adams, 1853)	A,C,E	x	x	x			
<i>Sagenotriphora ampulla</i> (Hedley, 1903)	K,A,C	x	x	x	x	x	x

– Table 1 continued over page

	Regions	NE coast Cape Maria Whangarei	Hauraki Gulf Whangarei- Miranda	Great Barrier and Coromandel	NW coast Ahipara- Hokianga	W coast Kaipara- Awhitu	Live
<i>Scissurellidae</i> indet.			x				
<i>Scrinium neozelanicum</i> (Suter, 1908)	A,E	x		x			
<i>Scrupus hyalinus</i> (Odhner, 1924)	A,M,E	x	x				
<i>Seila cincta</i> (Hutton, 1885)	A,C,M,E	x	x	x	x		x
<i>Seila terebelloides</i> (Hutton, 1873)	A,C,F,An,E	x	x	x			x
<i>Serrata fasciata</i> (G.B. Sowerby II, 1846)	A,C,E	x	x	x	x		
<i>Sinezona brevis</i> (Hedley, 1904)	A,C,F,M,An,E	x	x	x		x	x
<i>Sinezona laqueus</i> (Finlay, 1926)	A,C,F,M,An,E			x			
<i>Skenella spadix</i> (Ponder, 1965)	A,E		x	x			x
<i>Solariella tryphenense</i> (Powell, 1930)	A,E	x		x			
<i>Striarcana cryptolina</i> Laws, 1937	A,C,M,E	x					
<i>Striodostomia orewa</i> Laws, 1940	A,E	x	x		x		
<i>Suterilla neozelanica</i> (Murdoch, 1899)	A,C,M,E	x	x	x		x	
<i>Synthopsis acuminata</i> B.A. Marshall, 1978	A,C,E		x				
<i>Synthopsis caelata</i> (Powell, 1930)	A,C,E	x	x	x			x
<i>Syrnola crawfordi</i> Powell, 1927	A,E	x	x		x		
<i>Syrnola lurida</i> (Suter, 1908)	A,E	x	x	x	x		
<i>Syrnola menda</i> Finlay, 1926	A,E	x		x			
<i>Terelimella aupouria</i> (Powell, 1937)	A,E	x			x		
<i>Terelimella larochei</i> (Powell, 1930)	A,M,E	x	x	x			x
<i>Trichosirius inornatus</i> (Hutton, 1873)	A,C,F,M,E	x	x	x		x	
<i>Trimusculus conicus</i> (Angas, 1867)	K,A,C,F,M	x			x	x	
<i>Tubbreva exigua</i> (Ponder, 1965)	A,C,F,E	x	x	x		x	x
<i>Tubbreva minutula</i> (Powell, 1937)	A,E	x					
<i>Turbonilla aoteana</i> (Powell, 1930)	A,E		x	x			
<i>Turbonilla barrierensis</i> (Laws, 1937)	A,E		x				x
<i>Turbonilla bucknilli</i> (Laws, 1937)	A,C,E	x	x	x		x	x
<i>Turbonilla cookiana</i> (Laws, 1937)	A,E		x	x			
<i>Turbonilla finlayi</i> Powell, 1926	A,C,E	x					
<i>Turbonilla kingi</i> (Laws, 1937)	A,E	x	x	x			
<i>Turbonilla</i> spp.		x	x	x	x	x	x
<i>Turbonilla verecunda</i> (Laws, 1937)	A,E			x			
<i>Turbonilla vigilia</i> (Laws, 1937)	A,E			x			
<i>Uberella</i> cf. <i>vitrea</i> (Hutton, 1873)	A,E	x	x	x			
<i>Uttleya ahiparana</i> (Powell, 1927)	A,E				x		
<i>Volvulella nesentus</i> (Finlay, 1926)	A,C,E	x		x	x	x	
<i>Williamia radiata nutata</i> (Hedley, 1908)	K,A	x					
<i>Xymenella pusilla</i> (Suter, 1907)	A,C,F,E	x	x	x		x	x
<i>Zaclys murdochi</i> B.A. Marshall, 1978	A,C,F,E	x	x	x			x
<i>Zaclys sarissa</i> (Murdoch, 1905)	A,F,An,E	x	x		x		x
<i>Zalipais lissa</i> (Suter, 1908)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Zebittium editum</i> Powell, 1930	A,E		x				
<i>Zebittium exile</i> (Hutton, 1873)	A,C,F,E	x	x	x	x		x
<i>Zebittium laevicordatum</i> Powell, 1937	A,E	x					
<i>Zelippistes benhami</i> (Suter, 1902)	A,E	x		x			
<i>Zemitrella choava</i> (Reeve, 1859)	A,C,F,An,E	x	x	x	x	x	x
<i>Zemitrella daemona</i> (Webster, 1906)	A,E	x		x			
<i>Zemitrella fallax</i> Powell, 1940	A,C,E	x	x	x	x	x	x
<i>Zemitrella laevigata curvirostris</i> Powell, 1937	A,E	x					
<i>Zemitrella laevigata laevigata</i> Powell, 1937	A,E	x			x		
<i>Zemitrella pseudomarginata</i> (Suter, 1908)	A,C,E	x	x	x		x	x
<i>Zemitrella stephanophora</i> (Suter, 1908)	A,C,E	x	x	x	x	x	x
<i>Zemitrella turgida</i> Powell, 1937	A,E	x					
<i>Zeradina odhneri</i> Powell, 1927	A,E	x			x		
<i>Zeradina ovata</i> (Odhner, 1924)	A,C,E	x				x	
<i>Zerotula</i> sp.			x				x
<i>Zetela textilis</i> (Murdoch & Suter, 1906)	A,C,E			x			
Bivalves							
<i>Acar sandersonae</i> Powell, 1933	A,C,F,M,E	x		x	x	x	
<i>Acar sociella</i> (Brookes, 1926)	A,C,F,M,E	x	x	x	x	x	
<i>Arthritica bifurca</i> (Webster, 1908)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Arthritica crassiformis</i> Powell, 1933	A,C,E		x			x	x

	Regions	NE coast Cape Maria - Whangarei	Hauraki Gulf Whangarei- Miranda	Great Barrier and Coromandel	NW coast Ahipara- Hokianga	W coast Kaipara- Awhitu	Live
<i>Austroneaera finlayi</i> Powell, 1937	A,E	x					
<i>Benthocardiella hamatadens</i> Powell, 1930	A,E			x			
<i>Benthocardiella obliquata</i> Powell, 1930	A,E	x	x	x	x		
<i>Benthocardiella orbicula</i> Powell, 1930	A,E	x					
<i>Borniola bidentifera</i> (Powell, 1933)	A,E	x					
<i>Borniola reniformis</i> (Suter, 1908)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Condylocardia crassica</i> Bernard, 1897	A,C,F,M,An,E	x	x				
<i>Condylocuna concentrica</i> (Bernard, 1897)	A,C,F,M,An,E	x	x	x			
<i>Cosa filholi</i> (Bernard, 1897)	A,C,F,M,An,E	x		x			
<i>Cosa laevicostata</i> Powell, 1933	A,E	x					
<i>Cosa serratocostata</i> ? Powell, 1933	A,E	x	x	x			
<i>Cratis delicatula</i> Powell, 1937	A,E	x					
<i>Cuna manawatawhia</i> Powell, 1937	A,E	x					
<i>Cuna waikukuensis</i> Powell, 1937	A,E	x	x	x			x
<i>Cycloclamys mestayerae</i> (Dell, 1956)	A,C,E	x	x	x			
<i>Divariscintilla maoria</i> Powell, 1932	A,C,E	x	x	x			
<i>Ennucula strangei</i> (A. Adams, 1856)	A,C,F,M,E	x		x			
<i>Epicodakia neozelanica</i> Powell, 1937	A,E	x					
<i>Gaimardia finlayi</i> (Powell, 1933)	A,C,E	x	x			x	x
<i>Gonimyrtea concinna</i> (Hutton, 1885)	A,C,E	x		x			
<i>Haliris setosa</i> (Hedley, 1907)	A,C,F,M	x		x			
<i>Hamacuna gibbosa</i> (Powell, 1937)	A,E	x	x				
<i>Kidderia aupouria</i> Powell, 1933	A,E	x	x	x			
<i>Kidderia costata</i> Odhner, 1924	A,C,F,M,An,E	x	x	x			x
<i>Lasaea hinemoa</i> Finlay, 1928	A,C,F,M,An,E	x	x	x	x	x	x
<i>Lasaea maoria</i> (Powell, 1933)	A,C,F,E	x	x	x		x	x
<i>Lasaea parengaensis</i> Powell, 1935	A,C,E	x	x			x	
<i>Linucula hartvigiana</i> (Dohrn, 1864)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Lissarca</i> sp.			x				
<i>Lyrodus medilobatus</i> (Edmonson, 1942)	A	x	x	x			
<i>Melliteryx parva</i> (Deshayes, 1856)	A,C,F,M,An,E	x	x	x	x		x
<i>Montacuta semiradiata</i> Tate, 1889	A,M,E	x	x	x	x		x
<i>Montacuta semiradiata neozelanica</i> (Dell, 1956)	A,M,E	x	x				
<i>Myadora antipodum</i> E.A. Smith, 1881	A,C,F,M,E	x	x	x		x	
<i>Myadora boltoni</i> E.A. Smith, 1881	A,C,E	x	x	x	x	x	x
<i>Myadora novaezelandiae</i> E.A. Smith, 1881	A,C,F,M,An,E	x		x			
<i>Myllita stowei</i> (Hutton, 1873)	A,C,F,E	x	x	x	x		x
<i>Myllitella vivens vivens</i> Finlay, 1926	A,C,F,E	x	x	x	x	x	
<i>Mysella larochei</i> Powell, 1940	A,E	x	x				x
<i>Mysella tellinula</i> ? (Odhner, 1924)	A,E	x		x			
<i>Neolepton antipodum</i> (Filhol, 1880)	K,A,C,F,M,An	x	x	x	x	x	x
<i>Nucinella maoriana</i> (Hedley, 1904)	A,C,F,M,E	x		x			
<i>Nucula certisinus</i> Finlay, 1930	A,E	x	x	x			
<i>Nucula nitidula</i> A. Adams, 1856	A,C,F,M,An,E	x	x	x	x	x	x
<i>Parilimya neozelanica</i> (Suter, 1914)	A,C,F,E					x	
<i>Parvithracia suteri</i> Finlay, 1927	A,C,F,E	x					
<i>Philobrya acutangula</i> (Powell, 1935)	A,C,E	x	x				
<i>Philobrya</i> cf. <i>modiolus</i> Suter, 1913	M,An,E	x	x	x			x
<i>Philobrya munita</i> (Finlay, 1930)	A,C,F,M,An,E	x	x	x	x	x	x
<i>Pleuromeris benthicola</i> Powell, 1937	A,E	x					
<i>Pleuromeris latiuscula</i> Powell, 1937	A,E	x		x			
<i>Pleuromeris paucicostata</i> Laws, 1940	A,E	x	x	x			
<i>Pleuromeris zelandica</i> (Deshayes, 1854)	A,C,F,E	x	x	x			
<i>Poromya laevis</i> E.A. Smith, 1885	A	x					
<i>Powellina brookesi</i> (Finlay, 1926)	A,E	x	x	x			x
<i>Rhomboidella radians</i> Monterosato, 1884	A,E	x		x			
<i>Saccella hedleyi</i> (Fleming, 1951)	A,C,M,E			x			
<i>Saccella maxwelli</i> Beu, 2006	A,C,F,M,E	x		x	x		
<i>Scintilla stewartsoni</i> Powell, 1932	K,A	x	x	x			
<i>Scintillona zelandica</i> (Odhner, 1924)	A,C,F,An,E	x	x	x			x
<i>Theora lubrica</i> Gould, 1861	A,C	x	x	x	x	x	x
<i>Trichomusculus barbatus</i> (Reeve, 1858)	A,C,M	x	x	x	x	x	x
<i>Varinucula gallinacea</i> (Finlay, 1930)	A,C,M,E	x		x			

different pattern with increasing diversity from the inner Manukau Harbour (1-10 spp.) to a maximum just inside the entrance (20-40 spp.). Outside the harbour on the exposed west coast of the Waitakere Ranges and Awhitu Peninsula diversity is as low as inside the inner and middle reaches of the harbour (5-30 spp.).

BIOGEOGRAPHIC DISTRIBUTION ANALYSIS

On the cluster analysis dendrogram based on presence/absence data we recognise nine sample site cluster associations with nine samples unclustered (Fig. 2). The geographic distribution of these nine associations is shown in Fig. 3. To identify the species which most

characterise each association we used a combination of their persistence and fidelity values with respect to each association (Table 2). The characterising species are not always the most commonly occurring in an association, as some species (e.g. *Austrolittorina antipodum*, *Linucula hartvigiana*, *Theora lubrica*) are widespread (persistent) through many of the associations without having a high fidelity to just one (Table 2).

Assoc 1: *Linucula hartvigiana* – *Arthritica bifurca* – *Theora lubrica*

The 35 sites in this association have the lowest mean species diversity (6 species per site) of all nine associations. The three most characterising species

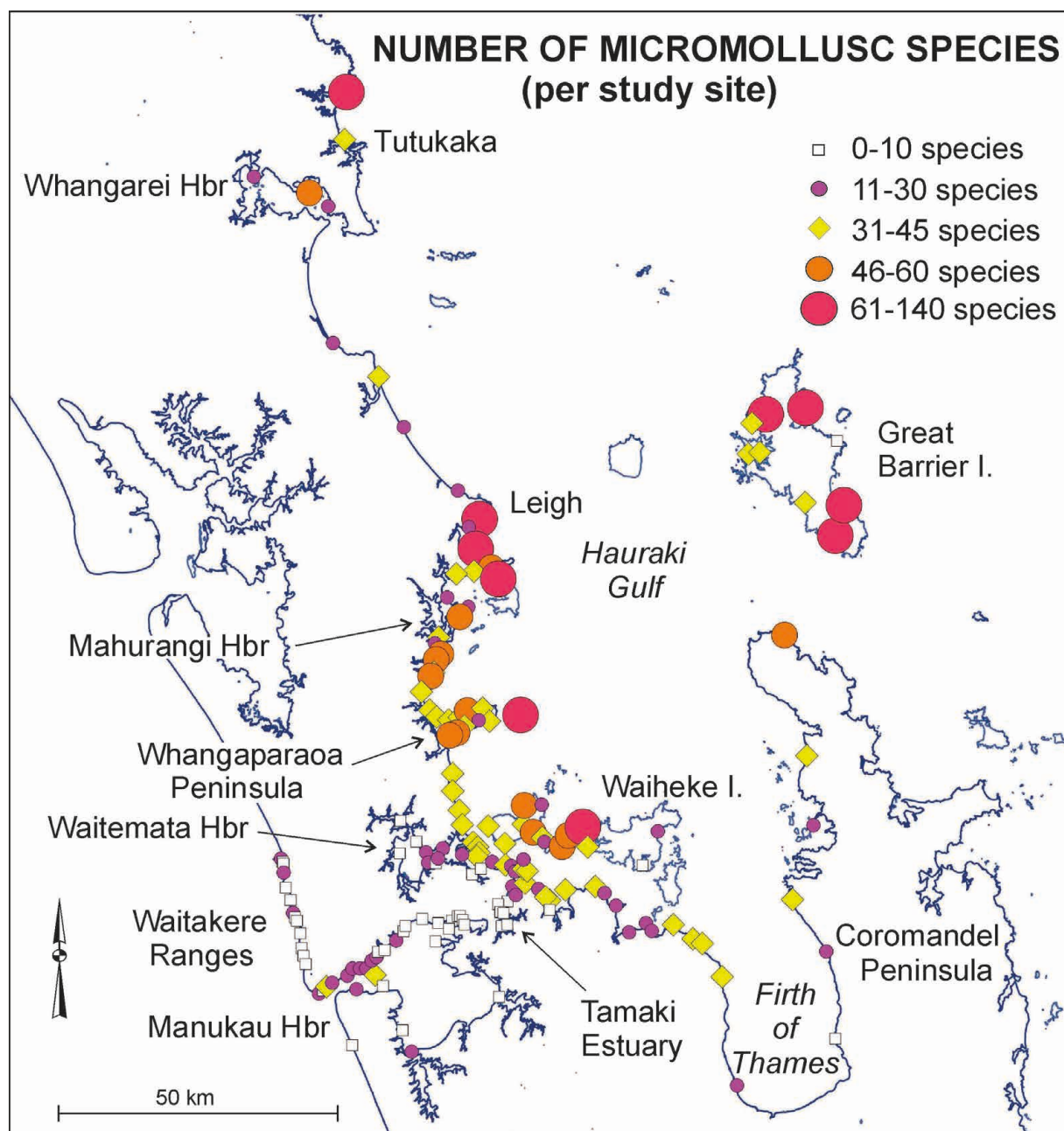


Figure 1. Number of species of micromolluscs (live and dead) in each of the 162 study locations in northern New Zealand.

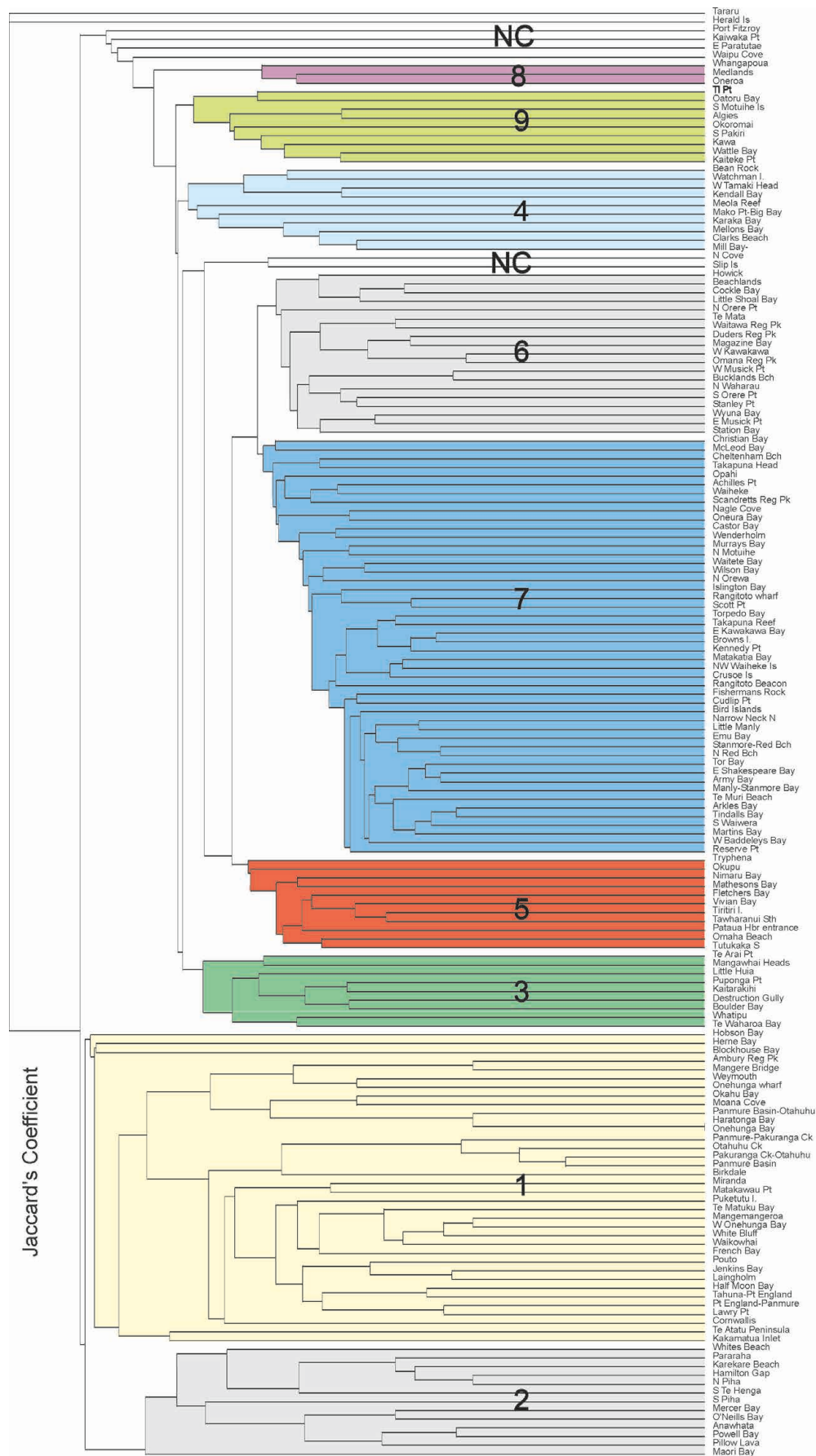


Figure 2 (above and continued on adjacent page). Cluster analysis dendrogram of 162 localities produced using Jaccard coefficient of similarity based on the presence/absence of 257 micromollusc species. Nine associations have been recognised (1-9) with 9 unclustered sites (NC).

(Fig. 4) are all infaunal microbivalves that live in low tidal mud or fine sand. This association mostly occurs along the muddy shores of the Manukau Harbour, Tamaki Estuary and upper Waitemata Harbour with three sites in the muddier more sheltered inlets along the edge of the Tamaki Strait and one near the head of the Firth of Thames at Miranda.

Assoc 2: *Notoacmea parviconoidea* – *Micrelenchus tessellatus* – *Gaimardia finlayi*

This association of 13 sites has the second lowest mean species diversity (7 species per site).

This low diversity reflects the harsh environment at these sites, all of which occur on the exposed west coast of Auckland. The pounding waves mean that few micromollusc shells survive abrasion sufficiently long to be washed up on the exposed sand beaches. At these sites there are few suitable habitats for diverse micromolluscs. The intertidal pools are mostly scoured out by the waves and there are virtually no stable intertidal cobbles or boulders for micromolluscs to seek shelter under. The three most characterising species (Fig. 4) live in a mix of rocky shore habitats where micromolluscs can shelter. *N. parviconoidea* finds protection from surf among barnacles and in mid tidal crevices. *M. tessellatus* clings to low tidal rocks and *G. finlayi* attaches to *Vidalia colensoi* by hairs.

Assoc 3: *Amphithalamus semen* – *Notoacmea parviconoidea* – *Philobrya munita*

The nine sites in this association have moderately high micromollusc diversity (mean 26 species per site) reflecting their location in or close to relatively clear oceanic water with sufficient stable intertidal cobbles or boulders for microgastropods to shelter under. All occur on or around rocky coastlines mostly just inside the entrance to the Manukau Harbour on the northern side (Whatipu to Puponga Pt) but including the most protected section of shoreline just south of Muriwai on the west coast and around two rocky headlands on the more exposed section of the east coast at Te Arai Pt and Mangawhai Heads. Of the three most characterising species (Fig. 5), *A. semen* shelters in coralline algae or beneath stones; *N. parviconoidea* shelters in crevices and among barnacles, and *P. munita* attaches by byssal threads to the undersides of low tidal rocks.

Assoc 4: *Eatoniella limbata* – *Theora lubrica* – *Tubbreva exigua* – *Linucula hartvigiana*

The ten sites in this association have a moderately low mean diversity (18 species per site). This is a reflection of their locations around the sheltered fringes of the middle reaches of the Manukau and Waitemata Harbours. Of the characterising species (Fig. 5), *Eatoniella limbata* grazes on algae, *Tubbreva exigua* shelters in intertidal pools or under stable cobbles; and the infaunal bivalves *Theora lubrica* and *Linucula hartvigiana* burrow in low tidal fine sediment.

Assoc 5: *Merelina taupoensis* – *Fictonoba rufolactea* – *Merelina lyalliana* – *Herpetopoma bellum* – *Eatonina subflavescens* – *Austromitra rubiginosa* – *Trichomuscus barbatus*

The eleven sites in this association have the second highest mean species diversity (59 species per site) of all the associations. This reflects the similarity of the suite of habitats at each site and their similar locations around the edges of the outer Hauraki Gulf (Fig. 3). Much of this high diversity (such as *M. taupoensis*, *M. lyalliana*, *H. bellum*, *A. rubiginosa*, *T. barbatus*) lives on the undersides of stable low tidal cobbles in slightly more sheltered localities inside the entrances to harbours or bays or on the lee side of an island or headland. *Fictonoba rufolactea* and *E. subflavescens* (Fig. 6) live on algae.

Assoc 6: *Theora lubrica* – *Neolepton antipodum* – *Pisinna olivacea impressa*

This association of 19 sites has moderate mean diversity (29 species per site). It is restricted to the east coast around the relatively sheltered shores of the inner Hauraki Gulf from the outer parts of the Firth of Thames north to Motutapu Island and Coromandel Harbour and into the entrance of the Waitemata Harbour as far as the harbour bridge. Most sites occur along the southern side of Tamaki Strait from Kawakawa Bay to Musick Pt. The characterising species (Fig. 7) reflect the diversity of habitats present at most sites – low tidal muddy sediment (*Theora lubrica*), coralline turf (*Neolepton antipodum*) and sediment beneath stable cobbles (*Pisinna olivacea impressa*).

Assoc 7: *Merelina taupoensis* – *Herpetopoma bellum* – *Anabathron hedleyi* – *Pisinna olivacea impressa*

This association has the largest number of sites (40) and relatively high mean diversity (48 species per site). It is restricted in its occurrence to the east coast, mostly around the fringes of the middle Hauraki Gulf (east and west sides) with two sites on the northern shores of the outer Whangarei Harbour. Once again the characterising species (Fig. 7) mostly live in sediment in sheltered locations in mid-low tidal pools or under stable cobbles.

Assoc 8: *Uberella* cf. *vitrea* – *Philobrya* cf. *modiolus* – *Eatoniella roseospira* – *Myadora antipodum* – *Asteracmea suteri*

This small association of just three sites has by far the highest mean species diversity (115 species per site) which may partly reflect the extended level of study undertaken at Oneroa, Waiheke Island. The extreme diversity at Medlands and Whangapoua on the east side of Great Barrier Island compared with all other sites is believed to be true. There is a long list of species with high fidelity scores for this association, probably because they include many that are from beach wash-ups of micromolluscs that live subtidally offshore. The characterising species (Fig. 8) are a mix of infaunal sediment-inhabiting bivalves and gastropods and rocky-shore grazers.

Table 2. Characterising species (bolded) of each of the Jaccard site associations (1-9) based on their percentage scores for persistence (P) within each association and fidelity (F) to each association compared with all other associations. Class abbreviations are B = Bivalvia, G = Gastropoda.

Association	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9
	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F
Number of sites in assoc	35		13		9		10		11		19		48		3		9	
Mean no of spp per site	6		7		26		18		59		29		40		115		16	
<i>Linucula hartvigiana</i>	74	-1	15	-60	56	-19	100	25	91	16	100	25	94	19	67	-8	78	3
<i>Arhritica bifurca</i>	54	2	0	-52	22	-30	60	8	27	-25	84	32	67	15	100	48	56	4
<i>Notoacmea parvicornioidea</i>	G	-48	100	52	89	41	0	-48	18	-30	11	-37	21	-27	100	52	44	-3
<i>Micrelenchus tessellatus</i>	G	-32	62	30	56	24	0	-32	27	-5	0	-32	0	-32	100	68	11	-21
<i>Gaimardia finlayi</i>	B	-9	46	37	22	13	0	-9	0	-9	0	-9	2	-7	0	-9	0	-9
<i>Amphihalimulus semen</i>	G	-25	0	-25	89	63	0	-25	18	-7	21	-4	8	-17	67	41	0	-25
<i>Philobrya munita</i>	B	-34	46	0	67	33	0	-34	45	12	11	-23	2	-32	100	66	0	-34
<i>Theora lubrica</i>	40	13	0	-27	0	-27	70	43	0	-27	79	52	19	-8	33	7	11	-15
<i>Eatoniella limbata</i>	G	-44	0	-47	33	-13	80	33	18	-28	74	27	79	33	67	20	22	-24
<i>Tubbreva exigua</i>	G	-35	8	-33	33	-7	70	30	64	23	42	2	63	22	33	-7	11	-29
<i>Fictonoba rufolactea</i>	G	-18	0	-18	0	-18	10	-8	91	73	0	-18	10	-8	33	15	0	-18
<i>Merelina lyalliana</i>	G	-31	0	-31	0	-31	0	-31	91	60	0	-31	48	17	100	69	11	-20
<i>Herpetopoma bellum</i>	G	-31	8	-23	0	-31	0	-31	91	60	5	-26	77	46	67	36	0	-31
<i>Trichomusculus barbatus</i>	B	-33	0	-33	11	-22	0	-33	91	57	0	-33	44	10	100	67	22	-11
<i>Merelina taiupoensis</i>	G	-28	0	-28	0	-28	0	-28	100	72	5	-23	88	59	33	5	0	-28
<i>Eatonina subflavescens</i>	G	-45	8	-37	67	22	20	-25	100	55	53	8	33	-11	67	22	11	-34
<i>Austromitra rubiginosa</i>	G	-46	0	-46	56	9	0	-46	100	54	63	17	63	16	67	20	22	-24
<i>Neolepton antipodum</i>	B	-66	0	-68	11	-57	70	2	91	22	100	32	98	29	100	32	78	9
<i>Pistina olivacea impressa</i>	G	-49	0	-49	0	-49	30	-19	91	42	84	35	85	37	67	18	33	-15
<i>Rastodens puerilis</i>	G	-2	0	-2	0	-2	0	-2	0	-2	16	14	0	-2	0	-2	0	-2
<i>Mesoginella vaiiei</i>	G	-1	0	-1	0	-1	0	-1	0	-1	11	9	0	-1	0	-1	0	-1
<i>Anabathron hedleyi</i>	G	-54	0	-54	11	-43	40	-14	100	46	79	25	94	39	100	46	11	-43
<i>Eatoniella lutea</i>	G	-45	0	-45	11	-34	30	-15	73	27	68	23	81	36	100	55	0	-45
<i>Uberella cf. vitrea</i>	G	-14	0	-14	0	-14	0	-14	9	-5	0	-14	0	-14	100	86	0	-14
<i>Philobrya cf. modiolus</i>	B	-14	0	-14	0	-14	0	-14	9	-5	0	-14	2	-12	100	86	0	-14
<i>Eatoniella roseospira</i>	G	-15	0	-15	0	-15	10	-5	9	-6	0	-15	4	-11	100	85	0	-15
<i>Myadora antipodum</i>	B	-16	0	-16	11	-5	0	-16	0	-16	5	-11	0	-16	100	84	11	-5
<i>Asteracmea suteri</i>	G	-16	0	-16	0	-16	0	-16	27	11	0	-16	2	-14	100	84	0	-16
<i>Argalista fluctuata</i>	G	-8	0	-8	0	-8	0	-8	0	-8	0	-8	0	-8	67	58	0	-8
<i>Incisura rosea</i>	G	-8	0	-8	0	-8	0	-8	0	-8	0	-8	0	-8	67	58	0	-8
<i>Melanella sp.</i>	G	-8	0	-8	0	-8	0	-8	0	-8	0	-8	0	-8	67	58	0	-8
<i>Metaxia exaltata</i>	G	-8	0	-8	0	-8	0	-8	0	-8	0	-8	0	-8	67	58	0	-8
<i>Leuconopsis obsoleta</i>	G	-49	8	-47	33	-22	20	-35	64	9	42	-13	85	30	100	45	89	34
<i>Pistina zosterophila</i>	G	-78	15	-68	78	-5	80	-3	100	17	95	12	98	15	100	17	100	17
<i>Notoacmea elongata</i>	G	-18	15	-62	78	0	40	-38	91	13	100	22	98	20	100	22	100	22
<i>Risellopsis varia</i>	G	-44	31	-42	89	16	10	-63	100	27	95	22	92	19	100	27	67	-6
<i>Turbonilla spp.</i>	G	-33	15	-57	67	-6	90	17	82	9	100	27	96	23	100	27	33	-40
<i>Rissoina chathamensis</i>	G	-55	0	-55	78	23	20	-35	91	36	47	-8	81	26	67	12	56	1
<i>Austrolittorina antipodum</i>	G	-24	100	4	100	4	70	-26	100	4	100	4	96	0	100	4	100	4

Assoc 9: *Leuconopsis obsoleta* – *Pisinna zosterophila* – *Notoacmea elongata*

The nine sites in this association have relatively low mean species diversity (16 species per site). This association is more widespread than others, occurring around the middle and outer reaches of the Hauraki Gulf on the east coast and the Manukau Harbour on the west coast. The characterising species (Fig. 9) come from a wide range of habitats – inside crevices or oyster clumps (*Leuconopsis obsoleta*); grazing the microalgae on the insides of dead shells (*Notoacmea elongata*); in sediment under stable cobbles (*Pisinna zosterophila*); infaunal in low-tidal sediment (*Linucula hartvigiana*, *Arthritica*

bifurca). It is debatable whether this is a real association or not. Maybe it has brought together sites that were less intensely searched for micromolluscs or where for some reason some sites had lower diversities of micromolluscs, particularly in wash ups and under stable cobbles.

Unclassified

Nine sites were not clustered with others in the Jaccard dendrogram. Two of these (Herald Island, upper Waitemata; Tararu, Firth of Thames) had no micromolluscs at all, but the others ranged in diversity from 6 to 35 species. Most of the other sites are relatively sheltered bays, each with their own unique suite of habitats and species (listed with

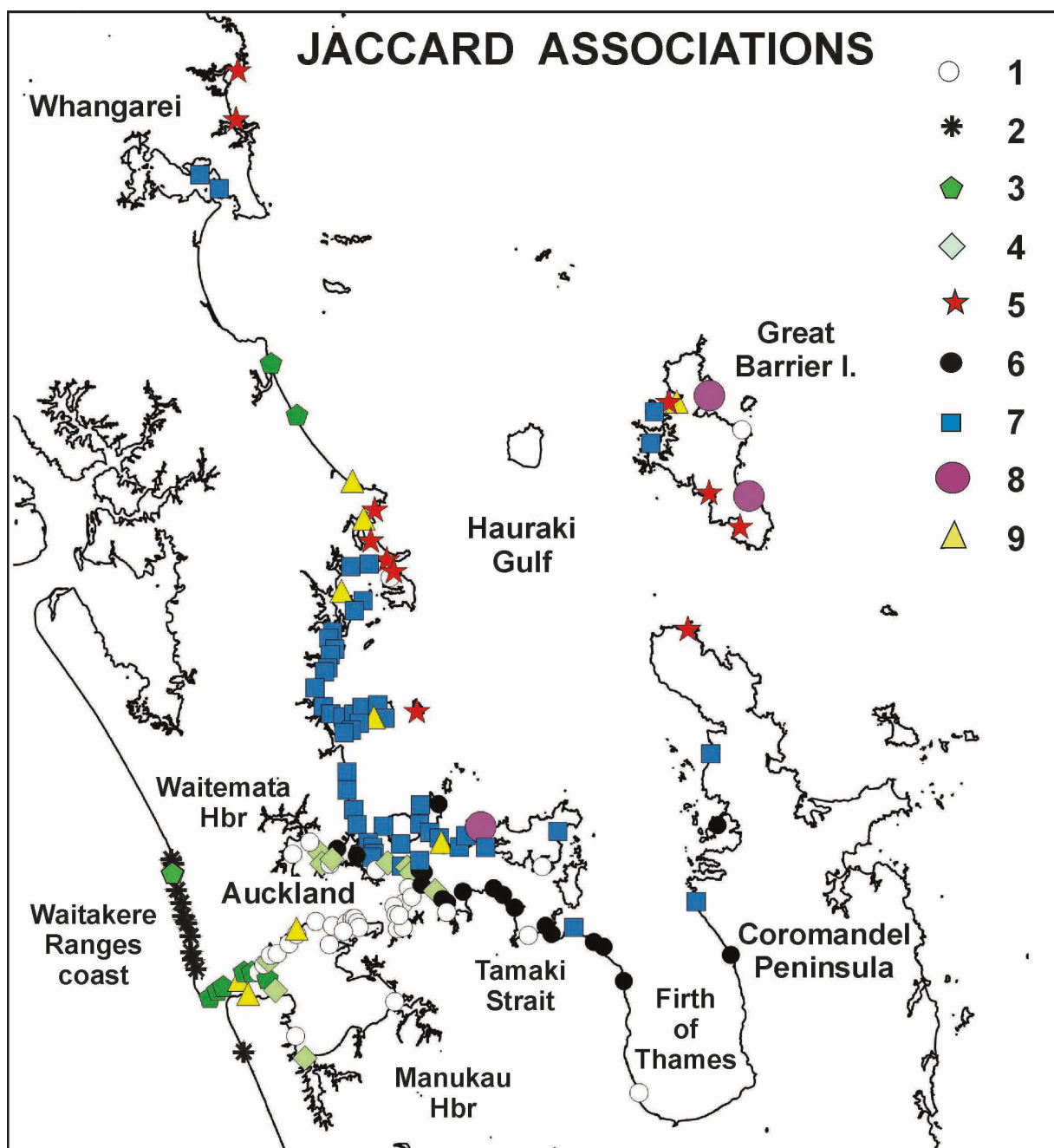


Figure 3. Distribution of study site clusters based on the presence/absence (Jaccard coefficient) of micromollusc species (live and dead) at each site.

increasing diversity): Hobson Bay, middle Waitemata; east side Paratutae, Manukau Hbr; Kaiwaka Pt, middle Whangarei Hbr; Waipu Cove; North Cove, Kawau Is; Rocky Bay, Kawau Is; Port Fitzroy, Great Barrier Is.

REGIONAL BIOGEOGRAPHY AND RANGE EXTENSIONS

In this section we include all the intertidal records in our database (Appendix 1). We have divided the northern New Zealand study area into five regions (one from the Cookian Province, three from the Aupourian Province and one spanning the boundary between the two (Powell 1955):

- west coast region, on the west coast from Hokianga to Awhitu correlates with the northernmost part of the Cookian Province (Powell 1955);
- northwest region, from Hokianga to Ahipara on the west coast, on the boundary between the Aupourian and Cookian provinces;
- northeast coast region, between Cape Maria van Diemen and Whangarei Heads;
- west Hauraki Gulf region, from Whangarei Harbour to Miranda;
- east Hauraki Gulf region, on the coasts of Great Barrier Island and Coromandel Peninsula.

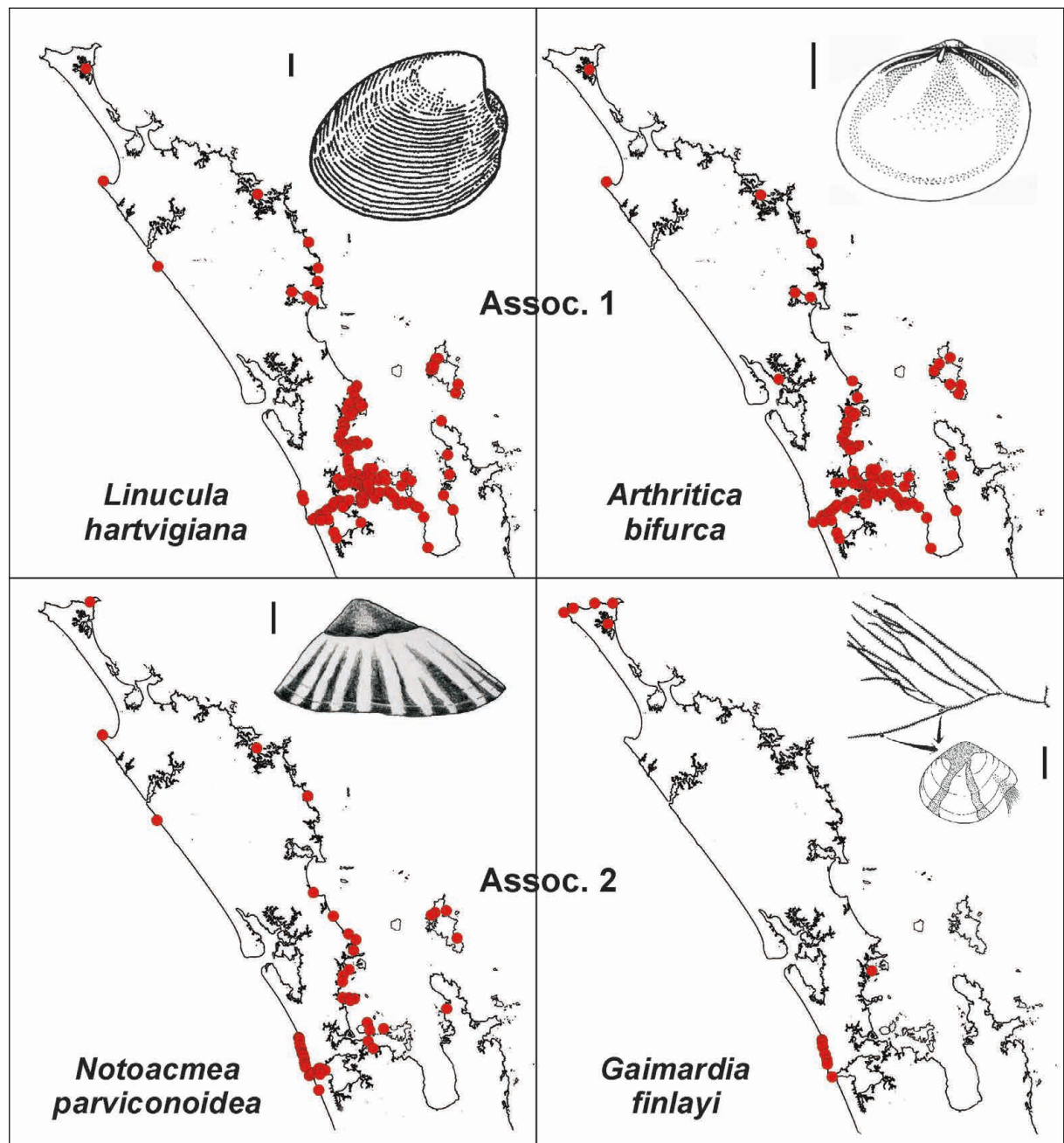


Figure 4. Characteristic micromollusc species of Associations 1 and 2 and our distribution records of them from northern New Zealand: *Linucula hartvigiana* (Dohrn, 1864) from Musick Point, Waitemata Harbour; *Arthritica bifurca* (Webster, 1908) from Orua Bay, Manukau Harbour (drawing by Powell 1979); *Notoacmea parviconoidea* (Suter, 1907) from Hamiltons Gap, Awhitu Peninsula (MA121572); *Gaimardia finlayi* (Powell, 1933) from Lion Rock, Piha, Waitakere coast. Scale bars 1 mm.

The greatest number of intertidal micromollusc records come from the warmest regions in the Aupourian Province (northeast – 313 spp., east Hauraki Gulf – 258 spp.) followed by the west Hauraki Gulf (234 spp.). The two western regions have much lower diversities – west coast (115 spp.) and northwest (108 spp.). A total of 157 species are recorded from the west coast and 361 species are recorded from the east coast, with just five species recorded intertidally only on the west coast, all of them as shells only: the gastropods *Eatonina crassicarinata*, *Odostomia geoffreyi*?, *Uttleya ahiparana*

and Pyramellidae indet and the bivalve *Parilimya neozelanica*. All have been recorded previously from the East Coast, Aupourian Province.

The percentage of endemic species overall in the study is 91% and varies little between the regions, ranging between 89 and 91%. Spencer et al. (2014) has summarised the geographic distributions of all New Zealand marine molluscs in terms of the biogeographic provinces proposed by Powell (1955). In this study we extend the provincial range of ten micromollusc species. With west coast records, 8 species are extended to the

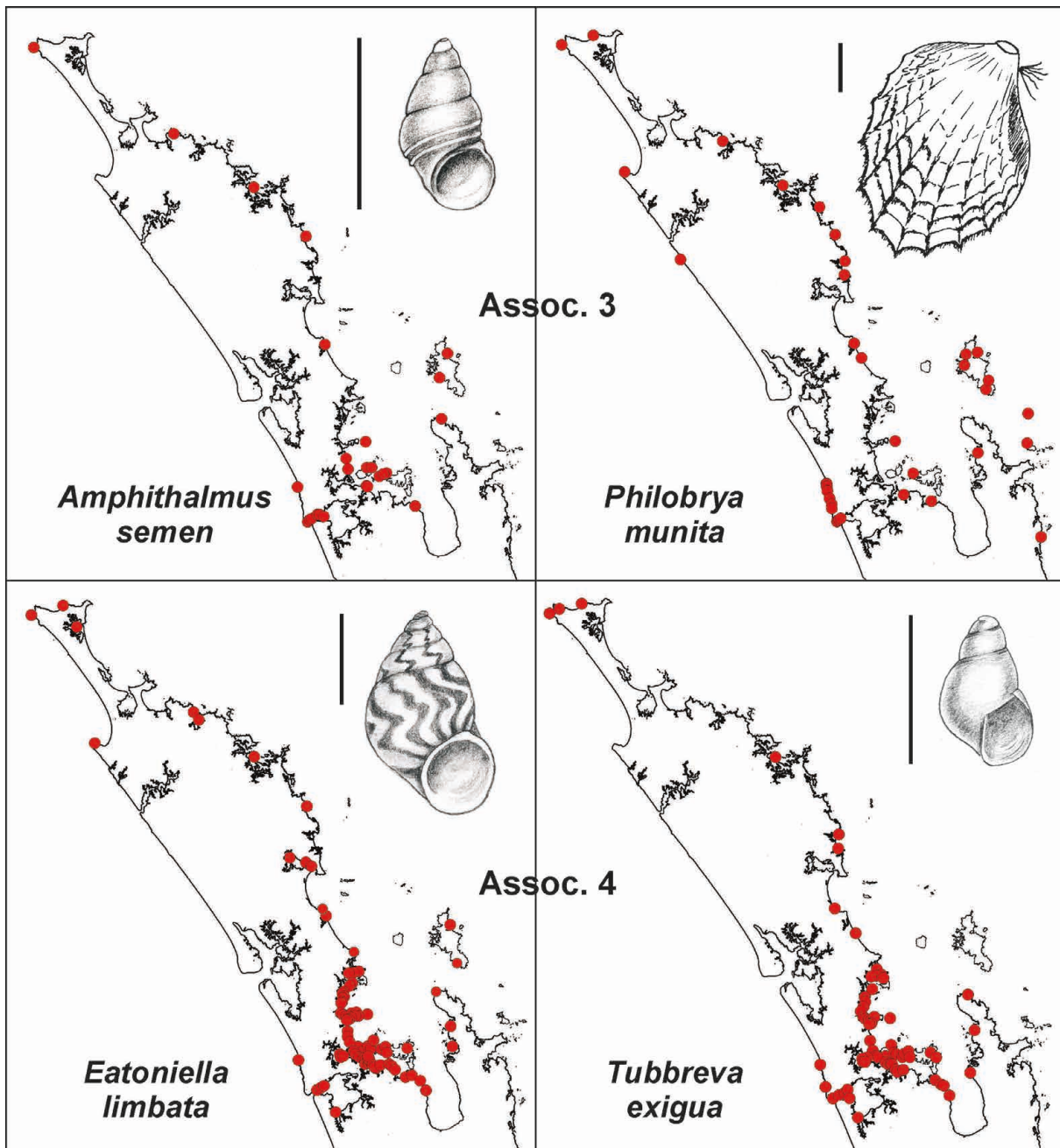


Figure 5. Characteristic micromollusc species of Associations 3 and 4 and our distribution records of them from northern New Zealand: *Amphithalamus semen* (Odhner, 1924) from Whatipu, Waitakere coast (MA121567); *Philobrya munita* (Finlay, 1930) from Motuarohia Island, Bay of Islands; *Eatoniella limbata* (Hutton, 1883) from Waiwera, Hauraki Gulf (MA121569); *Tubbrevia exigua* (Ponder, 1965) from Bucklands Beach, Tamaki Estuary. Scale bars 1 mm.

Cookian Province from the Aupourian Province. Two species ranges are extended to the Aupourian Province – one (*Merelina foliata*) from the far south Forsterian and Antipodian provinces, and the other (*Cylichna zealandica*) from the Cookian Province.

Range extensions to the Aupourian Province (east coast northern New Zealand):

Cylichna zealandica Kirk, 1880 is recorded here from a washup on Tom Bowling Bay, North Cape (MA120890) (Fig. 10).

Merelina foliata (Suter, 1908) is recorded here from a

washup on Spirits Bay, Far North (MA120890) (Fig. 10). MSM also has a specimen collected from Waitangi, Chatham Island which also extends this species range to the Moriorian Province.

Range extensions to the Cookian Province (west coast northern New Zealand):

Aequispirella finlayi (Powell, 1933) recorded here from Boulder Bay, north side of Manukau Harbour entrance.

Eatoniella notata Ponder & Yoo, 1978 recorded here from Mercer Bay on the Waitakere west coast and Mill Bay in Manukau Harbour.

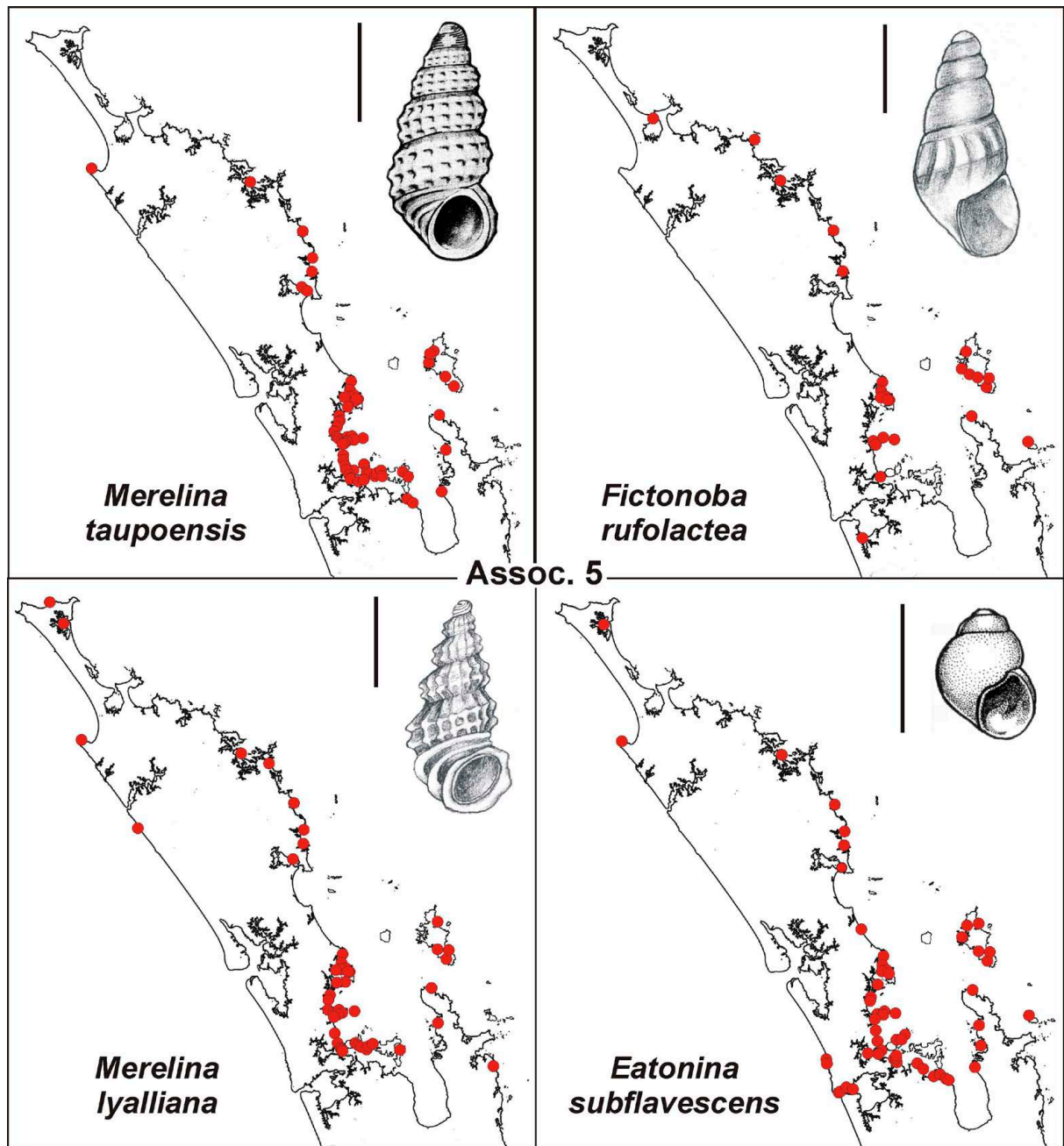


Figure 6. Characteristic micromollusc species of Association 5 and our distribution records of them from northern New Zealand: *Merelina taupoensis* Powell, 1939 from Taupo Bay, Whangaroa (drawing by Powell 1979); *Fictonoba rufolactea* (Suter, 1908) from Whangaruru Harbour (MA121571); *Merelina lyalliana* (Suter, 1898) from Taupo Bay, Whangaroa (MA121570); *Eatonina subflavescens* (Iredale, 1915) from Cornwallis, Manukau Harbour. Scale bars 1 mm.

Eatonina micans (Webster, 1905) recorded here from Puponga Pt and Mill Bay on the north coast of the Manukau Harbour.

Lodderia iota Powell, 1940 recorded here from Boulder Bay, north side of Manukau Harbour entrance (Fig. 10).

Odostomia geoffreyi? Laws, 1939 recorded here from Destruction Gully, north side of Manukau Harbour entrance.

Rissoina fucosa Finlay, 1930 recorded here from Kakamatua Inlet, north side of Manukau Harbour.

Turbonilla bucknilli (Laws, 1937) recorded here from Huia Bay, north side of Manukau Harbour.

Lasaea parengaensis Powell, 1935 recorded here from

Mill Bay, north side of Manukau Harbour.

The rare microgastropod *Eatoniella tenella* (Powell, 1937) (Fig. 10) has only been recorded previously from the Three Kings Islands (Powell, 1979), but here we extend its range south within the Aupourian Province to intertidal sites at the Bay of Islands, Poor Knights Islands, Orewa, Motutapu Island and Fletchers Bay, Coromandel Peninsula. The parasitic gastropod *Odostomia incidata* Suter, 1908 was sieved alive in low-tidal mud at Matakawau, Awhitu Peninsula. This appears to be the first live record of this species. Its prey is probably polychaete worms (W. Blom pers. comm.).

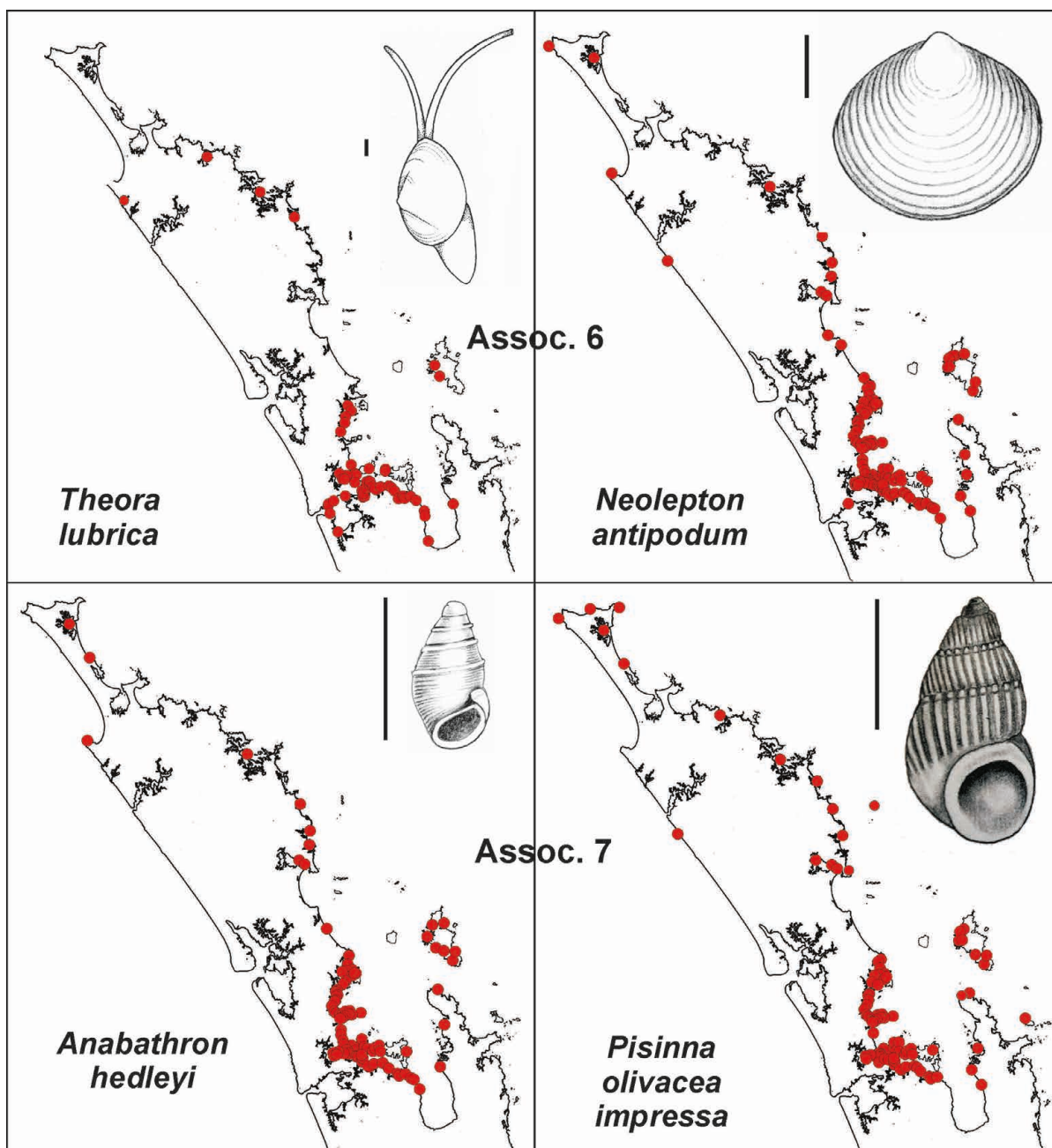


Figure 7. Characteristic micromollusc species of Associations 6 and 7 and our distribution records of them from northern New Zealand: *Theora lubrica* Gould, 1861 from Waitemata Harbour; *Neolepton antipodum* (Filhol, 1880) from Musick Point, Waitemata Harbour; *Anabathron hedleyi* (Suter, 1908) from Musick Point, Waitemata Harbour; *Pisinna olivacea impressa* (Hutton, 1885) from Great Mercury Island, east Coromandel Peninsula (MA121573). Scale bars 1 mm.

DISCUSSION

Biogeographic associations

Eight of the nine biogeographic associations recognised occur in distinct coastal areas (Fig. 3) characterised by their degree of exposure or whether they occur on the east or west coast of northern New Zealand. There appears to be no east-west difference between the two inner and middle harbour associations (Assocs 1 and 4) as both occur in the Waitemata and Manukau harbours. Two other, partly sheltered associations (Assocs 3 and 9) occur on both the east and west coasts – in the west

around the entrance to the Manukau Harbour and in the east on the coast around the middle reaches of the Hauraki Gulf. Just one association (Assoc. 2) is restricted to the west coast (Cookian Province) occurring along the exposed west coast of the Waitakere Ranges and Awhitu Peninsula (Fig. 3). The remaining four associations are restricted to the coast of the inner (Assoc. 6), middle (Assoc. 7) and outer (Assocs 5 and 8) Hauraki Gulf and Whangarei Harbour on the east coast.

Two of the four associations with the lowest diversity (Assocs 1 and 4) are restricted to the most sheltered locations, in the Waitemata and Manukau harbours. Here

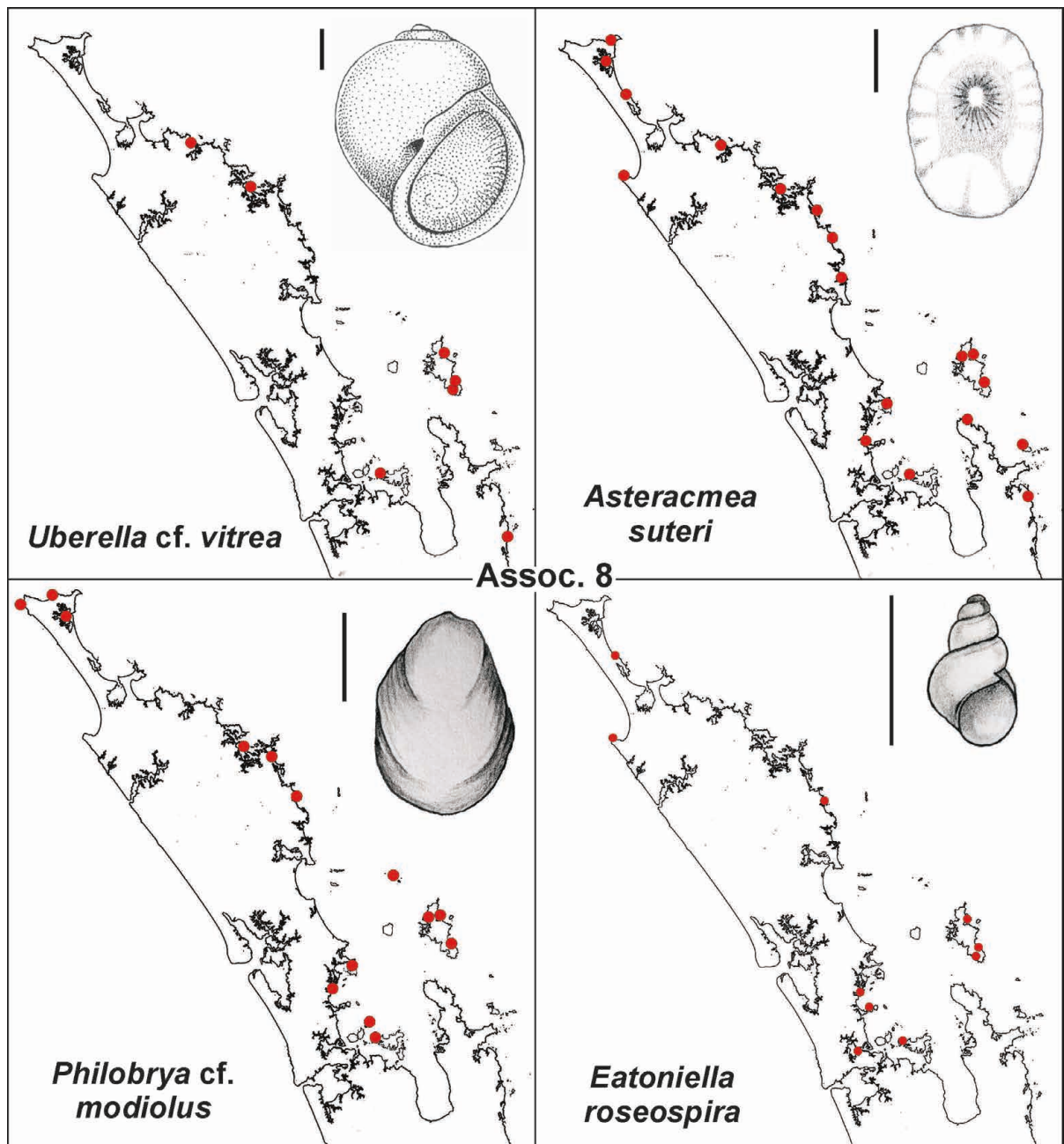


Figure 8. Characteristic micromollusc species of Association 8 and our distribution records of them from northern New Zealand: *Uberella* cf. *vitrea* (Hutton, 1873) from Bay of Islands (drawing after Powell 1979)(MA121565); *Asteracmea suteri* (Iredale, 1915) from Whananaki coast, east Northland; *Philobrya* cf. *modiolus* Suter, 1913 from Cape Maria van Diemen (MA121568); *Eatoniella roseospira* (Powell, 1937) from Poor Knights Islands. Scale bars 1 mm.

there is a low variety of habitats, mostly mid-low-tidal fine sediment and sometimes a few areas of mud-covered intertidal sandstone, hence the predominance of infaunal bivalves as the characterising species. The low diversity Assoc. 2 is the one exception to the general trend of increasing diversity with increasing exposure. It is restricted to the most exposed localities in the region along the west coast of the Waitakere Ranges and Awhitu Peninsula. Here there are no micromolluscs that can live intertidally in the surf-pounded beach sands. Similarly there are few places that are sheltered enough

for micromolluscs to live under stable cobbles or for fine sediment to accumulate in tidal pools.

The mapped occurrence of the fourth low diversity association (9) in a wide range of settings on both coasts (Fig. 3) strongly suggests that it is an artificial clustering perhaps of localities where the collection of micromollusc sand samples was less comprehensive than usual. The associations with moderate micromollusc diversity (26 and 29 species per location) mostly occur in the outer parts of the Manukau (Assoc. 3) and Waitemata (Assoc. 6) harbours, where there is an increasing diversity of available habitats

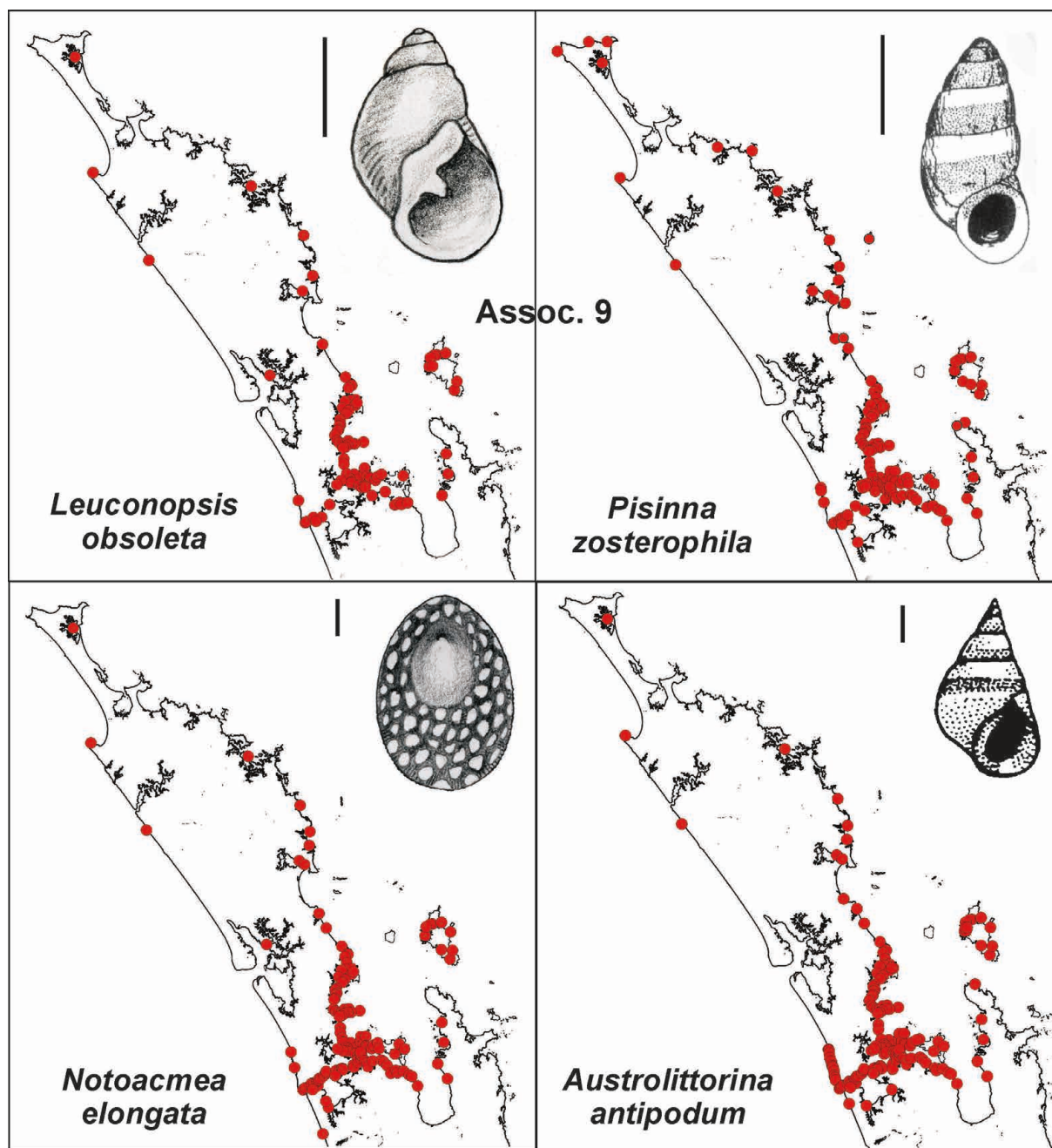


Figure 9. Characteristic micromollusc species of Association 9 and our distribution records of them from northern New Zealand: *Leuconopsis obsoleta* (Hutton, 1878) from Torbay, Hauraki Gulf (MA121566); *Pisinna zosterophila* (Webster, 1905) from Devonport, Waitemata Harbour (drawing from Powell 1979); *Notoacmea elongata* (Quoy & Gaimard, 1834) from Shoal Bay, Waitemata Harbour (MA121564); *Austrolittorina antipodum* (Philippi, 1847) from Te Werahi, Far North. Scale bars 1 mm.

compared with the sheltered inner harbours. The three associations with highest diversity (7, 5 and 8) all occur on the east coast in the warmer-water Aupourian Province with increasing diversity with increasing exposure, in part reflecting the increased washup of dead subtidal shells.

Human-influenced changes in micromollusc faunas

Because of the small size of micromolluscs, historical data on their occurrence and abundance is sparse, subjective and difficult to use in assessing the impacts of human-induced changes and degradation of the New

Zealand coastal environment. There is one obvious and well-known introduced micromollusc - the small, thin-shelled bivalve *Theora lubrica*, from Asia. It arrived in the Waitemata Harbour in 1979 and is now one of the dominant bivalves of infaunal fine sediment in sheltered harbours and estuaries and is widespread around the inner Hauraki Gulf. It has now spread to many of the other harbours around northern New Zealand (Fig. 7).

Morton and Miller (1968: 546) described “teeming” numbers of the microgastropods *Pisinna zosterophila* and *Eatoniella limbata* on *Zostera* seagrass leaves, reporting

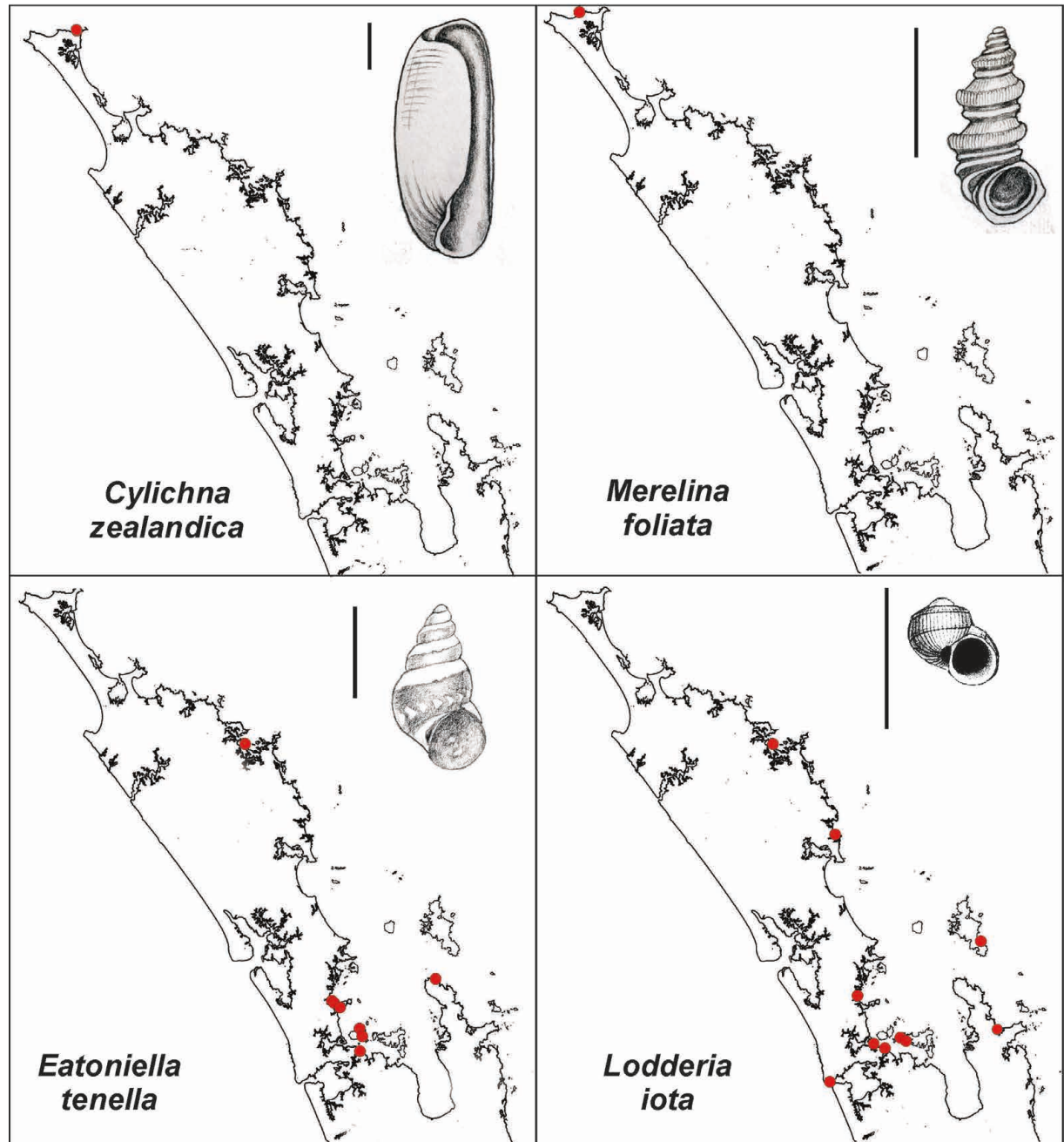


Figure 10. Some of the micromolluscs for which we record an extension of geographic range in this study. *Cylichna zealandica* Kirk, 1880 from Tom Bowling Bay, Far North; *Merelina foliata* (Suter, 1908) from Spirits Bay, Far North; *Eatoniella tenella* (Powell, 1937) from Hatfields Beach, Orewa; *Lodderia iota* Powell, 1940 from Boulder Bay, Manukau Harbour. Scale bars 1 mm.

1200–5000 of each species per m² of *Zostera* flat. In our studies we have found few if any micromolluscs in intertidal seagrass around the inner Hauraki Gulf. We are unsure of why the major difference between now and the 1960s. Since Morton and Miller do not specify the location of their counts we cannot exactly repeat them. Could it be that the micromollusc faunas of seagrass were decimated during the sea-grass demise due to the fungal slime *Labyrinthula* in the 1950–60s (Armiger 1964), and have not returned with the dramatic recovery of *Zostera* in the Waitemata Harbour in recent decades? Another possible cause of decline in the abundance and perhaps diversity of living micromolluscs in northern harbours could be the increased silt from land runoff and marina dredge dumping which now often chokes the seagrass and coralline turf (pers. obs.) that are favoured micromollusc habitats.

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APPENDIX 1: Micromollusc species records from northern New Zealand and species occurrence data in study sites used for cluster analysis and diversity trends analysis. Available on-line at www.aucklandmuseum.com/research/pub/records/51/sup/morley-hayward-micromollusca

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