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Distribution of Mysids (Crustacea: Mysidacea) in Auckland Region, New Zealand

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Abstract Given the ecological significance of mysids in brackish and freshwater food chains and the potential importance in toxicity testing in estuarine systems, it is important to understand the distribution of these animals. However, to date, few studies have been undertaken on mysids in the Auckland region. The main focus of this study was to find out the distribution of estuarine mysids in this region. Reconnaissance surveys took place to locate mysid habitats in the estuarine waters entering the Manukau Harbour and the East Coast estuarine environments from May of 2006 to January 2009. The samples were taken using a hand held dip net with 500 µm mesh size along an eighty meter transect at the edge of the stream during day time at low tide. At each site four replicate surveys were undertaken (transects of 10 m length, 10 m apart). Five species of mysids have been identified from and are described for estuarine environments in the Manukau Harbour and along the Auckland East Coast: the sometimes sympatric *Tenagomysis chiltoni* and *T. novaezealandiae*, and the non-sympatric and patchily distributed *Gastrosaccus australis*, *T. macropsis* and a potentially new *Tenagomysis* sp.. The present distributional studies in the North Island reflects that the native mysid *T. novaezealandiae* is the dominant mysid species along the east coast, and the most geographically widespread species on both east and the west coasts, while *T. chiltoni* was equally dominant with *T. novaezealandiae* in the Manukau Harbour. *G. australis* and *T. macropsis reported* from North Island estuarine waters for the first time. The salinity ranges where species occurred were different: *T. chiltoni* 0-18‰, *T. novaezealandiae* 0-26‰ and *G. australis* 1.5-12.6‰. *T. chiltoni*, *Tenagomysis* sp. and *T. novaezealandiae* shows that the higher percentages of females than males.

Keywords: *mysids, estuarine, Auckland, New Zealand, Tenagomysis*

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1. Introduction

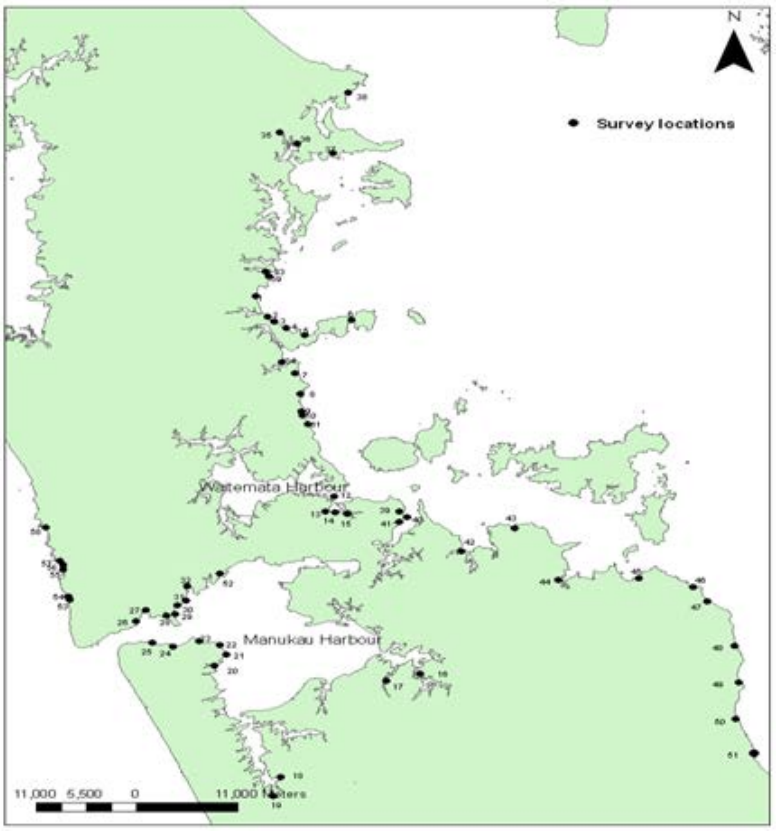
Mysids have a worldwide distribution and occupy a wide variety of aquatic environments, from fresh and brackish to fully saline oceanic waters. Given the internationally recognised ecological significance of mysids in brackish and freshwater food chains [1], it is important to understand the distribution of native estuarine mysid species. Mysids are not only an important food source or a main food link in estuarine ecosystem but also make use of them worldwide as most important bioindicators for toxicity testing in aquatic systems.

Since the establishment of the genus *Tenagomysis* to accommodate specimens as a new species, *Tenagomysis novaezealandiae* [3], from different locations, near Dunedin, in most of the New Zealand waters, the recorded mysids belong to the genus *Tenagomysis* (10 species). Twelve species reported during the "Terra Nova" expedition [2], and other shore collections in New Zealand waters. Sixteen mysid species have been so far described from New Zealand waters, presently accommodated within five genera. Among them, only few species are estuarine. Therefore, several of these species have not been reported subsequent to original descriptions, but other species have proven to be more widespread in distribution, and more regularly reported (*T. chiltoni*, *T. macropsis*, and *T. novaezealandiae*) in estuarine waters. However, the most of the studies on mysids in New Zealand has been carried out in South Island waters whereas there were very few studies from the North Island.

After the earlier studies [2,3], there have been only a few occasions that mysids recorded from the North Island and the Greater Auckland region: *T. novaezealandiae* from Raglan Harbour and the mouth of the Waikato River [4]; *T. chiltoni* from a fresh water coastal lake, near Waverley [5] and from the Waikato River ([6,7]) and both *T. novaezealandiae* and *T. chiltoni* together from stream at Piha [8]. Some studies on *T. novaezealandiae* also reported: *T. novaezealandiae* for toxicity testing [4,6] studied the biology of *T. chiltoni* of the lower Waikato River. However, no comprehensive study on mysids has otherwise been undertaken throughout the North Island of New Zealand, and also few studies of any nature have been undertaken within the Auckland region. The insufficiency of the knowledge on distribution of New Zealand mysids specially in greater Auckland region

requires a geographical survey to establish their estuarine habitats.

The objective of this study is to investigate the current distribution of mysids throughout the greater Auckland region in order to extend this knowledge in a comparative manner in other geographical regions as well.



Legend: 1. Orewa-Nukumea Stream, 2. Red Beach, 3. Puawai Bay, 4. Stanmore Bay, 5. Big Manly Bay, 6. Okoromai Bay 7. Awaruku Stream 8. Tor Bay 9. Murrays Bay (Taiorahi Creek), 10. Mairangi Bay, 11.Campbells Bay, 12. Hobson Bay, 13. Portland Road Stream, 14. Shore Road (stream), 15. Orakei Basin, 16. Drury Creek, 17. Karaka Stream, 18. Waitangi Falls, 19. Waiuku, 20. Awhitu Stream, 21.Grahams Beach, 22. Hudsons Beach, 23. Big Manly Bay, 24. Orua Bay, 25. Wattle Bay, 26. Little Huia, 27. Huia Bay, 28. Kakamatua, 29. Cornwallis, 30. Mill Bay, 31. Armour Bay, 32. Lower Nihotopu Reservoir (Spillway), 33. Wenderholm Beach, 34. Awanohi Bridge, 35. Matakana, 36. Campbells, 37. Tawaharanui, 38. Mathesons Bay, 39.Omaru Creek, 40. Point England (Tahuna Torea nature reserve)-Fresh water ponds, 41. Glendowie, 42. Mangemangerea Creek, 43. Te Puru Bridge, 44. Clevdon -Wairoa River, 45. Awapikopiko Stream, 46. Orere River, 47. Kurakuhanui Stream, 48. Waharau Stream, 49. Whakatiwai Stream, 50. Te Puaeharuri Stream, 51. Miranda Stream, 52. Paturoa Bay, 53. Karekare Stream, I 54. Karekare Stream II, 55. Piha Stream I, 56. Piha Stream II, 57. Piha Stream III, 58. Te Henga (Bethells Beach), 59. Waiwera.

Figure 1. Locations of 59 survey sites throughout the greater Auckland region

2. Methodology

Reconnaissance surveys for mysids in estuarine habitat were conducted at 59 sites extending from Mathesons Bay, north of Auckland, to Miranda in the Firth of Thames, along the east coast of the Auckland region, and from Bethells Beach, north of Manukau Heads, to Waiuku, Manukau Harbour, on the west coast of the Auckland region (Figure 1). For logistical reasons, most sites could be surveyed on a single occasion only; reconnaissance surveys commenced in May of 2006 and concluded in January of 2009. At each site reconnaissance surveys took place during day time at low tide. The samples were collected using a hand held dip net along an eighty meter transect at the edge of the stream. At each site four replicate surveys were undertaken (transects of 10 m length, 10 m apart). All mysids retained in the net along each transect were immediately collected into separate, appropriately labeled bottles containing 70% ethyl alcohol. On each sampling event, the environmental variables salinity, pH, dissolved oxygen (DO), temperature and turbidity were measured. Mysid samples collected from each transect were separated into species, sexed, and counted.

3. Results

Mysids were located at 26 of these survey sites (Figure 2, Table 1). Sites at which mysids were not recorded were surveyed only once. Among the sites from where mysids were collected, 12 were on the east and 14 on the west coast of Auckland (Table 1).

Five species were identified: the sometimes sympatric *Tenagomysis novaezealandiae* and *Tenagomysis chiltoni* (at 11 sites), patchily distributed *Gastrosaccus australis* (at four sites), and *Tenagomysis macropsis* (at one site) and a potentially new *Tenagomysis* sp. nov (at one site). Four taxa occurred on both west and east coasts; the most frequently encountered and most common species, *T. novaezealandiae*, occurred at 21 sites and *T. chiltoni* at 15 sites (Table 1 and Figure 2); *T. novaezealandiae* was the most geographically widespread species in both east and the west coasts while *T. chiltoni* occurred at a comparable

number of sites as *T. novaezealandiae* within west coast (12 sites each). In west coast both *T. novaezealandiae* and *T. chiltoni* were equally distributed (Table 1 and Figure 3). In east coast *T. novaezealandiae* had a wider distribution (nine sites) than west coast (three sites). *G.australis* occurred at more sites in east coast (three sites) than west coast (one site) (Figure 3). However, in east coast *G. australis* and *T. chiltoni* had similar occurrences (Figure 3). Makatane, Huia Bay and Waitangi falls *T. chiltoni* occurred as a single species. In nine sites *T. novaezealandiae* occurred as a single species (Table 1). Mysid occurrences in all 26 sites indicated that the native mysid *T. novaezealandiae* is the most geographically widespread species (Figure 3).

Table 1. Incidence of mysid taxa throughout the greater Auckland estuarine environments (P denotes Presence)

	Tenagomysis chiltoni	*Tenagomysis novaezealandiae*	*Tenagomysis macropsis*	*Gastrosaccus australis*	*Tenagomysis* sp. (new)
West coast					
Mill Bay	P	P			
Cornwallis	P	P			
Kakamatua	P	P		P	
Huia Bay	P				
Lower Nihotopu Reservoir		P			
Armour Bay		P			P
Orua Bay	P	P			
Waitangi falls	P				
Piha Stream I	P	P			
Piha Stream II	P	P			
Piha Stream III	P	P			
Karekare Stream I	P	P			
Karekare Stream II	P	P			
Paturoa Bay	P	P			
East coast					
Hobson Bay		P			
Murrays Bay		P			
Big Manly Bay		P		P	
Okoromai Bay		P			
Red Beach		P			
Orewa-Nukumea Stream		P	P	P	
Wenderholm Beach		P			
Makatane	P				
Awanohi Bridge				P	
Clevedon-Wairoa River	P				
Mathesons Bay	P	P			
Waiwera		P			

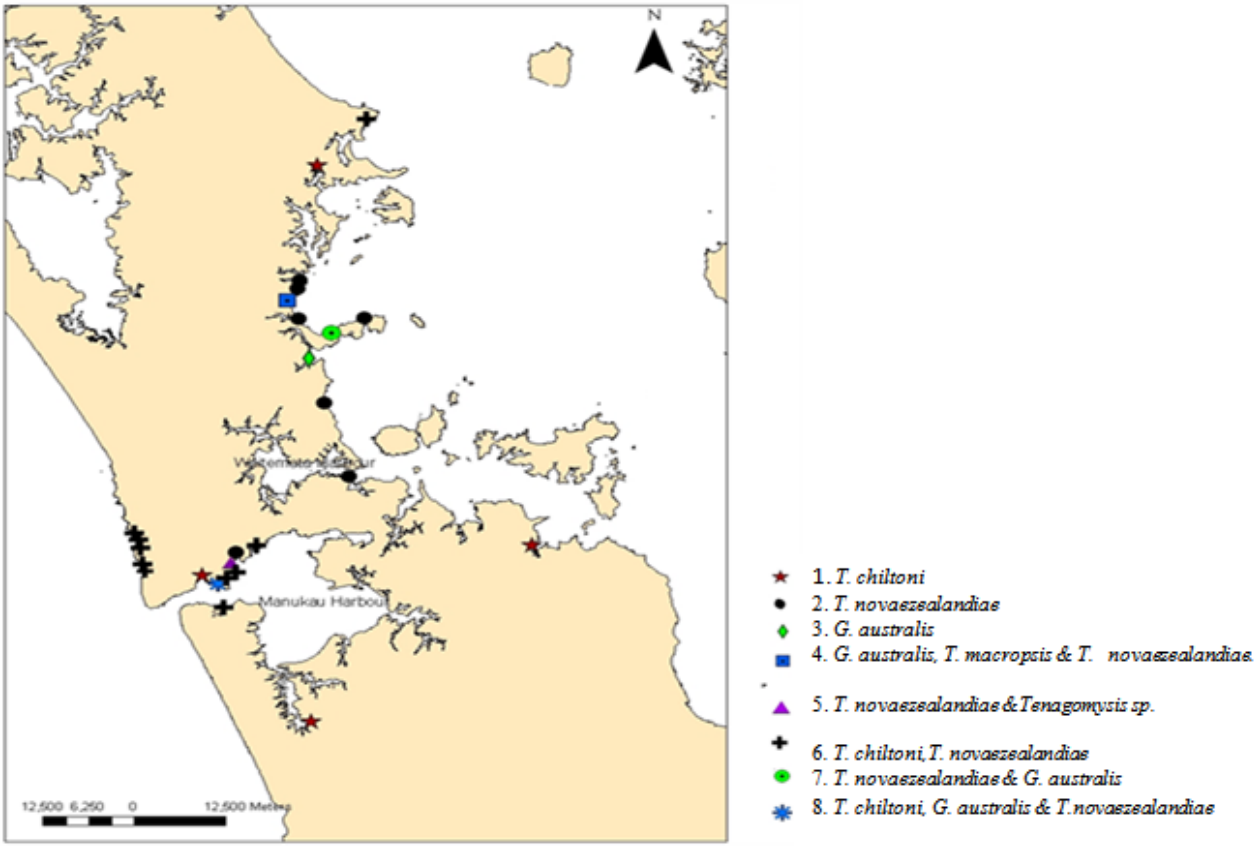


Figure 2. Recognised distribution of mysid taxa throughout survey region

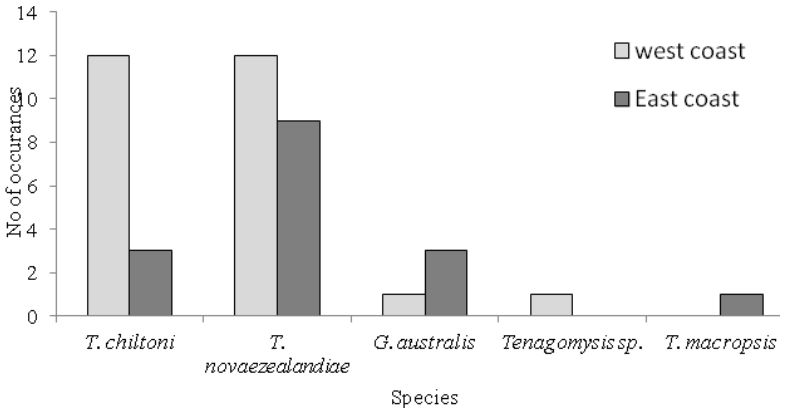


Figure 3. Number of occurrences of mysid species at west and east coast of Auckland

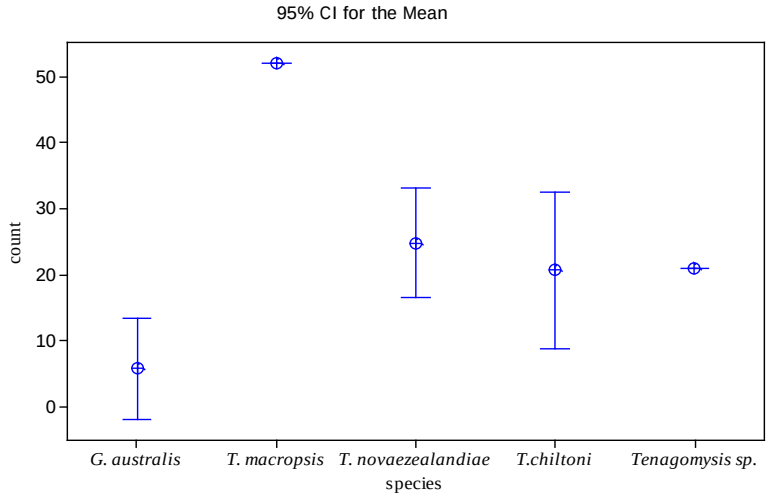


Figure 4. Mean number of individuals of all species in the entire survey

Figure 4 shows the mean number of individuals in each species. For each species mean values are different from each other. However, *T. chiltoni G. australis* and *T. novaezelandiae* values are overlapping. There is no significant difference between mysid species. *T. novaezelandiae* shows the highest number of individuals with a mean of 24.87, *T. chiltoni* shows the second highest number of individuals with a mean of 20.67 and *G. australis* with a mean of 5.8. *Tenagomysis* sp. and *T. macropsis* recorded only once with 21 and 52 individuals respectively.

3.1. Sex Ratio

The sex ratio of all mysid species in the entire survey was determined on the basis of examination of all individuals captured during the entire survey during 2006-2009 is presented in Table 2. The sex ratio of all mysid species in the entire survey was determined on the basis of examination of all individuals captured during the entire survey during 2006-2009 is presented in Table 2. Sex ratios (male to female ratio) of *T. chiltoni* (2.13), *Tenagomysis* sp. (3) and *T. novaezealandiae* (2.86) varied, more or less higher percentages of females (68%, 74% and 75% respectively). However, *G. australis* and *T. macropsis* 23 and 52 females with broods were found respectively and none of the males were recorded (Table 2).

Table 2. Sex ratio of mysids from the entire survey

Species	Female	Male	Sex ratio
T. chiltoni	2269	1067	2.13
T. novaezealan-diae	2417	845	2.86
G. australis	23	0	Only females
T. macropsis	52	0	Only females
Tenagomysis sp	6	2	3

3.2. Salinity Preference

The error bar plotted for salinity verses mysid species is shown in Figure 5. *T. novaezelandiae* occurred within varying ranges of the salinity indicating the wider salinity tolerance, (0-25‰) and mean occurrence of this species show under the lower salinity. Similarly, the occurrence of the majority of *T. chiltoni* were also confined to the lower salinity range and two extreme conditions also noted (12.6‰ and 17.9‰). *G. australis* occurrences show nearly symmetric distributions within lower salinities. *Tenagomysis* sp. and *T. macropsis*, were only found in higher and lower salinity ranges respectively. However, the occurrence of these two species shows oppositely different salinity.

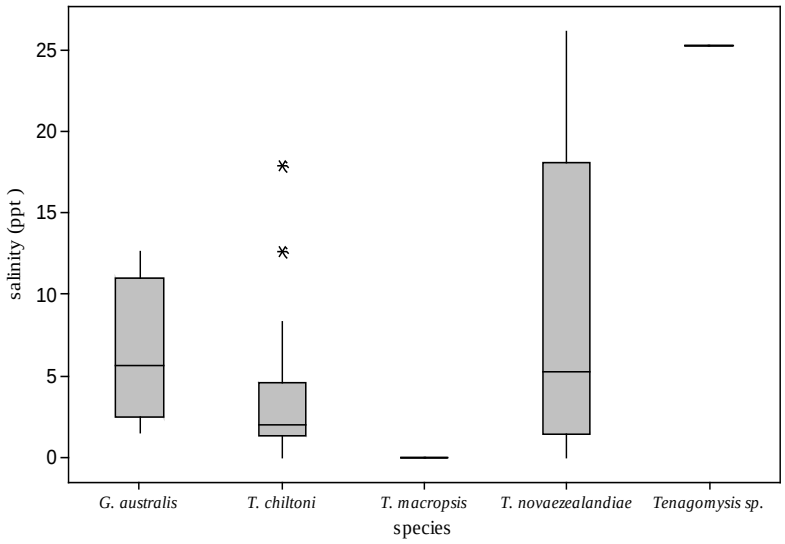


Figure 5. Salinity variation of mysid species recorded from entire survey

Considering the occurances of these mysids, 80% of *T. chiltoni*, 47.6% of *T. novaezealandiae* and 25% of *G. australis* were recorded between the salinity range of 0-5‰. Overall the salinity ranges which species occurred were different: *T. chiltoni* 0-18‰, *T. novaezealandiae*, 0-26‰ and *G. australis* 1.5-12.6‰ (Figure 5). *T. macropsis* recorded only once at the 0‰ salinity.

4. Discussion

However, mysids are recognized to be widely but sporadically distributed throughout the Auckland region, present at less than half, 26, of those 59 sites surveyed during the reconnaissance of mysid habitat reported herein. The apparent absence of mysids at 33 sites could be a cause for concern, although sites could be assessed once only for the purposes of the reconnaissance survey; reconnaissance surveys were conducted over 31 months over three years, and during certain months mysid abundance is known to be relatively low (and thus they might have been missed); mysids may have been present at low numbers or in aggregated populations; and some mysid taxa (ex: *G. australis*) are known to be more active at night (and no reconnaissance surveys were undertaken during night). Additionally, without historical data on the presence, abundance and diversity of mysid taxa throughout the Auckland region, it cannot be determined whether any change in their distributions and population dynamics have occurred. As an aside, similar studies in the South Island, around Otago, encountered mysids at 27 of 30 surveyed estuarine sites [9].

Only five species of mysid are recognised at those surveyed estuarine sites throughout Manukau Harbour and the east coast of the Auckland region: *T. novaezealandiae*, *T. chiltoni*, patchily distributed *G. australis*, *T. macropsis* and a potentially new species of *Tenagomysis*. With the exception of the potentially new *Tenagomysis* species, these same taxa occured within the Avon-Heathcote Estuary, Christchurch ([10,11]), Taieri River [12] and the Otago coastline [9]. However, another species, *T. robusta* reported [13] from the mouth of Taieri River, sympatric with *T. macropsis*, *T. novaezealandiae*, and a species of *Gastrosaccus*. Those surveyed New Zealand estuarine environments appear to be dominated by a limited number of widely distributed species of *Tenagomysis* and *Gastrosaccus*, although the combination of species present in any estuarine aquatic body can differ.

Earlier studies have reported only two species of mysid from North Island aquatic environments: *T. chiltoni* from, Lake Oturi near Waverley [5] *T. novaezealandiae* from Raglan Harbour [4] and at the mouth of the Waikato River; *T. chiltoni* in the Waikato River ([6,7]), *T. novaezealandiae* and *T. chiltoni* at Piha [8], west coast, Auckland. During this present study, *T. chiltoni* and *T. novaezealandiae* were found to be sympatric at 10 locations on the west coast and one location at the east coast of the Auckland region, including five streams at Piha. This overall mysid distribution supports the finding that *T. novaezealandiae* and *T. chiltoni* are the common species present in estuarine environments in the North Island.

Of 26 sites at which mysids occurred throughout the greater Auckland region, *T. chiltoni* occurred at 15 of them and *T. novaezealandiae* at 21 of them. Thus, *T. novaezealandiae* is the most geographically widespread of regionally occurring estuarine mysid taxa, followed by *T. chiltoni*, although the former species is prevalent on the east coast and the latter in Manukau Harbour (occurring at 12 sites). *Tenagomysis novaezelandiae* is also the most regularly encountered species in both open and closed estuarine systems around Otago [9]. Both the North Island and South Island distributions reflect that *T. novaezealandiae* is the most geographically widespread estuarine mysid species in New Zealand.

G. australis is reported from North Island estuarine waters for the first time since 1923[2] in estuarine waters at four sites, during daylight hours. They were collected from the stream floor in low water covered with sand. Therefore, it becomes difficult to collect them during daylight. However, the same species was recorded in South Island localities to be abundant species at night ([2,9,11]) in addition to an undescribed *Gastrosaccus* sp.

[13]. As the previous studies reveal *G. australis* to be largely nocturnal, its apparent absence from 55 of 59 daylight-surveyed sites in the present study might not be particularly remarkable.

T. macropsis was collected during both day and night sampling in the surface waters and deep waters of North Cape, and Bay of Islands in the North Island [2]. This species has not been previously reported from North Island estuarine waters. Herein, it is recorded from Orewa-Nukumea Stream, but only on one occasion, when 52 brooding females were encountered within a small channel in the mid estuary (0‰ salinity). The distribution of this species in estuarine waters around Auckland is limited. However, it appears [2] that the habitat of this species extends into fully saline and offshore waters that were not surveyed over the course of this research programme. Perhaps and somewhat unusually, this species is both abundant and widespread in South Island estuarine waters ([9,10,11,13,15]). However, *T. macropsis* has wide salinity tolerance limits (optimum salinity 18.5‰), as determined from its distribution in the Avon-Heathcote Estuary [15].

5. Conclusion

During this investigation, mysids were abundant and widely distributed on a variety of streams from smaller channels to larger streams throughout the west and the east coast of the Auckland region.

This is the first study to incorporate comprehensive spatial survey throughout the this region for discovery of mysid habitats. From these surveys including 59 streams, 26 mysid habitats were detected. There has been no mysid distributional data provided previously for the estuarine environments in the Auckland region except an observation at Piha, Auckland west coast [8]. Since the Terra Nova expedition, surveying the north of the North Island [2], until the present study there have been no extensive mysid distributional studies in the North Island, only studies of a few individual sites [4,5,6,8]. Therefore this work contributes novel information on the spatial distribution of mysid taxa throughout the greater Auckland region.

The number of mysid taxa detected in this present study was five, from the estuarine environments in the Manukau Harbour and along the Auckland east coast: *T. novaezealandiae* (in 21 sites), *T. chiltoni* (in 15 sites), *G. australis* (in four sites), *T. macropsis* (in one site) and a new *Tenagomysis* sp (in one site), demonstrating their distribution in the Auckland region. Earlier studies have reported only two species. *T. novaezealandiae* and *T. chiltoni*, at Piha [8], west coast, Auckland. Therefore, the diversity of mysid taxa occuring throughout this region has been significantly increased.

The present distributional studies in the North Island reflects that the native mysid *T. novaezealandiae* is the dominant mysid species along the east coast, and the most geographically widespread species on both east and the west coasts, while *T. chiltoni* was equally dominant with *T. novaezealandiae* in the Manukau Harbour. It is also important to consider that this is the first time *G. australis* and *T. macropsis* have been recorded in the Auckland region, and also anywhere in the North Island, after the historical studies [2]. Although the number of occurances were highest for *T. novaezealandiae* for the entire survey, *T. chiltoni* recorded the highest number of individuals.

T. novaezealandiae occurred within varying ranges of the salinity (0-25‰) than the other species. This smay be the reason that the number of occurrences was highest for *T. novaezealandiae* for the entire survey.

Acknowledgement

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