

TIDAL ZONATION OF OSTRACOD AND MICROMOLLUSCAN FAUNAS IN CORALLINE TURF ON THE EAST AND WEST COASTS OF AUCKLAND, NEW ZEALAND

MARGARET S. MORLEY AND BRUCE W. HAYWARD

Abstract. Samples of coralline turf and associated sand were taken from high-, mid- and low-tidal pools on relatively sheltered harbour shores on Auckland's east coast (Musick Pt) and west coast (Cornwallis). Complete census counts of the live and dead carapaces and shells of ostracods and micromolluscs in replicate 25 cm³ samples resulted in the identification of 80 species of ostracod (59–60 from each coast) and 81 species of mollusc (64 from the east, 47 from the west). Forty five ostracod and 49 mollusc species were found living on the coralline turf or in the associated sediment.

Correspondence analysis of the data indicates that biogeographical differences between east and west coast faunas are far stronger in the molluscs than the ostracods. Environmental factors related to tidal elevation (zonation) also seem to be major drivers of the differences in composition of the live faunas in both groups, with the low-tidal faunas more distinct than those from mid- and high-tidal pools. All samples show significant differences between live and dead assemblages. The differences are stronger in ostracods than in the larger, denser-shelled micromolluscs. The differences are mostly attributed to post-mortem wave transport in and alongshore of shells from other, mainly soft sediment habitats. The rapid post-mortem break-up and loss of the thin carapaces of 5 species of common live ostracod also contributes to the differences between live and dead assemblages. Seasonal changes in the composition of the live faunas may also contribute to the live-dead differences but these were not investigated in this study.

KEYWORDS: New Zealand; Waitemata Harbour; Manukau Harbour; Ostracoda; Mollusca; coralline turf; *Corallina officinalis*; *Arthrocardia corymbosa*.

INTRODUCTION

Coralline algae are relatively common globally, forming a closely intertwined stiff turf on intertidal and shallow subtidal rocks (Bussell *et al.* 2007). In New Zealand they are common and often conspicuous wherever suitable substrates occur (Harvey *et al.* 2005). The highly branched fronds have a high surface area to volume ratio when compared to other algae (Hicks 1977) creating a secure habitat for microfauna. The branching coralline algae are not easily penetrated by predators

(Coull & Wells 1983), nor are its inhabitants totally at the mercy of waves and currents. Silt, in sheltered environments, collects in the holdfasts at the base of the fronds (Hicks 1977) providing a soft sediment substrate for some fauna e.g. the bivalve *Neolepton antipodum*. Fine silt from the land can also clog the entire surface of the turf close to urban development and this was present to varying degrees at both our study localities in the outer suburbs of Auckland City.

The coralline turf often consists of mixed algal species. Proportions present vary according to tidal levels and their geographical locations on the east and west coasts of New Zealand.

This study documents the ostracod and micromollusc assemblages that inhabit intertidal coralline algal turf and associated sediment around Auckland, northern New Zealand. Using our quantitative census counts we investigate the role of tidal elevation, wave transport of dead carapaces and shells, and biogeography in producing differences in the distribution patterns of these two groups of coralline algal inhabitants. To our knowledge this is the first quantitative study of New Zealand ostracods in intertidal coralline algal turf. It is also the first to provide comparisons between west and east coasts, and low-, middle- and high-tidal ostracod or micromollusc assemblages.

PREVIOUS WORK

The only significant previous work documenting living ostracods in coralline algal turf around New Zealand is that by Eagar (1999). His study investigated the impacts of a coastal sewer outlet on the ostracods in low-tidal rock pools in Island Bay, Wellington, at the south end of New Zealand's North Island. Around Auckland, the distribution of 58 species of ostracods has been documented in the intertidal and subtidal sediments of Waitemata Harbour on the east coast (Morley & Hayward 2007). Changes in ostracod faunas inhabiting intertidal, soft-sediment substrates following the establishment of introduced cord grass and Asian date mussel communities has been documented from five localities (both east and west coast harbours) around Auckland (Hayward *et al.* 2008). The elevational influence on the distribution of 39 ostracod species inhabiting intertidal and shallow subtidal, sediment has also been investigated in Whangapoua Estuary on Coromandel Peninsula (Fig. 1), east of Auckland (Morley & Hayward 2006).

Early mollusc researchers and keen shell collectors in New Zealand recognised coralline turf as a rich habitat for microscopic molluscs. Ponder (1965) gave detailed accounts of micrograzers and microdetritus feeders in the family Eatoniellidae, which he described as the dominant small, algal-dwelling molluscs. Where known, he named the algal species on which they were collected. Morton and Miller (1968) recorded details of micromolluscs in coralline algae, and noted that the brown alga *Carpophyllum plumosum* was a preferred habitat of rissoid microgastropods. Powell (1979) recorded a number of marine mollusc species living on specific plant substrates, e.g. the trochids <10 mm, *Micrelenchus dilatatus* and *M. sanguineus*, on brown kelp and *M. huttonii* on sea grass, *Zostera*. The small bivalve *Neolepton antipodum*, common in this study, is recorded by Powell (1979) as abundant among coralline algae.

In a study specifically on the foraminifera living on New Zealand intertidal coralline algae, Hedley *et al.* (1967) recorded *Rosalina bradyi*, *R. irregularis* and *Trochulina dimidiatus* (as *Discorbis dimidiatus*) attached to several coralline species around both North and South Islands. Mucilaginous material, often embedded with sand grains, usually surrounds these attached foraminiferal shells.

Overseas studies on the fauna of intertidal coralline algae include one in Wales on the diversity (101 species, including molluscs but not ostracods) of the invertebrate assemblage in *Corallina officinalis* (Bussell *et al.* 2007). Hull (1997) studied monthly samples of 18 species of ostracods in rock pool algae in England, including *Corallina officinalis*. The abundance and diversity demonstrated pronounced seasonal variation in the living fauna. The life cycle of eight

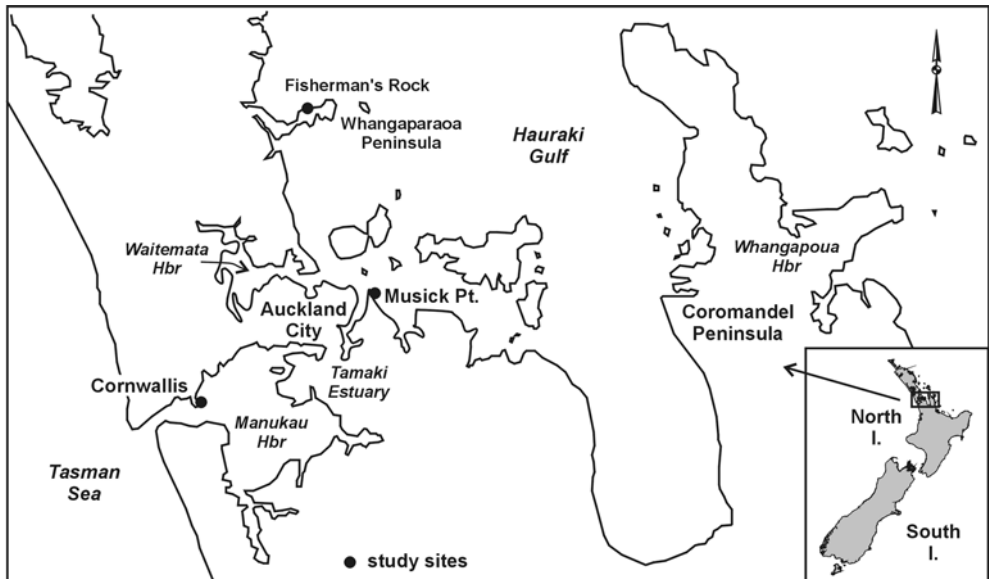


Fig. 1. Map of study sites and other places mentioned around Auckland.

ostracod species was determined. A second study by Hull (1999) in England indicated that there were significant differences in the ostracod assemblages in tidal-pool algae between four shores and between tidal elevations. A further study in California (Frame *et al.* 2007) showed that the abundance of live ostracods differed significantly among algal types, with many more ostracods per gram of algae in structurally complex species (such as coralline algae) than on blade-like algae. Hagerman (1968) and Horne (1982) have also documented the ostracods living in *Corallina officinalis* in Norway and the United Kingdom respectively.

PILOT STUDY

A pilot study was carried out at Fisherman's Rock, Whangaparaoa Peninsula, east coast of Auckland (Fig. 1). Four low-tidal algal species (*Ecklonia radiata*, *Splachnidium rugosum*, *Cystophora torulosa*, *Scytothamnus australis*) were washed for ostracods and molluscs. None were found on the fronds, although a few of each were living in *E. radiata* holdfasts. Abundant molluscs and ostracods were washed however, from intertidal coralline algal turf making this the most suitable algal group for the proposed study. A common coralline red alga, *Jania micrarthrodia*, attached around the margins of low-tidal pools, proved to be an especially rich habitat. Unfortunately *J. micrarthrodia* was not present in our chosen study site at Cornwallis and was found only in low numbers at Musick Point. It appears to require a more exposed habitat (MSM pers. obs.).

Due to the difficulties of identifying and quantifying the overwhelming numbers of ostracods and micromolluscs at Fisherman's Bay, particularly the small, algae-grazing eponiellids, it was decided to study localities with somewhat lower diversity and fewer specimens.

STUDY SITES

Musick Point, Waitemata Harbour, East Auckland (Fig. 2)

The east Auckland site chosen was Musick Point, Waitemata Harbour (36° 50' 57.4" S, 174° 54' 8.9" E, Auckland Museum Catalogue Number L34585; spring-tidal range 3.2 m) on the east-facing side near its northern tip. This is a semi-exposed shore with a wide intertidal platform composed of sandstone and mudstone (Waitemata Formation). Numerous elongate, intertidal pools follow the strike of the strata. Samples were taken on 31 August 2007 when the low spring tide was 0.3 m. The dominant algal species in pools at all three study levels is the coralline *Arthrocardia corymbosa* (70–99%) with subdominant *Corallina officinalis* (19–28%) in the high-tidal pool.

Cornwallis, Manukau Harbour, West Auckland (Fig. 3)

The west Auckland site chosen was Cornwallis, Manukau Harbour (37° 00' 58.4" S, 174° 36' 27.7" E, Auckland Museum Catalogue Number L35109; spring-tidal range 3.9 m). This is a semi-exposed shore with a narrow intertidal platform composed of volcanic conglomerate (Piha Formation) often covered with cobbles and large boulders. There are few intertidal pools. It is possible that the intertidal boulders provide more local shelter for this site than that Musick Pt. Samples were collected on 31 August 2008 when the low spring tide was 0.5 m. Both sites were sampled in August to avoid possible seasonal variation. The dominant alga at all three study levels was the coralline *Halimnion roseum* (35–90%) with common *C. officinalis* (5–15%) at high- and low-tidal levels and common *A. corymbosa* (25–35%) at low tide. Subdominant in the turf at low and mid tide levels was the non-coralline, red alga *Gelidium caulacanthum* (10–60%).

METHODS

FIELD

Six samples were taken at both Musick Pt and Cornwallis. At each locality, two replicate samples were taken in coralline alga-lined pools at three tidal levels – high, mid and low tide. In each sample, all coralline turf and underlying sediment in a 15 cm² area was collected down to hard rock substrate. Wherever possible the sample site was 0.1–0.2 m below the water surface in the pool. Replicates were randomly sited within 1 m of each other at each tidal level. At Cornwallis, there were no low tide pools, so samples were taken from water-saturated turf that was out of the water for less than 2 hours during spring tides (located just above the *Sargassum sinclairii* zone). As far as possible the proportion of coralline mat and sediment within each sample was kept the same.

LABORATORY

In the laboratory, samples were washed in fresh water and dried. A 25 cm³ split of each sample was obtained by adding dried algae and sediment to a measuring cylinder partly filled with water. After drying, the algae and sediment were weighed and then passed over a 500 µm sieve to obtain a coarse fraction, mostly coralline algae and molluscs, and over a 125 µm sieve to obtain a fine fraction, a mix of ostracods and molluscs. Both fractions were fully examined under a dissecting microscope and all specimens of Mollusca and Ostracoda were picked onto gummed, gridded slides. They were later identified and counted (Appendix 1).

COMPUTER ANALYSIS

The census data for Ostracoda and Mollusca were treated separately. For each sample, the data was standardised as proportions of ostracods and molluscs separately. Detrended Correspondence



Fig. 2. Study site at Musick Point, Waitemata Harbour, Auckland.



Fig. 3. Study site at Cornwallis, Manukau Harbour, Auckland.

Analysis (Decorana) was run on each data set using MVSP (Kovach 1993) and the resulting two-dimensional ordination used to interpret the results.

Species diversity in samples was assessed using the number of species (S) in each sample and Fisher's Alpha Index (α) to account for variations in the number of specimens present in each sample.

ASSESSING LIVE OR DEAD

Ostracoda

Where the carapace of some species of ostracods is transparent, the live animal within could be determined, especially when wet (e.g. *Xestoleberis*). Ostracod appendages often protrude from the ventral margin of the conjoint carapace and indicate that the specimen was probably alive when collected (e.g. *Quadracythere mediaruga*). The valves of the ostracod *Loxococoncha punctata* conveniently open when wetted allowing a check for the animal. A proportion of other specimens with conjoined valves was crushed to confirm whether they contained soft parts and would have been live or not. Soon after death, the ostracod carapace opens and the valves separate because of intense bacterial activity (Swanson 1979). Post-mortem transport of ostracod valves by waves and currents aids their separation. Therefore we consider that the majority of double valves in this study are likely to represent the more recent generations of species that lived in the coralline algae at the site.

Mollusca

The presence of an operculum is taken to indicate that a gastropod specimen was living. Sometimes it could be seen in the aperture, but it can also be withdrawn out of view. The claw of tiny hermit crabs, *Pagurapseudes* in *Eatoniella* species can easily be mistaken for the operculum. In some cases sand grains and detritus adhere to the aperture, probably drawn in by the dying animal as a response to dehydration (pers. obs.). The soft parts of the animal can often be seen through a translucent shell, (e.g. *Eatoniella lutea*), but not through an opaque one (e.g. *E. olivacea*). A proportion of the picked common gastropod and conjoint bivalve specimens from each sample was crushed while being observed under the microscope. If present, the remains of the live animal could then be confirmed.

IDENTIFICATION PROBLEMS

For quantitative studies like this, all specimens need to be identified to a species. With ostracods, the various instars can be a challenge to identify correctly as the sculpture and shape in some species change during the eight moulting stages.

In molluscs, some juvenile bivalves (<0.5 mm) are difficult to identify as their distinguishing features have not yet developed (e.g. the produced anterior end of *Nucula hartvigiana*). Juveniles of the mytilids *Limnoperna pulex* and *Perna canaliculus* are not elongated and difficult to tell apart, and were counted together as Mytilidae. In other species it is possible to distinguish juvenile specimens of larger species from micromolluscs by their immature lip, large protoconch or the presence of their characteristic features (pers. obs.). Many specimens of *Eatoniella* gastropods from low tide at Cornwallis were heavily encrusted with pink coralline paint making it impossible to identify to species confidently. In addition specimens of *E. albocolumella* and *E. limbata* showed marked variation in colour pattern making positive identification uncertain. Juvenile specimens of a white, umbilicated microgastropod from mid- and low-tidal samples at Musick Point were a problem to identify, and have been referred tentatively to *Eatoniella perforata* as their features do not match those of any described intertidal *Eatoniella* species.

SPECIMEN LODGEMENT

Sediment samples, slides of ostracod and micromollusc faunas and figured specimen slides are lodged in the marine collections at Auckland War Memorial Museum under location numbers prefixed by L.

RESULTS

OSTRACOD DISTRIBUTION

At both Musick Pt and Cornwallis live, high-tidal ostracod faunas had lower diversity than mid-tidal faunas and mid-tidal faunas had slightly lower diversity than low-tidal faunas (Fig. 4). The dead faunas at Musick Pt also had lower species diversity in high-tidal pools than mid- and low-tidal. At Cornwallis however, the low-tidal fauna had lower diversity (α) than the mid- and high-tidal faunas. The live, high-tidal ostracod faunas from both coasts had similar diversity ($\alpha = 1.7\text{--}2.4$, $S = 8$), whereas the live mid- and low-tidal faunas were more diverse at Musick Pt ($\alpha = 6\text{--}7$, $S = 21\text{--}22$) than Cornwallis. The dead faunas do not exhibit the same diversity difference between east and west coast, but the samples from Musick Pt contained far more dead ostracod tests than the samples from Cornwallis and thus more species were recorded from the east coast ($S = 13\text{--}33$) than west ($S = 14\text{--}23$).

At all six study sites (12 samples) one species, *Xestoleberis* sp., was the dominant or a co-dominant member of the live faunas. The thin-shelled *Sclerochilus* sp. A was co-dominant at all tidal levels at Cornwallis and at high tide at Musick Pt, but occurred in lower abundances at mid and low tide at the latter locality (Fig. 4). One other species was a second-order subdominant in the live faunas at all six sites – *Loxoconcha punctata*. All other common species occurred living in only some of the study sites. *Cytherelloidea willetti* was second or third in relative abundance in the live faunas from all tidal levels at Musick Pt, but only one specimen was found at Cornwallis. Also among the subdominants at mid- and low-tidal levels at Musick Pt, but not recorded living at Cornwallis were *Munseyella aequa* and *M. tumida*. *Quadracythere radizea* was also a subdominant at low- and mid-tidal levels at Musick Pt and only recorded live in low numbers at Cornwallis. *Habansus* sp. was subdominant at low tide at both localities and also at mid-tidal levels at Musick Pt. Subdominant species that had greater relative abundances at Cornwallis than Musick Pt were *Ancohenia* sp., *Mutilus pumilus*, *Neosidea* cf. *amygdaloides* (especially at low tide) and *Quadracythere mediaruga*.

In all instances, the dead faunas at each study site have higher species diversity (α) and a higher number of recorded species than their accompanying live faunas. The numbers and proportion of some species are much lower in the dead assemblages than the live faunas and these include the thin-shelled taxa *Ancohenia* sp., *Cytherelloidea willetti*, *Habansus* sp., and *Sclerochilus* sp. A. *Xestoleberis* sp. and *Loxoconcha punctata* have similar high relative abundances in the dead assemblages to the live faunas throughout. Species that have considerably higher relative abundances in dead than living assemblages include *Callistocythere innominata*, *C. neoplana*, *Loxocythere crassa*, *Munseyella tumida*, and *Phlyctenophora zealandica*. Species that are present in reasonably high relative abundances as dead specimens but were not recorded living include *Copytus novaezealandiae*, *Cytheropteron* aff. *latiscaipum*, *Cytheridea aoteana*, *Paradoxostoma augustense?*, *Procythereis* aff. *lyttletonensis*, and *Waiparacythereis joanae*.

Total (live plus dead) ostracod faunas at both locations have similar levels of species richness with a total of 59 species recorded from Musick Pt and 58 from Cornwallis. Twenty-one species were

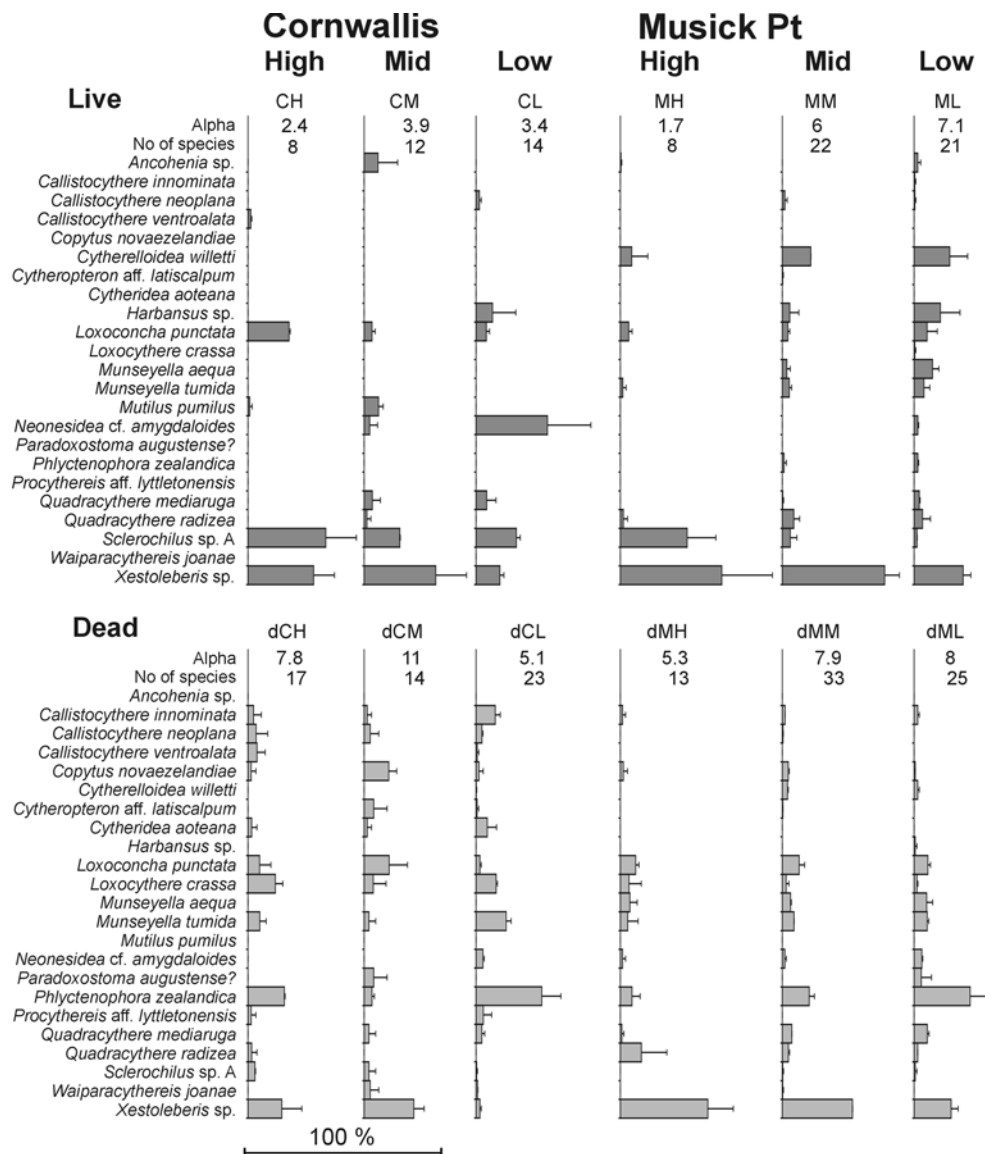


Fig. 4. Mean relative abundance of the common Ostracoda in live and dead assemblages treated separately, from high-, mid- and low-tidal levels at Cornwallis (west coast) and Musick Pt (east coast), Auckland. Standard deviation of the two replicates at each sample site is shown.

is no clear subdivision between faunas from east and west coasts with some mixing of plots from both localities, especially of mid- and high-tidal faunas. Replicate faunas from the study sites plotted closest to each other in most instances, the exception being live high-tidal faunas from both sites which overlap in composition, and the dead mid- and high-tidal faunas from Cornwallis which also overlap.

MOLLUSC DISTRIBUTION

The live and dead molluscs had similar levels of diversity (α) at all tidal levels at Cornwallis, but live molluscs were slightly more diverse at low-tidal levels than higher at Musick Pt (Fig. 6). Not surprisingly dead mollusc shells are more diverse (α) at all levels than live specimens at both sites. There is no significant difference in diversity levels between live or between dead molluscs on either the east or west coasts. However, there is a correlation between the abundance of specimens in a sample and the number of species present, with highest numbers at low tide at Musick Pt ($S = 21-29$) and Cornwallis ($S = 12-23$).

Significant differences are seen in the composition of the live mollusc faunas between the east and west coast study sites (Fig. 6). Three live species that are co-dominant at mid or high tide at Musick Pt (microgastropods *Anabathron hedleyi* and *Caecum digitulum*, and microbivalve *Neolepton antipodum*) were virtually absent from Cornwallis. Also more abundant living at Musick Pt than Cornwallis were the microgastropods *Eatoniella albocolumella* and *Eatonina micans*. Live species that were common at one or more tidal levels at Cornwallis but virtually absent from Musick Pt were the microgastropods *Eatoniella olivacea* and *Eatonina subflavescens* and the introduced Asian mussel *Musculista senhousia*. There were also differences in the live faunas between tidal levels, with the horn shell *Zeacumantus subcarinatus*, plus *A. hedleyi*, *C. digitulum*, and *N. antipodum* more common at higher than lower tidal levels. Species of *Eatoniella* and *Eatonina* plus the microgastropods *Tubbreva exigua* and *Zalipais lissa* were more common living at mid- and lower tidal levels.

East-west differences in the live faunas were largely repeated in the dead assemblages, although dead specimens of *Musculista* were relatively more common at Musick Pt than living specimens. Additional significant east-west differences in the dead faunas included the presence of the microgastropods *Linopyrga rugata*, *Merelina taupoensis*, *Pisinna olivacea impressa*, and *Rissoina chathamensis* at Musick Pt but not at Cornwallis. The gastropods *Maoricolpus roseus manukauensis* and *Notoacmea elongata* and the bivalves *Austrovenus stutchburyi*, *Crassostrea gigas* and *Hiatella arctica* were present at Cornwallis and not Musick Pt.

Unlike the ostracods, the total (live plus dead) number of species of molluscs on the east coast (Musick Pt, 64 species) was far larger than on the west (Cornwallis, 47 species). A total of 81 mollusc species were recorded from all the study samples combined.

The Decorana ordination (Fig. 7) of the 24 mollusc faunal samples shows that the strongest split (along axis 1) is between Musick Pt (left) and Cornwallis (right) faunas. The second strongest division (along axis 2) is between low-tidal faunas (upper) and mid- and high-tidal faunas (lower). Live and dead faunas are mixed together on the plot with no clear subdivision or trend. On the ordination the low-tidal faunas (dead and live) appear to be more different between east and west coasts than those from mid- and high-tidal levels. Replicate faunas from most study sites plot closest to each other in most instances, although mid- and high-tidal live and dead faunas at each locality are somewhat mixed together and statistically inseparable.

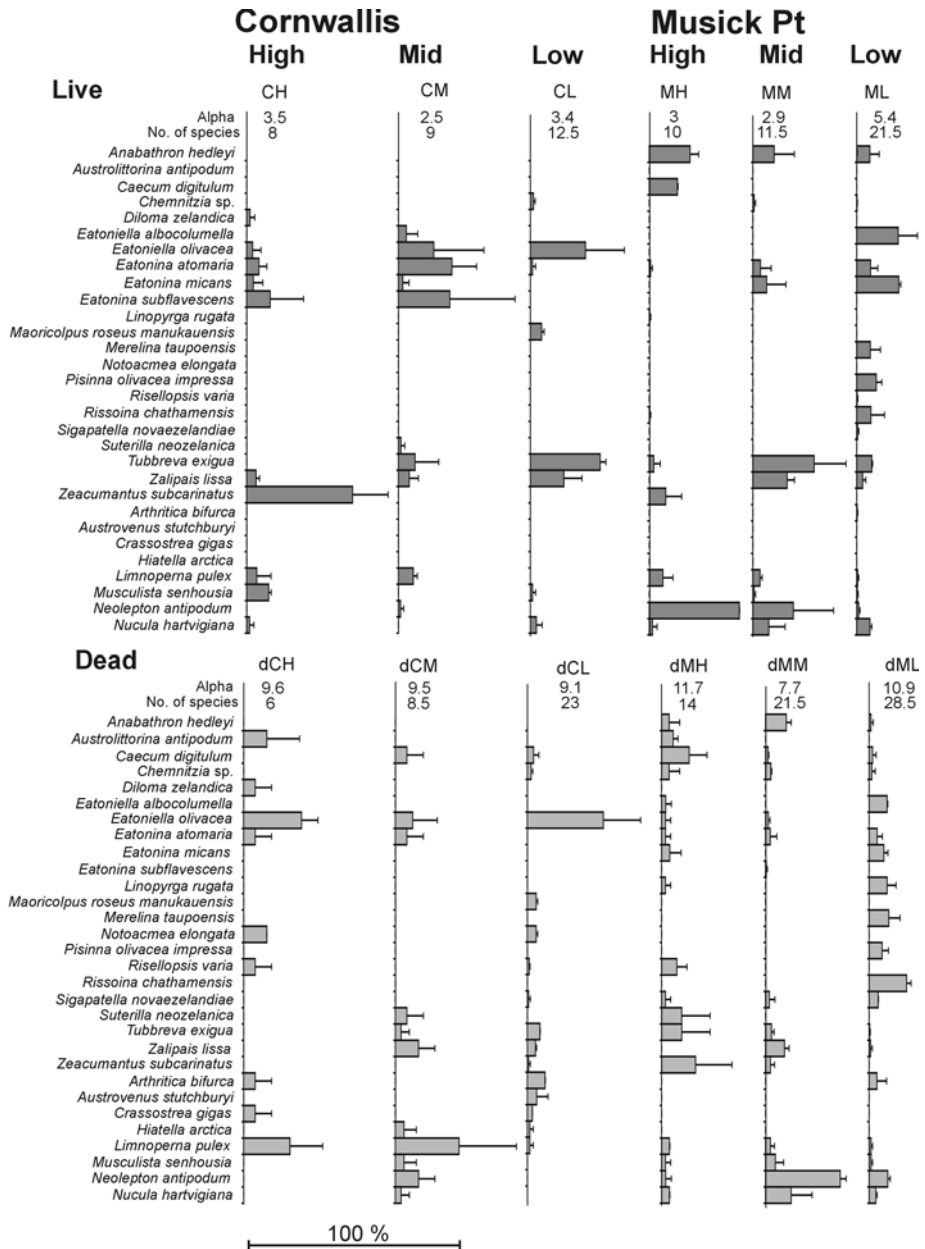


Fig. 6. Mean relative abundance of the common Mollusca in live and dead assemblages treated separately, from high-, mid- and low-tidal levels at Cornwallis (west coast) and Musick Pt (east coast), Auckland. Standard deviation of the two replicates at each sample site is shown.

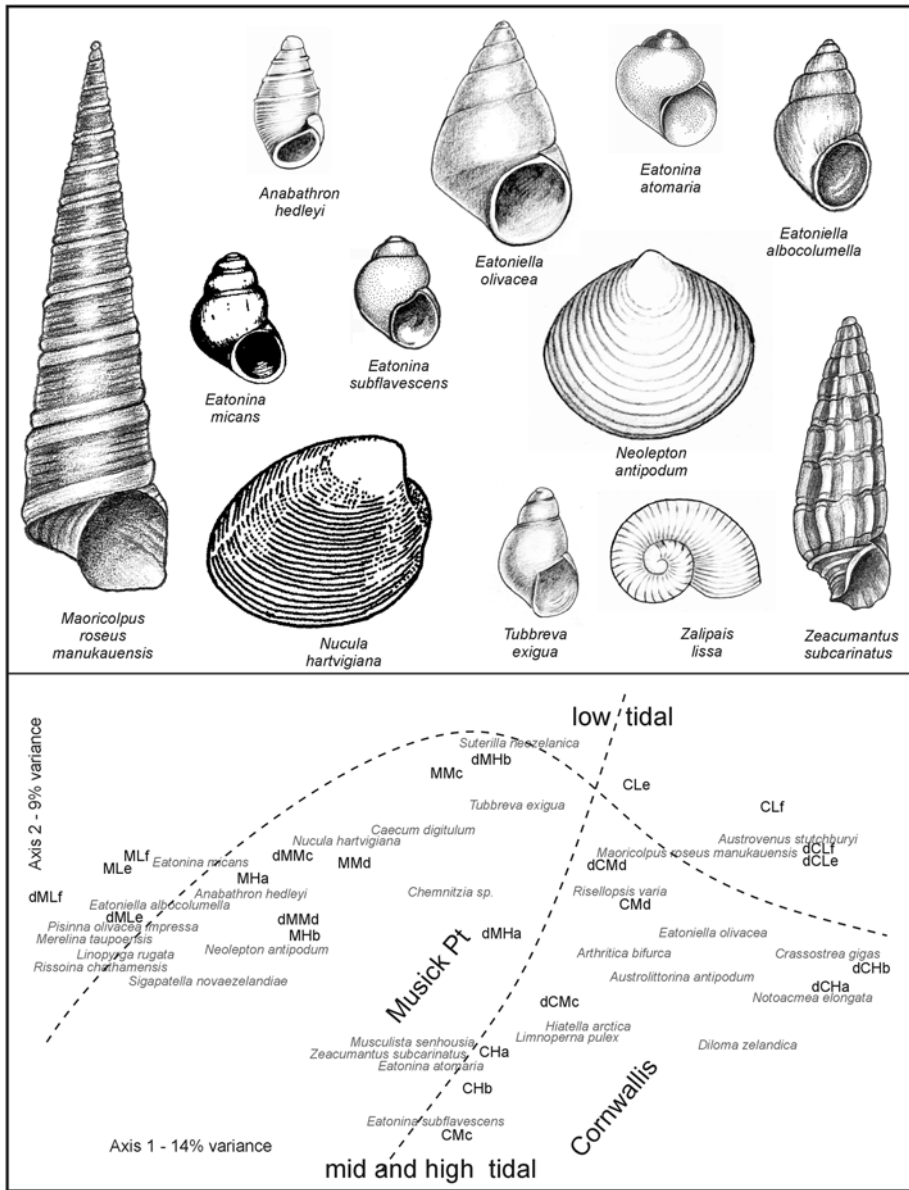


Fig. 7. Detrended correspondence analysis (DECORANA) ordination of live and dead mollusc assemblages (replicates a and b) and common species from the three tidal elevations at Cornwallis (west coast) and Musick Pt (east coast). The more common species are illustrated. Key to sample numbers: C = Cornwallis, M = Musick Pt, L = low-tidal, M = mid-tidal, H = high-tidal, d = dead.

DISCUSSION

BIOGEOGRAPHIC DIFFERENCES

Molluscs exhibit greater biogeographic differences than ostracods in this study. Although both live and dead ostracod faunas in low- and mid-tidal pools at Musick Pt have more species (21–33) than similar faunal samples at Cornwallis (12–23), both localities have the same total number of species (59–60). Over 50% of the total 80 ostracod species were only recorded from one of the two study sites. This study was not comprehensive enough for us to be confident that many of these taxa are limited to only the east or west coast of Auckland, as most of those not recorded from both sites were rarer species in these habitats. Four of the more commonly occurring species at Musick Pt were not recorded in this study from the west coast – *Munseyella aequa*, *Caudites* aff. *scopulicolus*, *Keiija demissa* and *Trachyleberis scabrocuneata*. Two of the more common species recorded from Cornwallis but not the east coast in this study were *Callistocythere ventrolata* and *Cytheridea aoteana*. The low level of biogeographic difference between the ostracod faunas is evident in the intermingling of faunas from the two localities in the ordination (Fig. 5).

The molluscs in this study exhibit a marked contrast in quantity and diversity mainly of gastropods between east and west coasts. This is reflected in the ordination (Fig. 5) where biogeography appears to be the strongest driver of faunal distribution in the intertidal pools. More mollusc species were recorded from the east coast (64) than the west coast (47) in this study. This parallels the observed decrease in diversity from east to west coast that is well documented for marine Mollusca (e.g., Powell 1979; Hayward & Morley 2004; Morley & Hayward 2009; Spencer *et al.* 2009). The following molluscs recorded from Musick Pt in this study are of species not yet known from anywhere on Auckland's west coast (e.g. Powell 1979; Hayward & Morley 2004): *Anabathron hedleyi*, *Eatoniella lutea*, *E. ?perforata*, *Fictonoba carnosus*, *Gumina* sp., *Merelina taupoensis*, *Pusillina hamiltoni*, *Zebittium exile*, *Zerotula crenulata*, *Limaria orientalis*, *Melliteryx parva*, and *Pleuromeris zelandica*. The only taxon recorded here from Cornwallis that is not recorded from anywhere on the east coast is *Maoricolpus roseus manukauensis*, a subspecies that is thought to be limited in its distribution to the west coast (Powell 1979).

TIDAL ZONATION

The ordinations suggest that the tidal elevation of the pools is a significant factor in driving the differences in faunal composition of both ostracods and molluscs, particularly between low-tidal and those from mid- and high-tidal levels. The live and dead ostracod faunas at the different tidal levels plot separately for Musick Pt, but the mid- and high-tidal faunas from Cornwallis are intermixed and not significantly different. The live mollusc faunas at the different tidal elevations plot separately but the dead assemblages from mid- and high-tidal levels are intermingled and not separable.

This suggests that, although these ostracods and molluscs all live in similar coralline algal habitats that are constantly submerged in water in the tidal pools, the elevation of the tidal pools still seems to have an influence on their faunal composition. Factors that might differ between the tidal pools at different elevations would be periodically increased summer or decreased winter temperature of the higher pools and occasionally increased salinity (through evaporation) of the higher pools. As the lower pools are part of the general water column for much longer than the high-tidal pools one can expect a greater supply of suspended detritus (food for some species) being deposited in the lower pools.

The main faunal difference in both live ostracods and live molluscs between the tidal elevations is a trend towards more species further down the shore. Among the common living ostracods, only

two species – *Sclerochilus* sp. A and *Xestoleberis* sp. – decreased in relative abundance from high- to low-tidal levels. Among the common living molluscs, three species – *Zeacumantus subcarinatus* (at both localities), *Anabathron hedleyi* and *Neolepton antipodum* (at Musick Pt only) – decreased in relative abundance going down the shore.

TRANSPORT AND FAUNAL MIXING

Both study sites are moderately sheltered, but are exposed to strong northeasterly or easterly winds that generate sufficient waves (less than 0.5 m high) to stir up sediment and transport ostracod carapaces and mollusc shells around the intertidal zone. At low tide, waves of this nature would readily pick up and transport carapaces and shells of subtidal or sediment-dwelling ostracods and molluscs into the intertidal zone, where they could be trapped with other sediment in the pools and around the bases of coralline algae. Tidal currents past the Musick Pt site are minimal but stronger around the Cornwallis coast. These too have some potential to transport ostracod carapaces and micromollusc shells along the shore.

Ostracods and molluscs living within the coralline turf are afforded considerable protection, which reduces wave or tidal current removal of live specimens. The hardparts of many of those that die within the coralline algal turf would be trapped in the sediment at the base and included in this study.

Our live and dead census counts provide clues as to what proportion of the dead fauna has been transported in from other environments.

In the ostracod ordination (Fig. 5) the strongest subdivision of faunas is between dead and live faunas. This could be a result of either differing seasonality in blooms of various live ostracod species or of dead ostracod carapaces introduced from other habitats. Common species found entirely or dominantly in the dead assemblages at both localities include *Callistocythere innominata*, *C. neoplana*, *Copytus novaezelandiae*, *Eucythere gravipunctata*, *Euphilomedes* spp., *Loxocythere crassa*, *Paradoxostoma augustense?*, *Phlyctenophora zealandica*, *Trachyleberis* spp., *Waiparacythereis joanae* and a large number of rarer species. Common species found only in the dead assemblages only at Cornwallis were *Cytheridea aoteana* and *Procythereis* aff. *lyttletonensis*. The majority of these species are the common ones that live in the shallow subtidal and intertidal mud and sand substrates of these harbours today and in the recent past (Morley & Hayward 2007; Hayward *et al.* 2009) and have clearly been transported in and mixed with the dead ostracods that have lived in the coralline algal turf. On the ordination the dead assemblages from Cornwallis plot further away from the live assemblages in the same sample than they do from Musick Pt. The implication from this is that there has been more mixing and post-mortem transport at Cornwallis than at Musick Pt (but seasonality difference could conceivably produce similar results).

In the mollusc ordination (Fig. 7) biogeographic and tidal influences are stronger than those caused by post-mortem transport. In most samples there is a significant change in composition between live and dead mollusc assemblages with the low-tidal faunas becoming more similar to the mid-tidal ones when dead. There are fewer dead mollusc species than ostracods that do not occur alive in the samples. This suggests that the heavier mollusc shells are not being transported around after death as much as the smaller, lighter ostracod carapaces. No common mollusc shells were found only dead in the study, but a number of rarer shells that had obviously been washed in from sediment or subtidal habitats were only present dead. These include the infaunal bivalves *Austrovenus stutchburyi*, *Macomona liliana*, *Nucula nitidula*, and *Paphies australis* and the gastropods *Maoricrypta monoxyla* and *Notoacmea elongata* which live on rocks or shells.

POST-MORTEM CARAPACE AND SHELL LOSS

Several ostracod species were recorded reasonably commonly living in this study but their carapaces were rare or absent in the dead assemblages. These species were *Ancohenia* sp., *Archasterope* cf. *dentata*, *Harbansus* sp., *Mutilus pumilus* (Cornwallis only), ?*Polycope* aff. *cingulata* and *Sclerochilus* sp. A. All of these, except *M. pumilus*, have thin, fragile carapaces that probably break-up or dissolve soon after the death of the organism and therefore they are under-represented in the dead assemblage and will seldom be found fossil. The first three of these species are made of a more soluble form of calcite than all the other ostracods in this study and hence their carapaces quickly dissolve after the animal dies (Eagar 1995). There is no evidence of any significant post-mortem loss of mollusc shells, although it is known to occur in the thin-shelled, introduced bivalves *Theora lubrica* and *Musculista senhousia* (Hayward *et al.* 1998).

CONCLUSIONS

This study of the ostracods and micromolluscs of coralline turf substrates in tidal pools shows that:

1. The diversities of ostracods and micromolluscs in these habitats are remarkably similar, both live (47 and 49 species) and total (82 and 81 species) assemblages.
2. There are strong biogeographical differences between west and east coast mollusc faunas but only weak differences in the ostracod faunas. East coast mollusc faunas are more diverse than those on the west coast, a well-documented observation usually attributed to the warmer water of the East Auckland Current.
3. Tidal-pool ostracods and micromolluscs exhibit intertidal zonation, as we document strong differences in the composition of the living faunas related to tidal elevation. The low-tidal faunas are more distinct than those from mid- and upper-tidal pools. The reasons for this are not entirely clear but could be related to more variable temperatures and salinity in the higher tidal pools, to differences in quality and quantity of food supply between tidal levels or differences in predator and competitor pressures.
4. Assemblages of dead ostracod carapaces and micromollusc shells show significant differences in composition from live faunas from the same samples. These differences are largely attributed to wave transport of dead carapaces and shells from other habitats and the trapping of these together with sand around the base of the coralline turf. Ostracod carapaces appear to exhibit more post-mortem transport than the denser and larger-shelled micromolluscs. Low-tidal sites are more mixed than those higher on the shore. Some of the differences between live and dead assemblages could be attributed to seasonality of the living populations, but this was not investigated in this study.
5. Further differences between the live and dead assemblages can be attributed to the rapid post-mortem break up and loss of some of the more common, thinner-shelled ostracods. Two thin-shelled bivalves also break up or dissolve rapidly after death, but they were not common in this study.

Acknowledgements. We thank Alan Beu and Stephen Eagar for refereeing the manuscript and suggesting helpful improvements; Bruce Marshall (Te Papa) for information on the mollusc *Ammonicera* sp.; and Ashwaq Sabaa for scanning original drawings for the figures.

REFERENCES

- BUSSELL, J.A., LUCAS, I.A.N., and R. SEED
2007 Patterns in the invertebrate assemblage associated with *Corallina officinalis* in tide pools. *Journal of the Marine Biological Association of the United Kingdom* 87: 383–388.
- COULL, B.C. and J.B.J. WELLS
1983 Refuges from fish predation—experiments with phytal meiofauna from the New Zealand rocky intertidal. *Ecology* 64: 1599–1609.
- EAGAR, S.H.
1995 Myodocopid ostracods from New Zealand collected with a light trap. In: RIHA, J. (ed), *Ostracoda and Biostratigraphy*. Proceedings of the 12th International Symposium on Ostracoda. Balkema, Rotterdam, pp. 399–406.
1999 Distribution of Ostracoda around a coastal sewer outfall: a case study from Wellington, New Zealand. *Journal of the Royal Society of New Zealand* 29: 257–264.
- FRAME, K., HUNT, G. and K. ROY
2007 Intertidal meiofaunal biodiversity with respect to different algal habitats: a test using phytal ostracodes from Southern California. *Hydrobiologia* 586: 331–342.
- HAGERMAN, L.
1968 The ostracod fauna of *Corallina officinalis* L. in western Norway. *Sarsia* 36: 49–54.
- HARVEY, A., WOELKERLING, W., FARR, T., NEILL, K. and W. NELSON
2005 Coralline algae of central New Zealand. *NIWA Information Series* 57, 145 pp.
- HAYWARD, B.W. and M.S. MORLEY
2004 Intertidal life around the coast of the Waitakere Ranges. *Auckland Regional Council Working Report No. 111*, 100 pp and maps.
- HAYWARD, B.W., MORLEY, M.S., HAYWARD, J.J., STEPHENSON, A.B., BLOM, W.M., HAYWARD, K.A. and H.R. GRENFELL
1998 Monitoring studies of the benthic ecology of Waitemata Harbour, New Zealand. *Records of the Auckland Museum* 36: 95–117.
- HAYWARD, B.W., GRENFELL, H.R., SABAA, A.T. and M.S. MORLEY
2008a Ecological impacts of the introduction to New Zealand of Asian date mussels and cord grass – the foraminiferal, ostracod and molluscan record. *Estuaries and Coasts* 31: 941–959.
- HAYWARD, B.W., MORLEY, M.S., SABAA, A.T., GRENFELL, H.R., DAYMOND-KING, R., MOLLOY, C., SHANE, P.A.R. and P.A. AUGUSTINUS
2008b Fossil record of the post-glacial marine breaching of Auckland's volcanic maar craters. *Records of Auckland Institute and Museum* 45: 73–99.
- HEDLEY, R.H., HURDLE, C.M. and I.D.J. BURDETT
1967 The Marine Fauna of New Zealand: Intertidal Foraminifera of the *Corallina officinalis* zone. *New Zealand DSIR Bulletin* 180, 86 pp.
- HICKS, G.R.F.
1977 Species composition and zoogeography of marine phytal harpacticoid copepods from Cook Strait, and their contribution to total phytal meiofauna. *New Zealand Journal of Marine and Freshwater Research* 11: 441–432.
- HORNE, D.J.
1982 The vertical distribution of phytal ostracods in the intertidal zone at Gore Point, Bristol Channel, U.K. *Journal of Micropalaeontology* 1: 71–84.
- HULL, S.L.
1997 Seasonal changes in diversity and abundance of ostracods on four species of intertidal algae with differing structural complexity. *Marine Ecology Progress Series* 161: 71–82.
1999 Intertidal ostracod (Crustacea: Ostracoda) abundance and assemblage structure within and between four shores in north-east England. *Journal of Marine Biological Association of the United Kingdom* 79: 1045–1052.

- KOVACH, W.L.
1993 MVSP shareware, multivariate statistics package. Kovach computing services, Penrth, Wales.
- MORLEY, M.S. and B.W. HAYWARD
2006 Molluscs and Ostracods in a tidal transect from the Whangapoua Estuary, Coromandel. *Poirieria* 32: 24–33.
2007 Intertidal and shallow water Ostracoda of the Waitemata Harbour, New Zealand. *Records of the Auckland Museum* 44: 17–32.
2009 Marine Mollusca of Great Barrier Island, New Zealand. *Records of Auckland Museum* 46: 15–51.
- MORTON, J.E. and M.C. MILLER
1968 *The New Zealand Sea Shore*. Collins, London. 653 pp.
- PONDER, W.F.
1965 The Family Eatoniellidae in New Zealand. *Records of the Auckland Museum and Institute* 6: 47–100.
- POWELL, A.W.B.
1979 *New Zealand Mollusca*. Collins, Auckland. 500 pp.
- SPENCER, H.G., MARSHALL, B.A., MAXWELL, P.A., GRANT-MACKIE, J.A., STILWELL, J.D., WILLAN, R.C., CAMPBELL, H.J., CRAMPTON, J.S., HENDERSON, R.A., BRADSHAW, M.A., WATERHOUSE, J.B. and J. POJETA Jr.
2009 Phylum Mollusca, pp. 160–254, In: *New Zealand Inventory of Biodiversity*. Vol. 1. Canterbury University Press, Christchurch.
- SWANSON, K.M.
1979 The marine Fauna of New Zealand: Ostracods of the Otago Shelf. *New Zealand Oceanographic Institute Memoir* 78.

M.S. MORLEY, Auckland War Memorial Museum, Private Bag 92018, Auckland, New Zealand.
B.W. HAYWARD, Geomarine Research, 49 Swainston Rd., St Johns, Auckland, New Zealand.

	CH	CM	CL	dCH	dCM	dCL	MH	MM	ML	dMH	dMM	dML
<i>Cypris</i> sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
<i>Cythereis incerta</i> Swanson, 1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
<i>Cytherella hemipuncta</i> Swanson, 1969	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	1.2
<i>Cytherelloidea willetti</i> Swanson, 1979	0.0	0.0	0.0	0.0	0.0	0.2	5.7	14.3	17.9	0.0	2.7	1.8
<i>Cytheridea aoteana</i> Hornibrook, 1952	0.0	0.0	0.0	1.9	1.5	5.7	0.0	0.0	0.0	0.0	0.1	1.2
<i>Cytheroma variabilis</i> Mueller, 1894	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
<i>Cytheropteron</i> aff. <i>laticarpum</i> Hornibrook, 1952	0.0	0.0	0.0	0.0	4.8	0.6	0.0	0.2	0.0	0.0	0.3	0.0
<i>Cytherura clausi</i> Brady, 1880	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0
<i>Eucythere gravepuncta</i> Hornibrook, 1952	0.0	0.0	0.0	0.8	1.5	0.2	0.0	0.0	0.0	0.0	0.6	0.3
<i>Eucythere mytila</i> Hornibrook, 1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
<i>Euphilomedes agilis</i> Hornibrook, 1952	0.0	1.4	0.6	0.0	0.0	0.0	0.0	0.5	1.9	0.0	0.0	0.0
<i>Euphilomedes</i> sp. 3 Morley unpub.	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
<i>Harbansus</i> sp.	0.0	0.0	8.3	0.0	0.0	0.0	0.0	3.7	13.2	0.0	0.0	0.6
<i>Harbansus</i> sp. 1 Morley unpub.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0
<i>Hemicythere brunnea</i> Brady, 1880	0.5	2.1	1.8	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0
<i>Hemicythere</i> sp.	0.0	0.0	0.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Hemicythere tarakohensis</i> Hornibrook, 1952	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Hermanites andrewsi</i> Swanson, 1979	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Hermanites</i> sp. 1 Morley unpub.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	1.5	0.0	0.0
<i>Keijia demissa</i> (Brady, 1868)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.4	0.0	0.8	0.0
<i>Kotoracythere formosa</i> Swanson, 1979	0.0	0.0	0.0	1.6	1.5	0.0	0.0	0.5	0.0	1.5	1.3	0.0
<i>Loxococoncha punctata</i> Hornibrook, 1952	20.6	3.9	5.2	5.8	12.6	1.9	4.2	2.8	6.5	7.7	8.5	6.9
<i>Loxocythere crassa</i> Hornibrook, 1952	0.0	0.0	0.0	13.8	4.5	10.1	0.0	0.0	0.4	4.3	1.9	1.5
<i>Macrocyprina</i> sp.	0.9	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Macrocypris</i> sp.	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
<i>Microcytherura?</i> <i>hornibrooki</i> McKenzie, 1967	0.9	0.6	0.5	0.9	0.0	0.0	0.9	2.2	0.8	1.5	0.5	0.6
<i>Microcytherura</i> sp. 1 Morley unpub.	0.0	0.0	0.0	0.9	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0

	CH	CM	CL	dCH	dCM	dCL	MH	MM	ML	dMH	dMM	dML
<i>Semicytherura sericava</i> Swanson, 1979	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.3
<i>Swansonella novaezealandica</i> Swanson, 1979	0.0	0.0	0.8	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
<i>Tasmanicypris</i> <i>dietmarkeyseri?</i> Swanson, 1979	0.0	0.0	0.8	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.3
<i>Trachyleberis probesoides</i> Hornibrook, 1952	0.0	0.0	0.0	0.0	2.4	0.6	0.0	0.2	0.0	0.0	0.6	1.2
<i>Trachyleberis rugibrevis</i> (Hornibrook, 1952)	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
<i>Trachyleberis scabrocuneata</i> (Brady, 1880)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.9
<i>Trachyleberis thomsoni</i> Swanson, 1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.4	0.3
<i>Trachyleberis</i> cf. <i>zeacristata</i> Hornibrook, 1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
<i>Trachyleberis</i> sp. 2 Morley unpub.	0.0	0.0	0.0	0.9	1.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0
<i>Waiparacythereis joanae</i> Swanson, 1969	0.0	0.0	0.0	0.0	3.0	0.8	0.0	0.0	0.0	0.0	0.2	0.0
<i>Xestoleberis</i> sp. 2 Morley unpub.	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Xestoleberis</i> sp.	32.9	35.9	12.0	17.0	24.9	1.9	50.9	51.4	24.6	43.9	35.2	18.6
MOLLUSCA												
Total shells												
Alpha	3.5	2.5	3.4	9.6	9.5	9.1	3.0	2.9	5.4	11.7	7.7	10.8
No of species	8	9	12.5	6	8.5	23	10	11.5	21.5	14	21.5	28.5
POLYPLACOPHORA												
<i>Notoplax violacea</i> (Quoy & Gaimard, 1835)	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
<i>Sypharochiton pelliserpentis</i> (Quoy & Gaimard, 1835)	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASTROPODA												
<i>Ammonicera</i> sp. 4 Spencer <i>et al.</i> 2009	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
<i>Ammonicera</i> sp. not A. sp. 4	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.7
<i>Amphithalamus falsestea</i> Ponder, 1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	1.1	1.8
<i>Amphithalamus semen</i> (Odhner, 1924)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.2
<i>Anabathron hedleyi</i> (Suter, 1908)	0.0	0.0	0.0	0.0	0.0	0.0	19.6	10.1	6.2	3.6	10.0	0.8
<i>Austrolittorina antipodum</i> Philippi, 1847	0.0	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0
<i>Austromitra rubiginosa</i> (Hutton, 1873)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0

	CH	CM	CL	dCH	dCM	dCL	MH	MM	ML	dMH	dMM	dML
<i>Merelina taupoensis</i> Powell, 1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	9.4
<i>Neoguraleus murdochi</i> (Finlay, 1924)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
<i>Notoacmea elongata</i> (Quoy & Gaimard, 1834)	0.0	0.0	0.0	11.1	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0
<i>Notoacmea</i> sp.	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	3.7	0.0	0.0
<i>Pisinna olivacea impressa</i> (Hutton, 1885)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	0.0	0.0	6.2
<i>Pisinna zosterophila</i> (Webster, 1905)	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.9	0.7
<i>Pusillina hamiltoni</i> (Suter, 1898)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2
<i>Risellopsis varia</i> (Hutton, 1873)	0.0	0.0	0.0	5.6	0.0	0.9	0.0	0.0	0.2	7.3	0.0	0.0
<i>Rissoella rissoaformis</i> (Powell, 1939)	0.0	1.6	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Rissoella</i> sp.	0.0	1.1	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
<i>Rissoina chathamensis</i> (Hutton, 1873)	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	6.8	0.0	0.0	17.9
<i>Serpulorbis</i> sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
<i>Sigapatella novaezelandiae</i> (Lesson, 1831)	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.4	1.8	1.9	4.3
<i>Suterilla neozelanica</i> (Murdoch, 1899)	0.0	1.3	0.0	0.0	5.6	0.0	0.0	0.0	0.0	9.6	0.0	0.0
<i>Trochus tianatus</i> Quoy & Gaimard, 1834	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
<i>Tubbreva exigua</i> (Ponder, 1965)	0.0	8.0	33.5	0.0	2.8	6.0	2.2	29.4	7.2	9.6	2.9	0.2
<i>Zalipais lissa</i> (Suter, 1908)	4.5	5.2	16.1	0.0	11.1	3.9	0.0	16.4	2.8	0.0	9.1	0.6
<i>Zeacumantus subcarinatus</i> (Sowerby, 1855)	50.8	0.0	0.0	0.0	0.0	0.6	7.9	0.0	0.0	16.2	2.4	0.0
<i>Zebittium exile</i> (Hutton, 1873)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.2
<i>Zemitrella choava</i> (Reeve, 1859)	0.0	0.0	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.4
<i>Zemitrella pseudomarginata</i> (Suter, 1908)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
<i>Zerotula crenulata</i> Powell, 1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
BIVALVIA												
<i>Arthritica bifurca</i> (Webster, 1908)	0.0	0.0	0.0	5.6	0.0	8.5	0.0	0.0	0.2	0.0	0.0	3.7
<i>Austravenus stutchburyi</i> (Woods, 1828)	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0
<i>Borniola reniformis</i> (Suter, 1908)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4
<i>Crassostrea gigas</i> (Thunberg, 1793)	0.0	0.0	0.0	5.6	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0

