EIGHT

Phylum
ARTHROPODA
SUBPHYLUM CRUSTACEA
shrimps, crabs, lobsters, barnacles, slaters, and kin

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Scyphax ornatus,
an endemic coastal slater.
Shane Ahyong

'No group of plants or animals on the planet exhibits the range of morphological diversity seen among the extant Crustacea.' This provocative quote from Martin and Davis (2001) highlights at least one attribute of the group. Nevertheless, the body plan of the Crustacea has a number of unifying characteristics, including a five-segmented head with two pairs of antennae and an elongate body that may be divided into two more-or-less distinct sections – generally the thorax or 'body' and the pleon or 'abdomen'. Each of these sections bears multisegmented appendages (mostly limbs) that are primitively biramous (forked) but some are uniramous in many groups. Brusca and Brusca (2002) gave a succinct summary of the characteristics of the subphylum. In addition to enormous diversity of form, crustaceans exhibit a great range of sizes (exceeded only by molluscs, which can claim the largest individual invertebrate in the form of the colossal squid), from minute interstitial and parasitic forms (e.g. Tantulocarida) measuring as little as a tenth of a millimetre to giant crabs, lobsters, and isopods with a body size of up to half a metre in length or breadth and weighing up to 20 kilograms. By virtue of their edibility, many crustaceans are prized items on restaurant menus around the world.

They are an ancient group, dating from at least the Early Cambrian (Chen et al. 2001), and have diversified abundantly since then. Calculations of the number of named living species of Crustacea range from approximately 50,000 to 67,000. Estimates of the potential number of species range from 10 to 100 times that number. The smaller species, such as those of the Peracarida and Copepoda may eventually be found in numbers comparable to those of the insects on land. By way of an example, the Isopoda currently number approximately 11,000 species, but estimates suggest that as many as 50,000 species of Isopoda could exist on coral-reef habitats alone (Kensley 1988), a figure close to the current total for all Crustacea, while Wilson (2003) estimated a total of 400,000 deep-sea species! Clearly, with thorough documentation, crustacean diversity will be found to be huge.

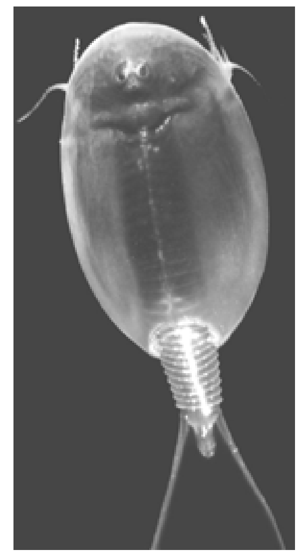
Five (Brusca & Brusca 2002) or six (Martin & Davis 2001) classes of Crustacea are recognised. Whichever classification is used, only the cave-dwelling

Remipedia have not yet been found in New Zealand waters. As one moves down the taxonomic hierarchy from class to species, the level of endemism increases. The New Zealand fauna currently stands at 2974 known species, of which at least 485 have not yet been named or described. This number is very conservative, and more than a thousand additional species will surely be discovered. Most major groups of Crustacea (orders) are to be found in New Zealand waters, though many families and genera will be found to be absent, particularly among those groups with strong warm-water representation, such as the commercially and gastronomically desirable 'prawns'. Prawns of the family Penaeidae (notably *Penaeus* and *Metapenaeus*) and portunid crabs of the genera *Portunus* and *Scylla* are rare or absent.

Class Branchiopoda: Fairy shrimps, water fleas, and kin

The approximately 1000 species of branchiopods ('gill feet') mostly inhabit fresh water (Dumont & Negrea 2002). They cover a wide range of body form from many-segmented, ancient-looking taxa – generally the larger-bodied forms such as Anostraca (fairy shrimps), Notostraca (tadpole shrimps), and 'Conchostraca' (clam shrimps) – to more-modified short-bodied taxa like the Cladocera (water fleas). The larger Branchiopoda do not collectively form a natural, evolutionary group but have a general similarity (many segments and same structure of trunk limbs) and are almost all adapted to a short life-span in temporary pools.

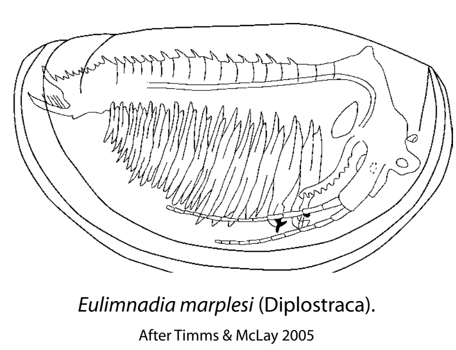
There are more than 250 species of Anostraca (fairy shrimps) worldwide (Dumont & Negrea 2002), none of which is naturally represented in New Zealand (Chapman & Lewis 1976) although the brine shrimp *Artemia franciscana* has apparently been introduced into saline Lake Grassmere near Blenheim. They are all relatively slow and graceful forms that swim with the back facing the bottom (opposite to most other Crustacea) while they use their 11 pairs of trunk limbs, beating in metachronal (wave-like) fashion, for both swimming and filtration.



Tadpole shrimp
Lepidurus apus viridis (Notostraca).
Stephen Moore

The Notostraca (tadpole shrimps) comprises about 10 species worldwide, one of which (*Lepidurus apus viridis*) is found in New Zealand. One of the most striking features of notostracans is the large, flattened dorsal carapace that originates immediately behind the head and overhangs a part of the body. Behind the carapace is a relatively long (sometimes *very* long), flexible and limbless abdomen that ends in a pair of superficially segmented tail-like processes. At the front end, the carapace has a conspicuous so-called 'dorsal organ' (used for osmoregulation). The first and second antennae – which often have sensory functions in the Crustacea – are much reduced in size in the adult, and the sensory function has been taken over by the very long endites (innermost branches) of the first pair of biramous trunk limbs. All notostracans have basically the same lifestyle. In contrast to most other branchiopods, notostracans are not filter-feeders, but remain near the bottom, where they use the heavily chitinised parts of the anterior trunk limbs to handle detritus and small organisms (Fryer 1988).

It has recently been shown that the former order 'Conchostraca' is most likely to be paraphyletic, having given rise to descendant evolutionary lineages (Braband et al. 2002; Olesen 1998, 2000; Spears & Abele 2000; Richter et al. 2007). The taxonomic rearrangement of Martin and Davis (2001) recognises the order Diplostraca, with four suborders – Laevicaudata, Spinicaudata, Cyclestherida, and Cladocera – of which only the Cladocera and Spinicaudata are represented in New Zealand, the latter by a species of *Eulimnadia*. All diplostracans have the body and legs enclosed between a large, sometimes bivalved carapace. The biramous second antennae are used for swimming, while the phyllopodous (leaf-like), often serially similar, trunk limbs are used for filtration. The most speciose group in New Zealand is the Cladocera, discussed below.



Eulimnadia marplesi (Diplostraca).
After Timms & McLay 2005

Summary of New Zealand crustacean diversity

A query (?) following an entry in the column for alien species indicates that alien status is suspected for some but not confirmed.

Taxon	Described living species + subspecies	Known undescribed/ undetermined species	Estimated unknown species	Adventive species named + unnamed	Endemic species	Endemic genera
Branchiopoda	44	5	7	3?	5	0
Anostraca	1	0	0	1?	0	0
Notostraca	1	0	0	0	0	0
Diplostraca	42	5	7	2?	5	0
Cephalocarida	1	0	1	0	1	1
Maxillopoda	661+2	139	2,067	16?	153	5
Ascothoracida	2	1	7	0	1	0
Acrothoracica	1	0	2	0	1	0
Rhizocephala	8	3	30	0	4	0
Thoracica	77	6	20	3	34	2*
Tantulocarida	3	0	8	0	2	0
Branchiura	1	0	0	1	0	0
Pentastomida	1	0	0	1	0	0
Copepoda	568	129	2,000	11?	111	3
Calanoida	252+1	9	290	6?	10	0
Cyclopoida	100	4	500	5?	8	0
Mormonilloida	1	0	3	0	0	0
Harpacticoida	130	99	850	0	63	3***
Siphonostomatoida	85+1	16	330	0	30	0
Monstrilloida	0	1	27	0	0	0
Ostracoda	356	86	320	3	89	7
Palaeocopida	3	0	0	0	3	0
Podocopida	275	82	200	3	61	6
Myodocopida	78	4	120	0	24	1
Malacostraca	1,425+1	255	2,665	23	850	85+10
Leptostraca	3	2	2	0	0	0
Stomatopoda	8	0	20	1	2	0
Anaspidacea	2	4	5	0	5	1
Bathynellacea	5	3	5	0	8	0
Lophogastrida	5	1	3	0	0	0
Mysida	17	1	50	0	11	0
Thermosbaenacea	0	0	5	0	0	0
Amphipoda	439	64	800	11	268	48+10
Isopoda	358	67	1,000	7	331	19**
Tanaidacea	40	77	300	0	12	0
Cumacea	51	24	110	1?	66	7*
Euphausiacea	19+1	0	15	0	0	0
Decapoda	480	12	150	4	147	10
Totals	**2,488+3**	**485**	**~5,060**	**46?**	**1,097**	**98+10**

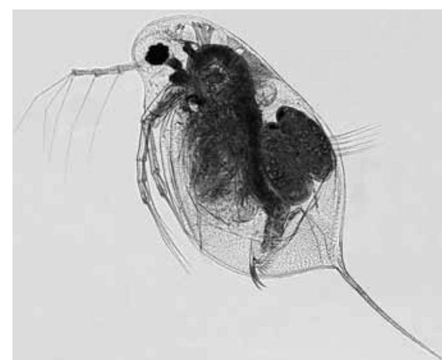
* including one new undescribed genus
** including two new undescribed genera
*** including three new undescribed genera

Order Diplostraca: Suborder Cladocera – water fleas

The Cladocera is generally believed to be a monophyletic group within the Branchiopoda (Martin & Cash-Clark 1995; Olesen 1998; Taylor et al. 1999; Spears & Abele 2000; Martin & Davis 2001), a notion that was called into question by Fryer (1987) when providing detailed diagnoses for all branchiopod 'orders' (the rank was changed by Martin & Davis 2001). The Cladocera is by far the most diverse and speciose group within the Branchiopoda, with approximately 640 species worldwide (Korovchinsky 2000), which is more than half of all branchiopod species described.

Historically, Sars (1865) had recognised four tribes within the Cladocera – the Haplopoda, Ctenopoda, Anomopoda, and Onychopoda – which are basically still accepted as monophyletic groups; these groups are now treated as infraorders (Martin & Davis 2001). The Anomopoda is the most species-rich, with at least five families (the number varies depending on the author), 75 genera (Dumont & Negrea 2002), and approximately 560 species (Korovchinsky 2000); the Ctenopoda has eight genera and 47 species (Korovchinsky 2000), the Onychopoda 10 genera with 34 species (Rivier 1998), and the Haplopoda is monotypic with only one species (*Leptodora kindtii* – not represented in New Zealand).

The four infraorders are rather different in their general morphology, which means that cladocerans are difficult to characterise overall. They are in general small, free-living crustaceans ranging from about 0.2–5.0 millimetres in length (with the exception of *Leptodora kindtii,* which is a giant at one centimetre long). Most are somewhat compact in appearance (except for *L. kindtii* and some Cercopagididae, an onychopod family not represented in New Zealand). They have a bivalved carapace (sometimes modified) with one compound eye, small tubular unsegmented antennules (*Ilyocryptus* excepted), large branching antennae, and a distinctive pair of so-called 'postabdominal setae' (similar setae are seen in other branchiopods). They swim using their antennae. The Ctenopoda and Anomopoda are somewhat alike and both have a bivalved carapace that covers the body (but not the head), a pair of curved caudal claws, and five to six (Anomopoda) or always six (Ctenopoda) flattened leaf-like trunk limbs that are used to filter food particles from the water. In the Ctenopoda the six trunk limbs show serial similarity (as in the 'large' branchiopods), while the trunk limbs of the Anomopoda have undergone remarkable evolutionary modifications in relation to food selection, with each limb in many cases being different from its neighbour limb (Fryer 1963, 1968, 1974, 1991). The remaining two groups, the Haplopoda and Onychopoda, are also somewhat alike, having, in contrast to all other branchiopods, narrow-footed segmented trunk limbs – four pairs in the Onychopoda and six pairs in the Haplopoda, used for predation or at least for selective feeding. Olesen et al. (2001) have shown how the segmented trunk limbs of the Haplopoda (*Leptodora kindtii*) have been derived secondarily from the typical phyllopodous limbs of other branchiopods. Both the Haplopoda and the Onychopoda have a relatively small carapace that does not cover the trunk limbs.



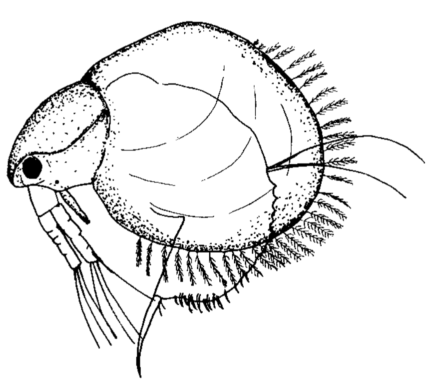
Water flea *Daphnia dentifera* (Cladocera).
Barry O'Brien

In New Zealand, as elsewhere, freshwater cladocerans (water fleas) can often be found in great abundance in open water or at the weedy edges and bottom deposits of lakes, ponds, and stream backwaters (Chapman & Lewis 1976). A child with a scoop-net can easily capture a good supply for a home aquarium. A few species are known from brackish and nearshore ocean environments (Rivier 1998). Among the freshwater species, some are strictly planktonic, others are bottom-dwelling, and *Scapholeberis* (Daphniidae) lives against the surface film. *Simocephalus* (Daphniidae) has the distinctive habit of interrupting its swimming and hanging down from algal filaments by a hooked bristle on one of the swimming antennae (e.g. Fryer 1991). Daphniids are specialist filter-feeders, while chydorids and many macrothricids feed by scraping particles off substrata

Summary of New Zealand crustacean diversity by environment

Taxon	Terrestrial species	Fully freshwater species	Marine/ estuarine species
Branchiopoda	0	41	8
Anostraca	0	0	1
Notostraca	0	1	0
Diplostraca	0	40	7
Cephalocarida	0	0	1
Maxillopoda	2	68	730
Ascothoracida	0	0	3
Acrothoracica	0	0	1
Rhizocephala	0	0	11
Thoracica	0	0	83
Tantulocarida	0	0	3
Branchiura	0	1	0
Pentastomida	1*	0	0
Copepoda	1	67	629
Calanoida	0	11	250
Cyclopoida	0	21	83
Mormonilloida	0	0	1
Harpacticoida	1**	35	193
Siphonostomatoida	0	0	101
Monstrilloida	0	0	1
Ostracoda	1	37	404
Palaeocopida	0	0	3
Podocopida	1**	37	319
Myodocopida	0	0	82
Malacostraca	120	90	1,470
Leptostraca	0	0	5
Stomatopoda	0	0	8
Anaspidacea	0	6	0
Bathynellacea	0	8	0
Lophogastrida	0	0	6
Mysida	0	0	18
Amphipoda	47***	54	402
Isopoda	72	17	336
Tanaidacea	0	1	116
Cumacea	0	0	75
Euphausiacea	0	0	19
Decapoda	1	4	487
Totals	**123**	**236**	**2,614**

* internal parasite of mammal
** damp forest litter
*** including 11 supralittoral species



Water flea
Ilyocryptus sordidus (Cladocera).
From Chapman & Lewis 1976

using their trunk limbs. Genera in the infraorders Onychopoda and Haplopoda are predaceous or at least raptorial feeders (Rivier 1998).

Cladocerans are able to produce non-fertilised (parthenogenetic) eggs that develop in a brood-pouch under the carapace and hatch as miniature adults. Females may continue to moult and grow after reaching sexual maturity, unlike copepods and ostracods. Cladocerans reproduce sexually as well as asexually and produce resting eggs after males have appeared in the population; these eggs undergo a period of dormancy before development begins. In the case of the Anomopoda, resting eggs are protected by a part of the mother's carapace, which is shed together with the eggs as an ephippium. The appearance of males is probably triggered by environmental conditions.

Summary of New Zealand fossil crustacean diversity

Taxon	Described fossil species + subspecies	Known undescribed/ undetermined species	Endemic species	Endemic genera
Maxillopoda	61	19	60	2
Acrothoracica	0	4	1	0
Rhizocephala	0	1	0	0
Thoracica	61+3	14	59	2**
Ostracoda*	284	127	22	5
Archaeocopida	0	2	0	0
Palaeocopida	1	0	1	0
Podocopida	283	124	21	5
Myodocopida	0	1	0	0
Malacostraca	67	44	61	8
Phyllocarida	7+1	1	7	0
Eumalacostraca	60	43	54	8
Isopoda	4	0	4	1
Decapoda	56	43	50	7
Totals	412	190	143	15

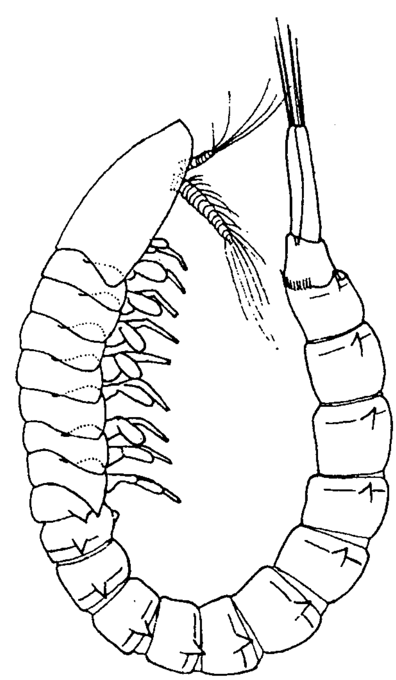
* Several species range to the present day; these are also in the Recent checklist.
** undescribed new genera

The end-chapter list of New Zealand Cladocera is based on the work of Chapman and Lewis (1976) for freshwater species and the records of Krämer (1895) and Jillett (1971) for marine species. The marine forms particularly need revising, as most of Krämer's species are not well known. The zoogeography of freshwater zooplankton in Australasia (Bayly 1995 and references therein) suggests that the New Zealand cladoceran fauna reflects the fact that New Zealand split from Antarctica during the Late Cretaceous. New Zealand, Australia, and South America completely lack the predaceous-raptorial families Polyphemidae and Cercopagididae (Onychopoda), the Leptodoridae (Haplopoda), and the Holopedidae (Ctenopoda). It seems likely that these families evolved in Laurasia after splitting from Pangaea (Bayly 1995). On the other hand, the Anomopoda, well-represented in New Zealand, are a very ancient group (from at least 130 million years ago) that was probably distributed over Pangaea.

Class Cephalocarida

The Cephalocarida was introduced as a new crustacean subclass by Sanders (1955) for a tiny, primitive-looking species taken off the Atlantic coast of North America. Since then, very few additional species have been discovered, and the most recent treatments recognise only one family with five genera and 10 species worldwide (Hessler & Wakabara 2000; Martin & Davis 2001). All are very small, measuring only 2–4 millimetres in length. The swimming limbs barely differ from one another, with the endemic New Zealand genus *Chiltoniella* being the least modified. The class is generally regarded as one of the more primitive of the living Crustacea.

Most species have been recorded from silty seafloors. In general, their biology is poorly known. New Zealand's sole species, endemic *Chiltoniella elongata*, is known from the Hawke's Bay region (Knox & Fenwick 1977).



Chiltoniella elongata (Cephalocarida).
From Knox & Fenwick 1977

Class Maxillopoda

Barnacles, seed shrimps, oar-footed bugs (copepods), and related parasitic groups – these are all examples of maxillopod crustaceans. They are a disparate lot, and carcinologists (crustacean specialists) are still arguing over whether or not they are a single evolutionary lineage (monophyletic). Apart from some barnacles, most species are small or minute. Most feed by means of mouthparts called maxillae (instead of using trunk limbs as filtration devices), barnacles again being a notable exception. Other characteristics of maxillopods include a basic body plan of five head and 10 trunk segments followed by a terminal telson. Abdominal segments usually lack appendages; elsewhere on the body, appendages are usually branched (biramous). As a group, maxillopod crustaceans are very important – economically, as in the case of many marine-fouling barnacle species, and more especially ecologically because of their shear abundance. Copepods, for example, are the most numerous crustaceans in open-ocean waters.

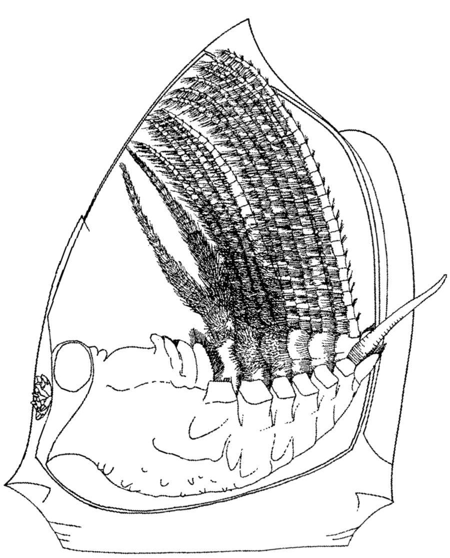
Subclass Thecostraca

This subclass comprises representatives of two infraclasses in New Zealand – the Ascothoracica and Cirripedia ('curly footed'). The latter includes barnacles, sessile crustaceans that use their trunk limbs to catch food particles. Most New Zealanders will be familiar with the acorn barnacles that carpet the upper zones of rocky seashores or, annoyingly, boat hulls, and perhaps the stalked goose barnacles that attach to floats and other buoyant objects, but few will know of the tiny burrowing and parasitic thecostracans.

Minute borings in mollusc shells, attributed to barnacles, have been well documented since Darwin (1854a) collected and described specimens during his voyage on HMS *Beagle*. Originally a number of parasitic organisms were included within this group of 'burrowing barnacles', e.g. the Ascothoracica and Rhizocephala (Newman et al. 1969), but these latter two taxa have been subsequently shown to possess spermatozoa, nauplius larvae, and newly settled cypris stages that are very different from barnacles. Following the re-evaluation of the Cirripedia by Newman (1987, 1996), the Ascothoracica and Rhizocephala are no longer considered as barnacles by some specialists; on the other hand, Martin and Davis (2001), Buckeridge and Newman (2006), and Lützen et al. (2009) treat the Rhizocephala as a superorder of Cirripedia. Ascothoracicans are represented in New Zealand by two species of starfish parasites (Palmer 1997); living rhizocephalans, virtually unknown in New Zealand until very recently, comprise 11 species (Brockerhoff et al. 2006; Lörz et al. 2008; Lützen et al. 2009).

The burrowing acrothoracicans possess a soft carapace, with calcareous plates reduced or absent. There are about 40 known species worldwide, including one endemic New Zealand species. All live buried in calcareous shells of a wide range of marine invertebrates, including molluscs, echinoderms, corals, bryozoans, and other barnacles. The group has a fossil record extending back to the Devonian (Tomlinson 1987), although no pre-Mesozoic taxa are known from New Zealand. As the fossil record of acrothoracicans is based solely upon burrows, two distinct acrothoracican nomenclatures have developed, one ichnomorphic, the other biological. This may lead to some confusion, as trace-fossil names such as *Zapfella* have equivalents such as *Australophialus*. Both systems are used in this review of the New Zealand fauna because the relationship between fossils and living species is unclear.

The familiar thoracican barnacles are classified into four orders with 81 living species in New Zealand – the stalked (pedunculate) Ibliformes, Lepadiformes, and Scalpelliformes, and the generally squat, nonstalked Sessilia, comprising the acorn (balanomorph) barnacles, wart (verrucomorph) barnacles, and the



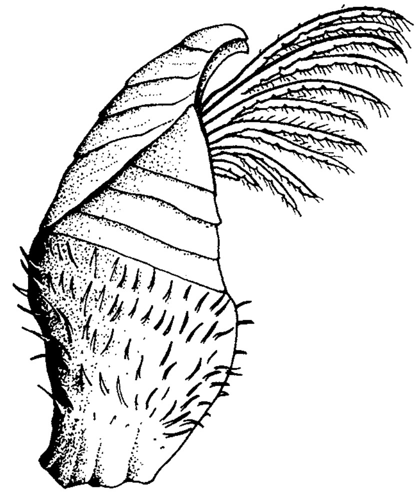
Cutaway view of *Calantica spinilatera* showing the long bristly feeding limbs (cirri) with smaller mouthparts to the lower left of the cirri.

From Foster 1979

Brachylepadomorpha (confined to deep-ocean hydrothermal vents and not yet known from New Zealand).

Most barnacles are hermaphrodites, although in some species the 'typical' hermaphrodite form may also carry minute or dwarf males within the capitulum (see below). These dwarf males possess either reduced or no appendages and capitular plates, being essentially packages of male gonads. Sexual differentiation does occur in some species, e.g. endemic *Idioibla idiotica*, (Ibliformes).

The pedunculate forms are the most ancient of the barnacles. They are characterised by a stalk (peduncle), by which they attach themselves to the substratum. A series of calcareous plates, together forming a capitulum, are found on top of the peduncle of most species, enclosing most of the soft tissue of the animal. A careful examination of this area verifies the evolutionary placement of the barnacles within the crustaceans, as the animal is effectively arranged head down, with its jointed limbs (cirri) extending out through a slit (orifice) in the capitulum wall. When the barnacle is submerged, the cirri extend into the surrounding water, netting planktonic food.



Idioibla idiotica.
John Buckeridge

As the number and arrangement of capitular plates varies considerably between taxa, they are of considerable value in classification. In the goose barnacle *Lepas* (Lepadiformes) there are five plates: paired terga and scuta with a single carina, arranged in a single whorl. However, in species like *Calantica spinosa* (Scalpelliformes) the number of capitular plates varies from 11 to more than 50, and these are arranged in two or more whorls. In taxa like *Calantica* and *Anguloscalpellum,* the peduncle is armoured with small overlapping plates or scales. In contrast, there are no plates or overlapping scales on the peduncle in Lepadiformes. The most primitive order of living thoracicans is the Ibliformes, with predominantly chitinous rather than calcareous plates. Of the five living genera, three of them are found in New Zealand, including the endemic genus *Chitinolepas* from Spirits Bay (Buckeridge & Newman 2006).

The Verrucomorpha are a group of barnacles that, because of their asymmetry, have intrigued cirripede workers since Darwin (1854b). Although they are amongst the most primitive Sessilia that are likely to be encountered as fossils, they are as yet unconfirmed from the New Zealand Mesozoic. They are, however, known from the Cretaceous of Australia (Buckeridge 1983). The Verrucidae are represented in New Zealand waters by species of *Altiverruca* and *Metaverruca,* both of which possess six calcareous plates. The lid (operculum) comprises just two articulating plates, the shell wall being made up of the remaining four: a fixed tergum and fixed scutum, plus rostrum and carina. Unlike other Sessilia, each wall plate in verrucids joins with its adjacent plate by interlocking ribs. The distribution of verrucid genera tends to conform to depth, with *Verruca* species characteristic of shallow coastal waters, *Metaverruca* to midshelf environments, and *Altiverruca* to the continental slope and deeper. Some verrucid species also have symbiotic or commensal relationships with other invertebrates, and these may be host-specific, e.g. *Brochiverruca* on cnidarians and *Rostratoverruca* on cidaroid urchins (Buckeridge 1997). This appears to be the situation with an as-yet-undescribed verrucid from northern New Zealand waters that inhabits the coral *Ellanopsammia rostrata*.

When one considers balanomorph or acorn barnacles, the image many people have is of a limpet-like creature commonly attached to vessel hulls. Although barnacle fouling on ships is well known, it represents only a small proportion of their distribution. They are best seen as ubiquitous opportunists of the marine environment attached to a great variety of living and inanimate objects. Barnacles include species specialised for attachment to whales, sea snakes, turtles, corals, sponges, and other crustaceans.

Chitinolepas spiritsensis.
From Buckeridge & Newman 2006

Many shallow-water acorn barnacles are known to have variable tolerances to both high temperatures and desiccation. Because of this, species in the intertidal zone may be found distributed in distinctive bands, e.g. on exposed

Coronula diadema, a barnacle that grows on whales.
John Buckeridge

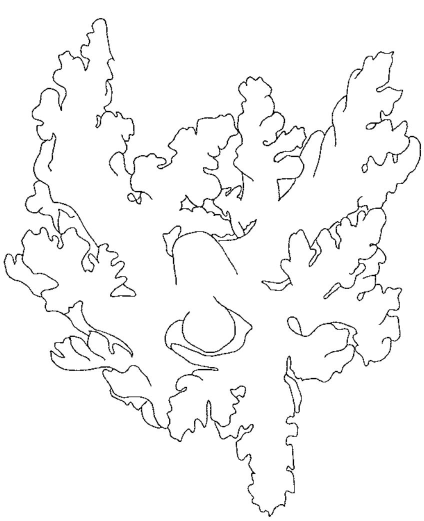
rocky shores, where *Chamaesipho brunnea* forms bands in the uppermost intertidal and *Epopella plicata* at mid- to low tide.

The balanomorph shell is made up of two parts: a rigid calcareous wall comprising four or more parietal plates, and an operculum or lid generally made up of paired scuta and terga. The opercular plates articulate to permit extension of the cirri between them during feeding. They also enable the animal to seal itself off from the environment in times of stress (e.g. predation, desiccation). As with the stalked barnacles, the plates are very important in identifying species. Parietal plates may be solidly calcified (e.g. *Austrominius*), calcareous with internal chitinous laminae (e.g. *Epopella*), calcareous with one row of vertical tubes (e.g. *Balanus*), or calcareous with chitin, arranged in multiple rows of tubes as in *Tetraclitella* (Buckeridge 2008). The number of parietal plates is also significant, with four in *Austrominius*, *Epopella*, and *Tetraclitella* and six in *Austromegabalanus*, *Balanus*, *Chamaesipho*, *Coronula*, *Megabalanus*, and *Notobalanus*.

The elements of barnacle anatomy and morphology, forming the basis of our modern classification and understanding, were elucidated by none other than Charles Darwin. His outstanding work on these creatures had a very strong influence on the ideas that eventually led to his revolutionary book *On the Origin of Species*. Indeed, Darwin was so amazed by the profusion and ubiquity of barnacles in the Cenozoic that he described Tertiary seas as 'abounding with species of *Balanus* to an extent now quite unparalleled in any quarter of the world'. (In Darwin's time, although most sessile cirripedes were ascribed to the genus *Balanus*, he was able to demonstrate groupings of similar taxa through the use of 'varieties'.)

That Darwin was infatuated with barnacles is clear, and he put much else aside to work on them: 'I have for the present given up Geology, and am hard at work at pure Zoology and am dissecting various genera of Cirripedia, and am extremely interested in the subject.' [Letter to Dieffenbach, February 1847]. But it was not always an agreeable infatuation: 'I have now for a long time been at work on the fossil cirripedes, which take up more time than the recent: confound and exterminate the whole tribe; I can see no end to my work.' [Letter to Hooker, 1850]. Darwin did persist, both with his monographs on fossil and living cirripedes (Darwin 1851a,b, 1854a,b) and his *Origin of Species.* Darwin's second cirripede volume was dated 1851 but came out quite late in 1852. His works endure as a monument to scholarship, and remarkably, one and a half centuries later, still provide the intellectual platform from which we are able to develop our present-day understanding of Earth's biodiversity.

Infraclass Ascothoracica



Adult female of *Dendrogaster otagoensis*.
From Palmer 1997

These curious creatures are primitive among thecostracans, ectoparasitic on feather stars and sea urchins, and endoparasitic within some corals and sea stars. Females have a much-reduced thorax and abdomen and a simplification or loss of limbs. The carapace is enlarged and grossly distorted, being much-branched and unrecognisable as belonging to a crustacean. Males are tiny and more recognisably crustacean in form, resembling larvae. They have a well-segmented body enclosed in a carapace and greatly elongated testes and and are found within the mantle cavity of females.

Ascothoracicans were unknown in New Zealand until Palmer (1997) found two species inhabiting sea stars off the Otago coast. *Dendrogaster otagoensis* was described as a new species, infesting *Asterodon miliaris*. Of a collection of 159 sea stars taken from the coast over an 11-month period, 124 (78%) were infested with the parasite. Found inside the arms and disc of the sea star, there can be as many as 15 female parasites, with their convoluted carapaces over 20 millimetres across, causing some atrophy of the sea-star's digestive caecae and gonads. Up to 19 creamy-white males 2.9–3.5 millimetres long occur inside the female parasite.

A second species, *Dendrogaster argentinensis*, was also found off Otago, infesting 96% of 152 specimens of the sea star *Allostichaster insignis* quite severely.

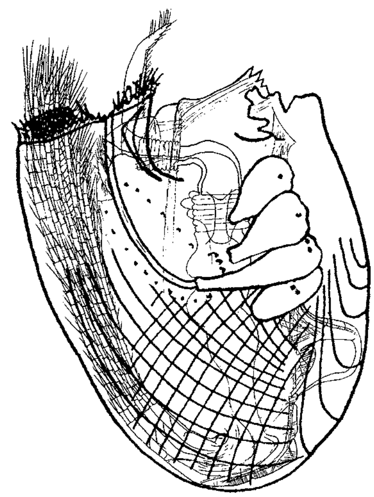
This particular parasite, previously known from southern South America and the Falkland Islands, can fill much of the sea-star's body cavity, comprising up to 28% of the wet weight. Gonads in such specimens are absent, and digestive caecae are severely atrophied. Curiously, specimens of *A. insignis* in other parts of its range (Cook Strait to the Auckland Islands) have never been noted as having such parasites, so it would be interesting to know what conditions promote such infestations in Otago waters.

Dendrogaster belongs to one of three families in the ascothoracican order Dendrogastrida. Palmer (1997) also mentioned an unpublished Te Papa (Museum of New Zealand) record of an undescribed member of the Synagogidae, one of three families in the only other ascothoracican order, Laurida.

Infraclass Cirripedia: Barnacles

Superorder Acrothoracica

Apart from the study by Batham and Tomlinson (1965) on *Australophialus melampygos*, there has been little work done on New Zealand acrothoracicans. They are a very difficult group to work with, particularly as most occurrences are known only by their tiny borings. *Australophialus melampygos* is often found infesting paua (*Haliotis iris*) and mussel (*Perna canaliculus*) shells, commonly in very large numbers (up to 3350 borings noted in a single paua shell. The family Cryptophialidae was revised by Tomlinson (1969), who introduced *Australophialus* to incorporate the austral members (including *A. melampygos*) of *Cryptophialus* that possessed four rather than three pairs of terminal cirri (feeding appendages).

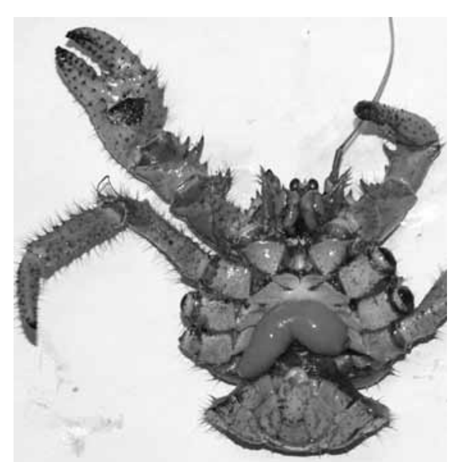


Australophialus melampygos removed from its excavation in a shell; five dwarf males attached middle right.

Modified from Batham & Tomlinson 1965

Existing literature infers that acrothoracicans have very low diversity in the New Zealand region. Further, they appear to be somewhat host-specific, and whilst this is not generally a problem where a host is a common marine invertebrate, there is cause for concern if the host is over-fished. Both *Haliotis iris* (paua) and *Perna canaliculus* (green-lipped mussel) are extensively harvested as a food source, and although they are now widely cultured in marine farms, the new aquacultural environment does not appear to provide the habitat so favoured by *Australophialus melampygos* in nature. The likelihood that the shell-infesting population represents more than one species should not be overlooked, especially in light of acrothoracicans' poorly mobile larval phase (which may account for its absence from the Chatham Islands). The distribution of these molluscs extends from Northland to Stewart Island; although both species range well into the subtidal, *A. melampygos* is not known much below low tide, its preferred habitat.

Australophialus melampygos falls within a group of southern acrothoracicans including *A. tomlinsoni* from the Antarctic and *A. turbonis* from South Africa. Newman and Ross (1971) considered the cirral arrangement of these taxa to be more generalised (and therefore phylogenetically older) than other Cryptophialidae, inferring a Southern Hemisphere origin for the family. However, rather than a South African centre of cryptophialid diversification, abundant cryptophialids in some turritellid gastropods within the Pakaurangi Formation (Early Miocene), Kaipara Harbour, should not rule out the New Zealand region as a potential centre of dispersal.



Briarosaccus callosus, a saccular rhizocephalan parasite under the abdomen of the king crab *Paralomis hirtella*.

Dianne Tracey

Superorder Rhizocephala

Rhizocephalans are wholly parasitic. They have little similarity with other cirripedes, or indeed other crustacean adults, as there are neither appendages nor segmentation (e.g. Høeg & Lützen 1995, 1996). A rhizocephalan consists of a sac-shaped body, the externa, which is mainly involved in reproduction and is attached to the outside of the host's abdomen. The host is always another crustacean, in most instances an anomuran or brachyuran crab. A mouth and a digestive tract are absent and nutrients are taken up from the host's interior by an internal trophic root system (or interna) which is distributed

Sacculina sp., a saccular rhizocephalan parasite under the abdomen (folded back) of the crab *Metacarcinus novaezelandiae*.
Annette Brockerhoff

within the haemolymph of the host (Høeg & Lützen 1995). The externae are most often attached singly or a few together to the host's abdomen, but some rhizocephalans are colonial and in such species many small externae may attach to the abdomen, appendages, or other parts of the host body (Høeg & Lützen 1993, 1996). Despite their bizarre appearance, rhizocephalans are related to the non-parasitic barnacles, which they resemble in reproducing via short-lived planktonic nauplii and/or cypris larvae (Høeg & Lützen 1993).

Apart from sparse records in the literature, rhizocephalans were almost unknown in New Zealand until the 2000s; there are now at least 10 genera and 11 species (Brockerhoff et al. 2006; Lörz et al. 2008; Lützen et al. 2009). Decapod host species belong to the families Paguridae, Lithodidae, Galatheidae, Chirostylidae, and Callianassidae. *Parthenopea vulcanophila* (Lützen et al. 2009), is the first rhizocephalan recorded from the vicinity of active cold seeps.

The recently discovered New Zealand rhizocephalans are registered in the invertebrate collections of the National Institute of Water and Atmospheric Research (NIWA) and the National Museum of New Zealand Te Papa Tongarewa, Wellington (NMNZ). Some of the specimens could not be identified because they were in turn infected by species of Cryptoniscinae, a subfamily of hyperparasitic isopods. In the final stage of this relationship of a parasite on a parasite the rhizocephalan host is no longer recognisable (Øksnebjerg 2000).

Recent gene-sequencing studies on the Rhizocephala have indicated that the conventional grouping of its members is in need of rearrangement (Glenner et al. 2003; Glenner & Hebsgaard 2006). Since these findings have not yet resulted in a taxonomic revision, the traditional division of the Rhizocephala into the orders Kentrogonida and Akentrogonida is followed in the end-chapter checklist; as a consequence of the study by Glenner and Hebsgaard (2006), however, *Parthenopea* is included in the Akentrogonida.

Superorder Thoracica

On 3 October 1769, in calm seas some 300 kilometres off what is now known as Mahia Peninsula, HM Bark *Endeavour*, under the command of James Cook, retrieved 'one peice of wood coverd with Striated Barnacles *Lepas Anserina*?' (Banks 1962). This was not only the first record of barnacles from New Zealand seas, but also one of the first records of marine life from the region. In an editorial footnote to Banks's journal, J. C. Beaglehole stated that Daniel Solander (the naturalist who accompanied Banks) considered the species to be *Lepas anserifera.* The next major scientific expedition to New Zealand was in 1827, when the *Astrolabe* collected extensive natural history material, including barnacles. The barnacles were subsequently described by Quoy and Gaimard (1834) as *Anatifera spinosa*, *Anatifera elongata*, and *Anatifera tubulosa* (now respectively known as *Calantica spinosa* (Quoy & Gaimard), *Lepas testudinata* Aurivillius, and *Heteralepas quadrata* (Aurivillius)). The first endemic New Zealand barnacle to be described was, therefore, *C. spinosa*.

In 1839 the New Zealand Company appointed Ernst Dieffenbach as surgeon and naturalist on the *Tory*. Dieffenbach made extensive biological collections during his time in New Zealand, and included in these were barnacles. These were later compiled by J. E. Gray into a *Fauna of New Zealand* and listed as an appendix to Dieffenbach's *Travels in New Zealand* (Gray 1843). Gray recorded nine thoracicans, now known as *C. spinosa*, *L. testudinata*, *H. quadrata*, *Coronula diadema*, *Epopella plicata*, *Tetraclitella depressa*, *Tubinicella major*, and two unidentified species of *Balanus*.

Shortly after this, Darwin's four comprehensive monographs on living and fossil cirripedes were published. Darwin had collected New Zealand barnacles from the Bay of Islands during the voyage of HMS *Beagle*, which, along with British institutional material, resulted in 14 species being listed from the New Zealand region. Ten were new to science, of which *Austrominius modestus*, *Notobalanus vestitus*, and *Notomegabalanus decorus* are endemic to New Zealand. Darwin included a complete description of the endemic species *Chamaesipho columna*, which had previously been described from material supposedly collected from Tahiti (Spengler 1790). Spengler's original description was, however, incomplete, as the shells he possessed were without opercula or soft tissue. In Foster and Anderson (1986), the status of *C. columna* was reviewed and it was concluded that Spengler's material came from New Zealand, where it is endemic. (They renamed the Australian species previously attributed to *C. columna* as *Chamaesipho tasmanica*.)

The last major systematic work of the 19th century that dealt with New Zealand barnacles was based upon specimens obtained during the 1873–76 HMS *Challenger* expedition. In an expedition report, Hoek (1883) described five new species, now known as *Amigdoscalpellum costellatum*, *Anguloscalpellum pedunculatum*, *Gymnoscalpellum intermedium*, *Smilium acutum*, and *Verum novaezelandiae*. During the early to mid-20th century, numerous descriptions of new records for the region, generally for single species, were published and a full list of these was given by Foster (1979). The latter work is the most comprehensive study ever written on living New Zealand Thoracica. In it, Foster listed a fauna of 61 species, nine (including a new subspecies) of which were new, one was a new name, and 15 species were recorded for the first time from New Zealand waters. Foster also made valuable observations on the geographic distribution, zonation, and ecology of barnacle species. In the 14 years following his 1979 monograph, Foster described a further two new species and add records of eight taxa not previously known from New Zealand waters (Foster & Willan 1979; Foster 1980, 1981; Foster & Anderson 1986). Brian Foster died suddenly in 1992, tragically cutting short what was, up to that time, a prolific and invaluable career in barnacle systematics and biology. Since then, J. S. Buckeridge, a student of Foster, has continued study of the New Zealand fauna, frequently in collaboration with W. Newman. The systematics of barnacles was reviewed by Buckeridge and Newman (2006), in which the Iblidae was identified as the most ancient family of Thoracica. Significantly, it was the discovery of an extraordinary but minute new species from New Zealand, *Chitinolepas spiritsensis*, that provided the impetus for this work, which demonstrated that the New Zealand region not only has a diverse living thoracican fauna but also one of the most primitive.

Although not specifically focussing on the New Zealand fauna, Newman's (1979) publication is an inspired revision of the phylogenetic and biogeographic relationships between barnacles of the Southern Ocean. His work led to a reappraisal of the entire fauna, with many of the proposed taxonomic concepts incorporated in Buckeridge (1983). The evolving nature of systematic biology results from an ongoing reappraisal of relationships between taxa. As our understanding of barnacle phylogeny becomes more sophisticated, this often creates the need to provide new names for species. The overview herein is based upon the comprehensive review of Cirripedia by Newman (1996), in which subgenera are elevated to full generic status. Consequently, species like *Elminius modestus* and *Austromegabalanus decorus* are now listed as *Austrominius modestus* and *Notomegabalanus decorus* respectively. A recent publication reviews the status of the Elminiinae and identifies *Austrominius* as a tetraclitoid, returning it closer to *Epopella*, where Darwin (1854) had originally perceived it to be (Buckeridge & Newman 2010).

There are 81 species of Recent thoracican cirripedes known from the New Zealand EEZ. Of these, six are currently undescribed. Four are stalked barnacles, comprising two species of *Scillaelepas* (Calanticidae) one of which conforms to a southern group of primitive scalpellids, and two species of Scalpellidae; an unusual undescribed verrucid is likely to represent a new genus; and a possible new species of *Acasta* (Archaeobalanidae) remains to be determined (J. Buckeridge is currently reviewing this genus of sponge-inhabiting barnacles). All

Chamaesipho columna.
Dennis Gordon

Smilium zancleanum, with plates on the right-hand side removed to show the cirri.
John Buckeridge

species referred to as new in the end-chapter checklist are held in the collections of the NIWA Invertebrate Collection, Wellington.

The vertical zonation of thoracican barnacles on New Zealand surf shores has been well documented (e.g. Morton & Miller 1968). The zonation is not always consistent, however, with ranges expanding/contracting in the absence/presence of other taxa (Foster 1979). Nevertheless, there are generalisations that can be made, and these provide useful ecological benchmarks: chthamalids are found higher on the shore than all other thoracicans; below them, and overlapping somewhat, are the tetraclitids; further down the shore the lower range of the tetraclitids overlaps the balanids. This chthamalid-tetraclitid-balanid arrangement appears to be fairly uniform on both temperate and tropical shores (Foster 1974, 1979). *Cantellius septimus*, a widespread Indo-Pacific species, has been found in *Montipora* coral off Raoul Island (Kermadec Ridge), representing the most southerly record of a coral-inhabiting barnacle (Achituv 2004).

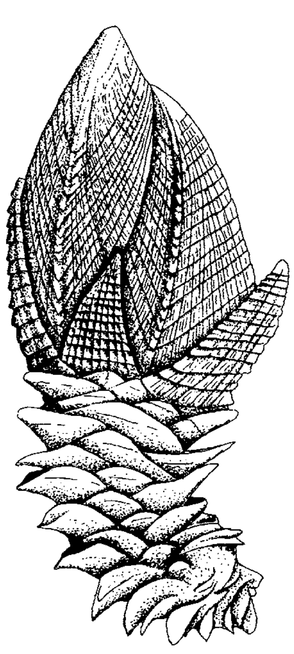
Metaverruca recta.
John Buckeridge

Some species are epizoic on cetaceans. *Conchoderma auritum*, *C. virgatum*, and *Coronula* species attach to whales and three species of the latter genus are found in the New Zealand fossil record.

The isolation of New Zealand since the late Mesozoic has led to high regional endemism in taxa that evolved during the Late Cretaceous–Early Cenozoic. This is no more evident than in the thoracican barnacles (Buckeridge 1996a,b, 1999a). Although 40% of the Recent species listed are endemic, the figure is a little misleading, as the current distribution of New Zealand species such as *Austrominius modestus* to include Australia and Europe has almost certainly been achieved via shipping. What is particularly significant about the New Zealand region is the high proportion of endemics that are phylogenetically primitive. The percentage of balanomorph and verrucid taxa that have their earliest (fossil) records in New Zealand is impressive, with 73% of all primitive sessilians with a generic age earlier than the Miocene being first recorded here (Buckeridge 1996a).

There are several species of thoracican barnacles that may be termed 'living fossils', i.e. they have fossil records extending back at least to the Early Miocene. Two of these, *Chionelasmus darwini* and *Notobalanus vestitus* extend back to the Eocene and Oligocene, respectively; two others, *Metaverruca recta* and *Chamaesipho brunnea*, to the earliest Miocene. The order Ibliformes extends back to the Permian and the Neolepadinae to the Jurassic.

Sampling of deep-sea cirripedes from the New Zealand EEZ is far from comprehensive, but 13 species are known from depths greater than 1500 m, the deepest of which are *Gymnoscalpellum intermedium* (to 2505 m) *Amygdoscalpellum costellatum* (to 3120 m), and *Verum raccidium* (to 4405 m) according to NIWA database records. Specimens have often been made available as bycatch from the fishing industry or from research cruises. Recent discoveries include the neolepadine *Vulcanolepas osheai* from ca. 1500 metres depth in the volcanically active Brothers Caldera (in the Havre Trough northeast of the Bay of Plenty) and a related taxon, *Ashinkailepas kermadecensis* (Buckeridge 2009), from a cold-water seep at 1165 m on the western flank of the Kermadec Ridge. Both of these taxa have specialisations, like long filamentous cirri, that permit them to feed on bacteria, the most abundant food source in the area, living on the barnacle exteriors and around the vents and seeps (Suzuki et al. 2009). Bathylasmatids such as *Tetrachaelasma tasmanicum*, although not yet formally recorded from within the New Zealand EEZ, almost certainly occur here. This taxon was recently described from 3600 metres on the southeastern Tasman Rise (Buckeridge 1999b) where it is widely distributed as disassociated shells that are very similar to isolated plates collected from New Zealand waters; in the absence of living tissue the latter material has not been placed to species.



Ashinkailepas kermadecensis.
From Buckeridge 2009

Although the total number of thoracican barnacle species from New Zealand is not high compared with the numbers of species of taxa such as the Bryozoa and Mollusca, it is high compared with cirripede faunas from other regions. In particular there is a broader representation of known cirripede taxa (especially phylogenetically primitive taxa) than in any region of comparable size, and there is a disproportionately large number of species, both living and fossil, that have their earliest records in New Zealand (Buckeridge 1996a).

Palaeontology and paleoecology

Acrothoracica

Acrothoracican burrows are known to occur in thick-shelled bivalves (e.g. trigoniids) of Late Triassic age from Nelson and Southland (H. J. Campbell pers. comm.) and belemnite guards (e.g. *Belemnopsis alfurica*) of Late Jurassic age from Kawhia. These can be attributed to the ichnogenus *Zapfella*, to which the burrow shapes generally conform; however, their true biological relationships remain unclear and, as such, no move is made to classify them at ordinal level or below. The Triassic record extends the range of *Zapfella* from that provided in Häntzschel (1975) of 'Jurassic to Tertiary'. Burrows are also known in Early Miocene deposits from the Auckland region, e.g. Waiheke Island (J. A. Grant-Mackie pers. comm.), and in turritellid gastropods from the Pakaurangi Formation, Kaipara Harbour. The later burrows appear indistinguishable from modern *Australophialus* borings, to which genus they are tentatively assigned.

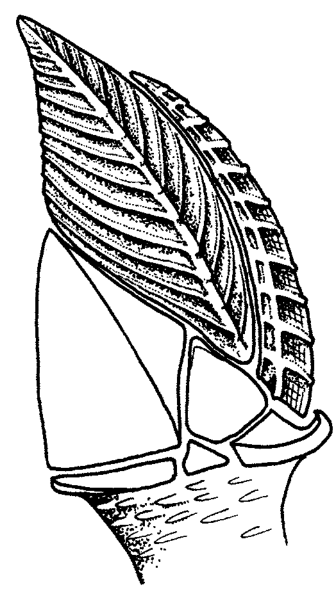
Rhizocephala

Perhaps surprisingly, given their parasitic lifestyle, rhizocephalans are detectable in the fossil record and are known from the New Zealand Miocene. Feldmann (1998) studied a large number of beautifully preserved specimens of the large xanthoid crab *Tumidocarcinus giganteus*. Several males had abnormally broad abdomens, which is normally attributable to the parasitic castration induced by the parasite.

Thoracica

Thoracican barnacles have a fossil record extending back to the Paleozoic, but not in New Zealand. The pedunculate order Cyprilepadiformes is known from the Silurian, attached to a eurypterid, and other thoracicans are known from the Early Devonian and the Pennsylvanian (upper Carboniferous) (Newman et al. 1969; Buckeridge 1983; Foster & Buckeridge 1987; Newman 1996; Buckeridge & Newman 2006). There is no record of Paleozoic cirripedes from the entire New Zealand–Australian–Antarctic region, the first such record being *Eolepas*? *novaezelandiae* from Middle Triassic strata of Southland (Buckeridge 1983).

Although there are rare scalpellomorphs of Jurassic age, it is not until the Cretaceous that significant records are known – locally abundant, as-yet-undescribed remains of *Cretiscalpellum*? are known from Middle Cretaceous rocks in the Coverham area. These scalpellomorphs are preserved in association with species of the large bivalve *Inoceramus*, upon which they appear to have been growing. Hence, apart from a new verrucid from the Cretaceous of the Waipara River in central Canterbury, the only barnacles known from the New Zealand Mesozoic are stalked ones. Surprisingly, even though there are barnacle-rich horizons in the Paleocene of the Chatham Islands, there are no barnacles of Mesozoic age known from there. This is not likely to have resulted from a paucity of appropriate facies, as there are some excellent Late Cretaceous fossiliferous horizons present on Pitt Island that could have been expected to have provided an appropriate environment for scalpellomorphs. At present, it must be concluded that the absence of a Cretaceous barnacle fauna reflects incomplete paleontological knowledge, and this provides an impetus for further fieldwork on the islands.



Reconstruction of the fossil barnacle *Anguloscalpellum euglyphum* (Oligocene).
John Buckeridge

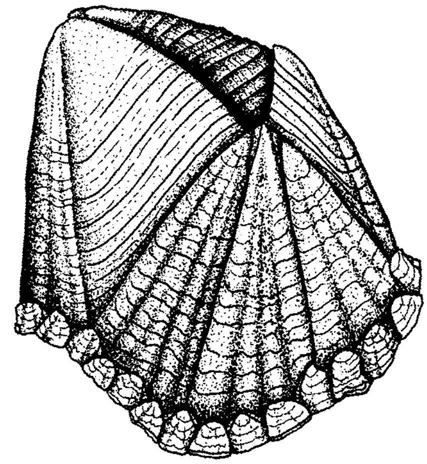
Cenozoic barnacles

The New Zealand Cenozoic barnacle fauna is dominated by balanomorphs. The first fossil cirripede to be described from New Zealand strata was the giant balanomorph *Bathylasma aucklandicum*, from Early Miocene strata near Auckland. The locally abundant, but generally disarticulated plates of this sessile barnacle were however, initially described as a pedunculate (Hector 1888). A quarter of a century was to pass before the true nature of the remains was established, in a paper wherein the author also described two new endemic species now known as *Anguloscalpellum ungulatum* and *Smilium subplanum* (Withers 1913) (see Jones 1992). In the early 1920s, Withers, working from the British Museum, was commissioned by the then Geological Survey of New Zealand to produce a monograph of the fossil cirripedes of New Zealand (Withers 1924). This listed 18 species, of which only 15 were truly fossil, and seven of these were both new and endemic to New Zealand. In 1953, he published his last major work that dealt specifically with cirripedes from New Zealand (Withers 1953). This included a revised list of the New Zealand fossil fauna, arranged according to stratigraphic horizons. He listed 15 species, none of which was new. Interestingly, he omitted the record for '*Balanus amphitrite*' that he included in his 1924 monograph, but added the record for what is now *Pristinolepas harringtoni*. No reason is given for his omission of '*Balanus amphitrite*', which is now recognised in the New Zealand fossil record as *Amphibalanus variegatus*. In all, Withers described nine fossil cirripedes from the region, all of which are endemic.

Many limestones are so enriched with balanomorph remains that they may justifiably be termed 'barnacle coquinas'. The first horizons with locally abundant balanomorphs are of late Paleocene age, occurring as lenses in the Red Bluff Tuff of the Chatham Islands. In some of these lenses, the barnacle *Pachylasma veteranum* is also the dominant macrofossil, with the other macrofauna primarily being teeth of the elasmobranch fish *Isurus* sp. plus brachiopod and bivalve shells. Although barnacle-rich horizons are also recorded in the Early Oligocene (Cobden Limestone, West Coast), and Early Miocene (basal Cape Rodney Formation, Auckland), it is the Pliocene coquina limestones of the North Island East Coast that are singularly spectacular, e.g. the Pukenui and Castlepoint Limestones, which contain extensive horizons dominated by *Fosterella tubulatus* and *Notobalanus vestitus.* These coquinas outcrop at Rangitumau and Castlepoint respectively (both in the Wairarapa), and have extensive beds in which *F. tubulatus* comprises more than 50% of the total mass. There are no modern equivalents of these deposits, although lesser shell banks of *N. vestitus* and *Notomegabalanus decorus* are today accumulating in the outer Hauraki Gulf near the Mokohinau Islands. It is inferred by Beu et al. (1980) that these deposits originated in subtidal settings dominated by strong currents, in a Pliocene sea occupying the East Coast Inland Depression. These Pliocene 'barnacle coquinas' are not only impressive from a cirripedological perspective, they are also the greatest accumulation of fossil crustaceans known!

Because barnacle species tend to be distributed along clearly delineated depth, salinity, and temperature zones, their presence as fossils can be most useful in paleoecological reconstruction. There are, however, some trends in the 'preferred' environments of some taxa over time, e.g. species of the genus *Pachylasma* are currently restricted to deep water, with the shallowest living species of the group not known from less than 55 metres. In the Paleocene, however, *Pachylasma veteranum* is known to have lived in very shallow water, along with a diverse fauna of bryozoans, molluscs, and cnidarians, well within the photic zone (Buckeridge 1983, 1999a). A similar pattern can be observed with species of *Bathylasma*, which also occupied upper subtidal environments in the Paleogene, but are now exclusively mid- to outer-shelf species. Indeed, this change, which was interpreted by Buckeridge (1983) as 'migratory', is now viewed more as a result of having been excluded (or outcompeted) from the shallower-water environments by 'modern' balanomorphs. Modern taxa such as *Austrominius modestus* have a higher metabolism and an earlier onset of sexual maturity, which has permitted the species to aggressively exploit desirable shallow-water niches. This has left refugial chthamalids (such as *Chamaesipho* *columna* and *Chamaesipho brunnea*) occupying upper littoral niches, and pachylasmatines (such as *Pachylasma scutistriata* and *Bathylasma alearum*) mid- to outer-shelf environments (Buckeridge 1999a).

By the Late Miocene, it appears that thoracican barnacles occupied much the same habitats as their modern counterparts (including as epibionts on other crustaceans – Glaessner 1960, 1969). As a consequence, the zonation of modern balanomorphs is useful in the reconstruction of the fossil depositional environments that existed in the Late Cenozoic, e.g. in the barnacle-rich Titiokura Limestone of the eastern North Island Te Aute Limestone Complex. The Titiokura Limestone (Beu 1995), outcropping in the northwest of Hawke's Bay, is characterised by a mixed assemblage of barnacles, including *Pachylasma* sp., *Notomegabalanus miodecorus*, and the inferred intertidal taxon *Epopella* cf. *plicata*. The depositional environment at that time is, however, considered to have been at more than 100 metres depth. The geological processes operating at the time resulted in the build-up of shallow-water sediments on the upper shelf to a point at which the accumulation became unstable. Sediments and faunas were then mobilised, to be transported and deposited alongside deeper-water elements as a mixed thanatocoenosis (death assemblage).



Waikalasma juneae (Miocene).
From Buckeridge 1983

The sessile Balanomorpha are not known from strata older than the Paleocene, with the first of these, *Bathylasma rangatira* and *Pachylasma veteranum*, being recorded from the Chatham Islands (Buckeridge 1983). There has been considerable conjecture concerning the origins of the balanomorphs, which diversified and spread very rapidly in the Early Cenozoic. Buckeridge (1996a, 1999a) proposed that the Chatham Islands was a centre of sessilian diversification during the Paleogene, with taxa evolving in the warm shallow seas that characterised the environmental conditions for strata like the Red Bluff Tuff. New Zealand has a remarkable fossil cirripede fauna, with the phylogenetically early taxa *Eolasma*, *Chionelasmus*, *Waikalasma*, *Pachylasma*, *Bathylasma*, *Tetraclitella*, *Palaeobalanus*, *Notobalanus*, *Chamaesipho*, and *Notomegabalanus* having their earliest records here.

As with the Recent fauna, there are a number of publications describing single new species of New Zealand fossil Thoracica. These are listed in the historical review provided in Buckeridge (1983), which also revised and improved current knowledge of the New Zealand and Australian fossil cirripede faunas. Buckeridge listed 69 fossil taxa from New Zealand, of which 36 were new. Of these, 94% (i.e. all but two) are endemic to New Zealand. Since 1983, Buckeridge has described a further six species of fossil cirripedes (Buckeridge 1984a,b, 1991, 1999a, 2008), and in addition has a further four new taxa awaiting formal description.

Economic aspects of barnacles

Marine fouling

The first 'close encounter' some New Zealanders may have with barnacles is when they need to remove fouling organisms from the hulls of their recreational or fishing vessels. Barnacles are opportunistic organisms that colonise almost any available surface in the marine environment. Boats and ships provide excellent surfaces for suspension-feeders – a platform within the upper subtidal zone that generally coincides with oxygenated, predator-poor, plankton-rich waters. In addition, the mobile substratum facilitates dispersal.

Exotic fouling species in the New Zealand environment are generally introduced through commercial shipping. It is in this way that the widespread species *Amphibalanus amphitrite*, *A. variegatus*, and *Lepas anatifera* were introduced many decades ago. *Lepas anserifera*, *Fistulobalanus albicostatus*, *Amphibalanus reticulatus*, *Megabalanus rosa*, *M. volcano*, and *Tetraclita squamosa japonica* were introduced on oil-drilling platforms (Foster & Willan 1979) but none appears to have become naturalised in New Zealand waters. Hosie and Ahyong (2008) reported the establishment of the Australian species *Austromegabalanus nigrescens* and its South American congener *A. psittacus* at Taharoa and Wellington respectively.

Research into the development of antifouling systems has intensified as a result of a greater understanding of the deleterious ecological impact of traditional antifouling paints such as tributyltin (Buckeridge 1998). Preliminary results indicate that low-level ultrasonic transmitters have the potential to restrict organic accumulation on certain hulls.

Barnacles as a food source

Although balanomorph barnacles such as the very large South American *Austromegabalanus psittacus* are considered a delicacy, they do not occupy a similar place in modern New Zealand cuisine. There is evidence, however, that barnacles were once eaten by Maori, as they are often found in middens (Foster 1986). In most cases, it appears that this was not through deliberate harvesting; rather it was incidental to the harvesting of other seafood such as *Perna canaliculus* (green-lipped mussel). This is no doubt a reflection of the small size of most shallow-water New Zealand barnacles – many hundreds of *Austrominius modestus* would need to be collected to make even a small meal. Nevertheless, somewhat larger species such as *Notomegabalanus decorus* and *Epopella plicata* may occasionally have been deliberately collected as a dietary supplement (Foster 1986).

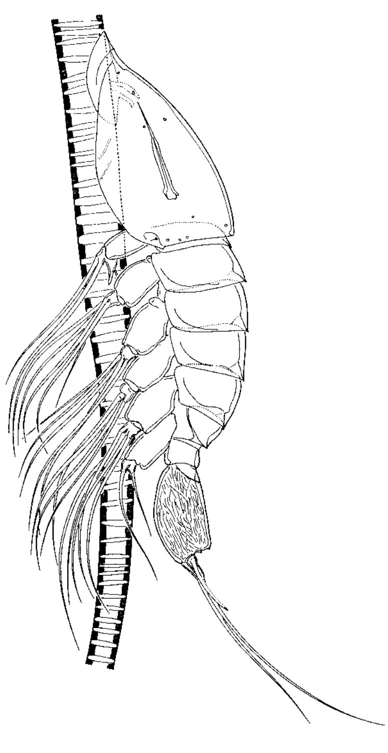
Environmental monitoring

Thoracican barnacles have a number of properties that may prove to be invaluable to humans. One that is currently under development is their use as environmental indicators. Common shallow-water fouling species such as *Austrominius modestus* and *Epopella plicata* are invaluable in monitoring environmental changes to marine systems during urbanisation (e.g. at Auckland's Long Bay–Okura Marine Reserve). A high metabolic rate, rapid onset of maturity, and frequent spawning make *Austrominius modestus* an excellent species for gauging the impact of human activities.

Biotechnology

Another feature of thoracican barnacles that has intrigued scientists is the means by which they attach themselves to surfaces. Barnacles are known to grow on a very wide range of materials, both natural and synthetic. Their ability to successfully adhere to flexible and elastic materials like plastic sheeting and fibreglass is of specific interest, for if the nature of this 'organic adhesive' is determined and commercially manufactured, it will have obvious use in fields such as dentistry.

Barnacles that are commensal or symbiotic with other marine organisms may need to produce chemicals to prevent the host overgrowing them. This is particularly the case with sponge-inhabiting taxa like *Acasta* and coral-inhabiting taxa like *Brochiverruca.* Isolation of chemical deterrents may be invaluable in the design of new drugs for restricting or reducing cell growth in other species, including humans.



Tantulus larva of *Deoterthron dentatum* attached to an antenna seta of its ostracod host.

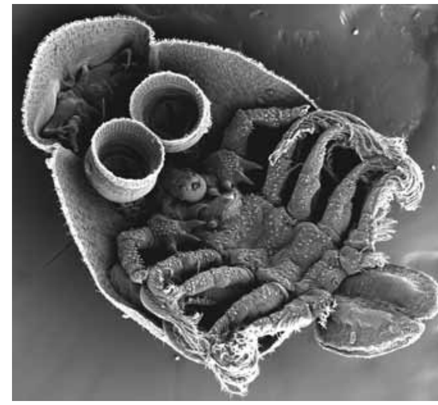
From Huys 1990

Subclass Tantulocarida: Tantulocarids

Nearly 30 years ago, a new maxillopodan subclass was created by Boxshall and Lincoln (1983) to accommodate, amongst others, three tiny parasitic crustaceans discovered in the New Zealand region (Bradford & Hewitt 1980; Boxshall & Lincoln 1983; Lincoln & Boxshall 1983). They infect benthic and hyperbenthic crustaceans such as amphipods. Tantulocarids are minute ectoparasites, not exceeding half a millimetre (0.04–0.40 millimetre) in length, with a unique dual life cycle that is completed, without moulting, on a crustacean host (Huys et al.

1993). There are now five recognised families with more than 20 genera and about 30 species worldwide (Ohtsuka & Boxshall 1998), notably with several taxa being recently documented from Japan (Huys et al. 1992; Huys et al. 1994; Ohtsuka & Boxshall 1998).

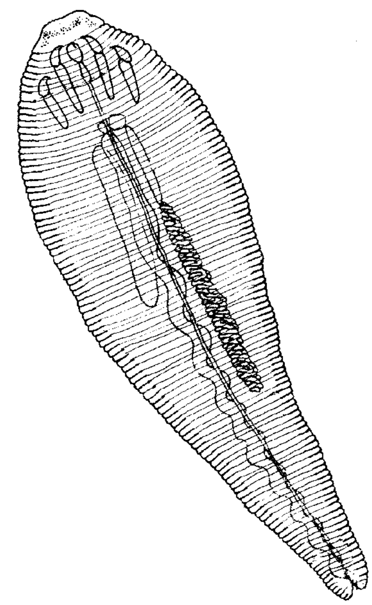
While there have been no further records of tantulocarids from New Zealand, it is very likely that more species of this subclass will be discovered as the benthic and benthopelagic fauna of the New Zealand region becomes better studied.



Argulus japonicus.
Note the paired suckers.
Kenneth M. Bart

Subclass Branchiura: Branchiurans

Branchiurans are parasitic on marine and freshwater fishes. They resemble copepods in many respects but differ in some important features. Unlike copepods, they have compound eyes and lateral head lobes, the opening of the genital ducts lies between the fourth pair of thoracic limbs, and they have a proximal extension to some of the exopodites (outer branch) of the thoracic limbs. They are good swimmers and females deposit their eggs on stones and other objects. The larvae differ little from the adult. *Argulus* has a pair of suckers on the maxillae and a poison spine in front of the proboscis. One introduced species has been recorded from goldfish in New Zealand (Hine et al. 2000). It is likely that more species will be discovered.



Tongue worm *Linguatula serrata*.
Composite from various sources

Subclass Pentastomida: Tongue worms

Tongue worms are obligatory parasites of reptiles, mammals, and birds, inhabiting their respiratory tracts (nasal passages and lungs). Particularly prevalent in the tropics, there are no native species in New Zealand, but one introduced species has been reported (Tenquist & Charleston 2001). This is *Linguatula serrata*, whose most regular host is the dog. It is rare in New Zealand, but developmental stages have also been reported from the brown hare, European rabbit, house cat, and sheep (Thomson 1922; Gurr 1953; Sweatman 1962).

Globally, there are about 130 species, ranging in length from about 3 to 150 millimetres or more and generally transparent or yellow to red-coloured. Like most parasites, their body form is simple and wormlike. Blood is their only food. The jawless mouth (sometimes protruding) and two pairs of lobe-like appendages with claws give the appearance of five orifices, hence, *penta-* (five) *stomida* (mouths). Long treated as a separate phylum of invertebrates, tongue worms are now regarded as highly modified crustaceans, based on sperm and larval morphology, the nervous system, and DNA studies. Some very convincing fossils of apparent larval pentastomids from the Late Cambrian give no evidence of a crustacean relationship, leading Maas and Waloszek (2001) to question it. On the other hand, recent mitochondrial DNA sequencing supports the evidence from sperm that pentastomids are most closely related to the Branchiura (Lavrov *et al*. 2004).

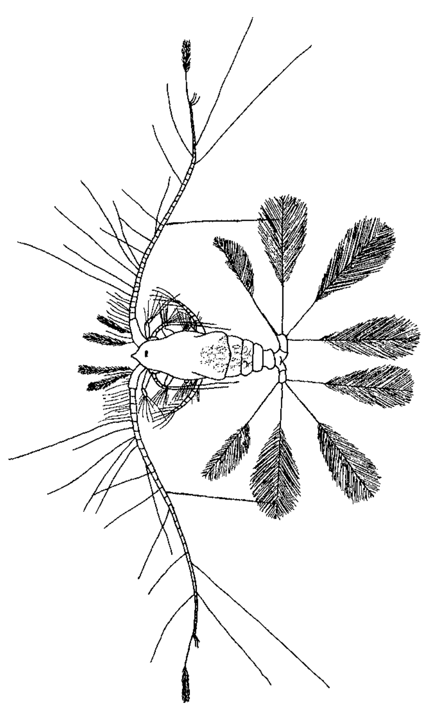
Subclass Copepoda: Copepods

Copepoda (oar-footed bugs) are small crustaceans that are common in aquatic and semi-aquatic environments, both marine and freshwater. Zoogeographical data indicate that copepods are ancient arthropods (Dussart & Defaye 1995) and fossils are known from the lower Cretaceous (Huys & Boxshall 1991). They have undergone extensive adaptive radiation and include a wide variety of open-water, bottom-dwelling, herbivorous, predatory, and parasitic forms. Copepods can often be extremely abundant and have been estimated to be among the most numerous animals on earth, mostly because of their dominance in the plankton of oceans and lakes. There are a number of excellent accounts that give general information on copepods. The comprehensive monograph by Huys and Boxshall (1991) deals especially with morphology and evolution, while Williamson

(1991) and Dussart and Defaye (1995) concentrate on the structure, function, and taxonomy of freshwater species. Coull and Hicks (1983) and Mauchline (1998) provide detailed information on the biology of harpacticoid and calanoid copepods, respectively, especially the marine species. These references are the main sources of the following notes.

The name 'Copepoda' is derived from two Greek words (*kope*, oar, and *podos*, foot), hence oar-footed. Copepods are typically small, mostly in the range 0.5–5.0 millimetres. Free-swimming forms may achieve a mimimum size of only 0.2 millimetres (some *Oncaea*) or a remarkable 18 millimetres (a *Valdiviella* species), but some parasites are even larger. The body is usually approximately cylindrical and segmented, and divided into three parts—cephalosome, metasome, and urosome (equivalent to head, trunk, and abdomen). There are 10 pairs of appendages on both the cephalosome and metasome, used for both feeding and locomotion (some of these appendages also have a sensory function), and the urosome ends in two bristle-bearing caudal rami. Uniquely among crustaceans, copepods have a flat plate that connects the basal segments of each pair of swimming legs. This plate is probably why copepods can have a rapid jumping mode of movement. In all copepods the first thoracic segment (bearing the maxillipeds) is incorporated in the cephalosome, unlike other maxillopodans.

The presence of a uniramous (unbranched) antennule is also a fairly reliable copepod characteristic. In male copepods the first antennae can be typically geniculate (with a prominent elbow), and are used to grasp the female during mating. The antennae, mandibles, maxillules, maxillae and maxillipeds are used in feeding. A wide variety of food types are utilised, including detritus, bacteria, algae, rotifers, nematodes, naidid oligochaete worms, crustaceans, and larval fish, and the structure of the feeding appendages varies in association with diet. The mechanics of feeding are complex, although copepods are probably fundamentally raptorial and use their mouthparts to grasp food particles. Many species, however, especially calanoids, are suspension-feeders and use the mouthparts to create water currents that bring food particles towards the copepod. Smaller particles are then captured passively and directed towards the mouth by bristles on the maxillipeds, maxillae, and maxillules, while larger particles are individually grasped by 'fling and clap' movements of the maxillae that grasp both the particle and a packet of water surrounding it and remove the water by an inward squeeze.



Calocalanus pavo.
After Giesbrecht 1893

Reproduction is usually sexual, and sperm are transferred from male to female in a sac-like spermatophore (a few harpacticoids can reproduce parthenogenetically). Egg sacs are probably not an ancestral condition of Copepoda as many groups lack true egg sacs. Nevertheless, in many copepods the eggs are carried in one or two egg masses, sacs, or strings until hatching. Under favourable conditions, multiple clutches of eggs can be produced, at intervals of a few days or weeks, so that each female may produce tens to hundreds of eggs in a lifetime. The egg hatches into a nauplius larva and the life-cycle typically includes six naupliar stages and six copepodite stages, the last of which is the adult stage. There is a marked metamorphosis between the last nauplius and the first copepodite stage. Development may sometimes be abbreviated, especially in parasites. Copepods are relatively long-lived compared to other microcrustaceans. Development times from egg to adult are typically in the order of 1–6 weeks, but may take several months, and the lifespan of adults may be from one to several months. Developmental times are markedly affected by temperature and food levels. Some copepods have resting stages that enable avoidance of detrimental environmental conditions and dispersal. Calanoids and harpacticoids produce resting eggs that have a thick shell and which can survive extended periods of dormancy and dryness. In cyclopoids and some harpacticoids, copepodites may enter diapause and encyst in bottom sediments.

There are 11 orders, approximately 213 families, 1763 genera, and 11,956 species worldwide (Humes 1994; Ho 2003). The Harpacticoida alone comprises

54 families, about 599 genera, and about 4400 species (J. Wells, unpublished data updating Wells 2007). The Calanoida has 42 families with about 2000 species (Boltovskoy et al. 1999); in the Poecilostomatoida there are 55 families, 359 genera, and about 1770 species (Ho 2003); and in the Siphonostomatoida there are 45 families, 377 genera, and about 1840 species (Ho 2003). The known New Zealand copepod fauna comprises 698 species, of which the Calanoida is the best known with 261 species, nine of which are undescribed. There are only 230 species of Harpacticoida, with about 99 of them undescribed; the remaining orders are also very poorly known.

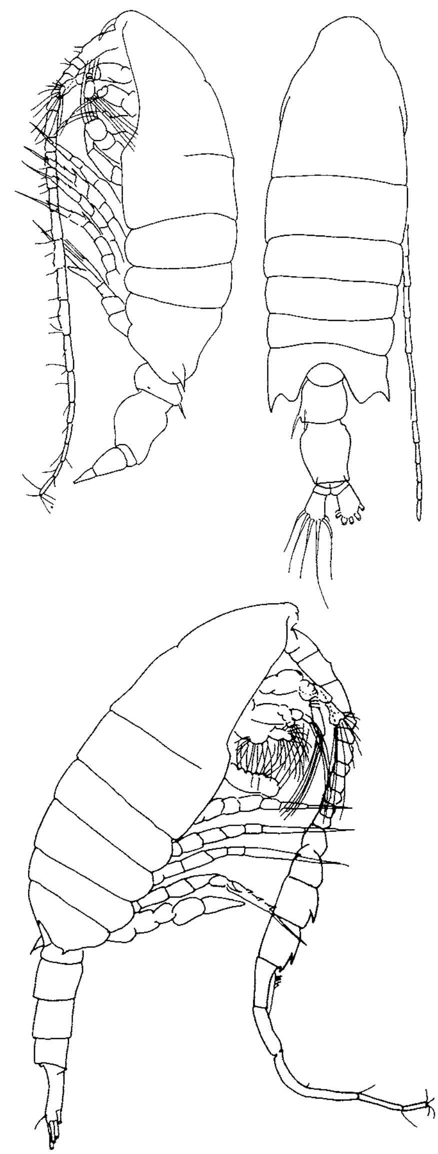
Copepods live in a remarkable number of environments. These include not only marine and freshwater planktonic realms but in or on aquatic sediments, in association with plants, forest litter, and damp moss, in subterranean habitats or anchialine (isolated-marine) caves, and deep-sea hydrothermal-vent settings, but also in association with other animals as commensals or parasites.

In the marine plankton, calanoid copepods ('insects' of the sea) are extremely abundant. Some typical New Zealand examples are *Acartia ensifera*, *Calanus australis*, *Centropages aucklandicus*, and *Paracalanus indicus*. They are adapted to swimming in the water column and are fine-particle feeders in near-surface waters, eating mainly phytoplankton and protozoans. Carnivorous or detritivorous forms occupy deeper water-layers down to the deepest trenches. In the water column we also find forms that are not strictly free-living but live associated in some way with surfaces – the sea floor, the underside of sea ice, or on other planktonic animals.

The freshwater plankton in New Zealand is dominated by calanoid copepods of the family Centropagidae, which are widespread and very abundant in lakes, ponds, and the lower reaches of larger rivers. Many of the species also occur in Australia, although there are at least three endemic species. *Calamoecia lucasi* and *Boeckella dilatata* are typical lake dwellers while *B. triarticulata* is found in ponds. As in marine habitats, the freshwater calanoids are suspension-feeders on algae and protozoans, although at least some of the boeckellids are also predatory on small zooplankters such as rotifers and nauplii. A few cyclopoid copepods also live in fresh water, although they are usually sparser than the calanoids. They are probably mostly omnivores, consuming both animals and algae. Some are found mainly in the bottom waters and are probably strays from the benthic and littoral areas.

In aquatic sediments, copepods (mainly harpacticoids) live either permanently within the sediment or alternate between the sediment and its surface, browsing on the microflora associated with the sediment particles or with the accompanying detritus. In well-oxygenated coarse-grained sediments such as beach sand, specialised copepods (again, mainly harpacticoids) are part of the 'interstitial fauna' that lives within the interstices of this habitat. This habitat is commoner in marine sediments than in freshwater sediments, although it does exist in river systems and their ground waters where a strong intra-sediment water flow occurs. Most families of Harpacticoida have representatives in all of the above habitats, with specialisations for the interstitial habitat having evolved many times in different lineages. These trends exist among the New Zealand fauna to the same extent as they do elsewhere and are represented by numerous endemic and non-endemic species. An extremely important characteristic of this fauna is that, with very few exceptions, the entire life-cycle is benthic and the larvae are not dispersed large distances by water movements. This not only must affect their ecology but must also impact on population genetics and eventually on phylogeny. As a result we should expect a high level of endemism.

Many copepods are associates of plants. In the marine intertidal zone many harpacticoids live in association with seaweeds and sea grasses and are highly specialised for life on the surface of the fronds. Members of the Porcellidiidae, Peltidiidae, and Tegastidae, for example, are especially adapted to this environment; each family is well represented in New Zealand. In the



Centropages aucklandicus – female at top (left profile and dorsal views), male below, with modified antenna for copulation.

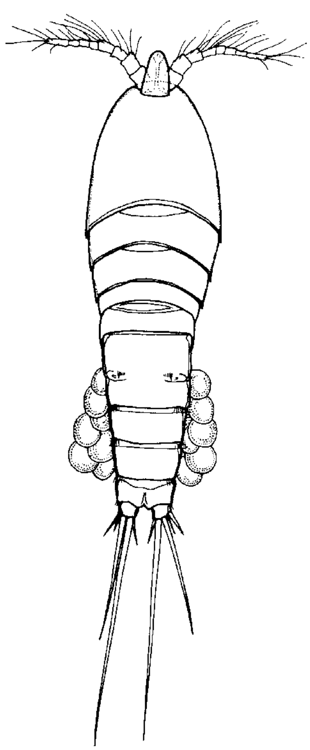
From Bradford-Grieve 1999

littoral areas of freshwater lakes, ponds, and running waters, cyclopoids and harpacticoids are abundant on and amongst macrophytes. Damp terrestrial situations are exploited by cyclopoid and harpacticoid copepods. These include damp soil, forest litter, sphagnum bogs, liverwort and moss clumps, and the pools between the leaves of bromeliads. Only the harpacticoids from this cryptic fauna have been extensively studied in New Zealand, and in these the same trends exist as elsewhere in the world; most species belong to cosmopolitan genera in the predominantly freshwater family Canthocamptidae, and most are endemic.

Copepods live in groundwater and can be caught in springs, wells, and pools in caves. In New Zealand these habitats have not been extensively surveyed (Chapman & Lewis 1976) and nothing is known about the copepods except that parastenocaridids have not been found, despite extensive searching (Schminke 1981a). Overseas, the Parastenocarididae (Harpacticoida) is a large family of ca. 270 species (190 of them currently placed in the genus *Parastenocaris*) that mostly inhabit the interstices of groundwater. These habitats range from the water table beneath beaches and sand banks, including a few fully marine beaches, to brackish systems such as the Baltic Sea, and riverine and lacustrine inland systems, above and below ground.

Recently the study of deep-sea hydrothermal vents and marine caves has revealed many interesting copepods of great importance to the study of evolutionary relationships between the various groups of copepods, as they are amongst the most primitive forms. Because isolated marine caves are not yet known in New Zealand and the microscopic fauna of New Zealand hydrothermal vents has not yet been studied, these types of copepods have not been recorded here.

In thermal waters of the central North Island only one copepod, the endemic cyclopoid *Paracyclops waiariki*, is known. It is restricted to Lake Rotowhero, which has seasonal temperatures varying between 29.5° and 37.5° C and an average pH of 3.1.



Paramphiascopsis waihonu.
From Hicks 1986

Nearly half of all known copepod species live in symbiotic relationships with other organisms. It is evident that commensalism and parasitism have evolved independently several times in the class, even within an order. Copepods parasitise virtually every phylum of animals from sponges and cnidarians to vertebrates including mammals. They also have a range of associations from external and internal parasitism to varied forms of commensalism. For example, two species of endemic New Zealand harpacticoids are associated with macroinvertebrates – *Porcellidium tapui* on hermit crabs and *Alteuthoides kootare* on sponges. It is interesting to note that these genera are highly adapted for clinging to a substratum and are genuinely 'phytal' in this respect. This particular association with macroinvertebrates is almost certainly of the same type as with marine plants, i.e. using them as a substratum on which bacteria, fungi, and microalgae grow abundantly. Similarly, *Paramphiascopsis waihonu* is known only from a sample of spent elasmobranch embryo cases (taken at 1116 m), where many specimens occurred along with a gastropod mollusc; an association with the gastropod is unlikely and it is most probable that both are feeding on detritus and decay products within the case. *Paramphiascopsis* comprises several other species that have been taken in association with ascidians, polychaetes, gorgonians, and decapod crustaceans but many species are also known from algae and sediments.

Harpacticoids are also found in burrows in wood inhabited by the gribble (*Limnoria* spp.), where the nature of the association is unclear (Hicks 1988a), with some authors arguing for an obligate commensal relationship and others believing the attraction for the copepod is the microhabitat created by the gribble. Evidence for the latter is the presence of copepods in decaying wood no longer occupied by *Limnoria*, but the fact remains that the copepod species have never been found in habitats that have not been associated with the gribble. Five species, of which four are endemic, occupy this habitat in New Zealand waters.

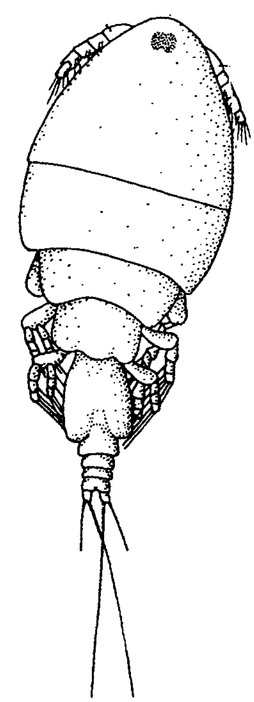
Importance of copepods

In both marine and fresh waters worldwide, abundant copepods form a vital link in the food web that leads from minute algal cells or phytoplankton and small protozoans (e.g. Chapman & Green 1987; Bradford-Grieve et al. 1998) to the largest fishes, and some whales in the oceans. Many commercial and non-commercial marine fish (and some crustaceans) are utterly dependent on copepods as a food source during a portion of their larval life. For example, in New Zealand it has been shown that the larvae of hoki (*Macruronus novaezelandiae*), which forms the basis of the largest New Zealand fishery, feed on copepod adults (e.g. *Calocalanus*) and copepodites almost exclusively (Murdoch 1990). With their large mouth size, hoki larvae actively select copepods such as *Calocalanus* and *Paracalanus* (Murdoch & Quigley 1994). For inshore benthos and for migratory fish, estuaries and lagoons are typically the critical location for this life-history phase. In a New Zealand estuary, *Parastenhelia megarostrum* is a principal prey item for young post-metamorphic flatfish during the first six months of their lives (Hicks 1984). The very smallest fish feed on the naupliar stages while larger specimens have an increasing proportion of older copepods in their guts. In lakes, copepods are an important part of the diet of smelt (e.g. Stephens 1984, Chapman & Green 1987), which in turn form a major part of the diet of rainbow trout. Copepods can be so abundant that their faecal pellets, produced at a rate of several per hour, are an important source of food for detritus feeders. Copepod grazing can significantly reduce the densities of at least some algal species (e.g. Edgar & Green 1994) and it has been suggested that they may have potential in the biomanipulation of the effects of eutrophication in lakes (Edgar 1993). Copepods are increasingly being used as test organisms in ecotoxicological testing. In New Zealand, the freshwater species *Calamoecia lucasi*, *Boeckella delicata*, and *Mesocyclops* sp. have been shown to be very sensitive to pentachlorophenol (Willis 1998) and the latter two species have been recommended as suitable candidates for the development of routine testing protocols involving acute and chronic endpoints (Willis 1999).

Copepods can be important economic pests when they parasitise commercial species. This is especially the case overseas, where ectoparasitic copepods of the families Ergasilidae and Caligidae ('sealice') infect salmonids reared in sea cages, causing damage and sometimes death of valuable aquacultured product reared in marine areas (Johnson et al. 1997). In New Zealand, copepod 'sealice' are not yet a problem in salmon culture (Hine & Jones 1994) but the causative copepod genera are present in the farms (Jones 1988a). Copepods of the family Sphyriidae are also of economic importance in that the anterior portion of the copepod is buried in the musculature of the host fish, while the posterior portion bearing egg strings trails from a hole in the skin. Skinning machines do not remove the 'head' from the fillet causing wastage and customer complaints.

In freshwaters, the ergasilid *Abergasilus amplexus* infests a wide variety of fish including longfinned and shortfinned eels, smelt, inanga, goldfish, and perch (e.g. Jones 1981). Two other parasitic copepods, *Thersitina inopinata* and *Paeonodes nemaformis*, are rather enigmatic (McDowall 1990). *Thersitina inopinata* is known only from its free-swimming males, while *P. nemaformis*, although endemic, is known to parasitise only introduced brown trout and salmon. The exotic copepod *Lernaea cyprinacea* has been recorded from introduced goldfish. Free-living copepods are also known to be intermediate hosts in the life-cycles of tapeworms of freshwater fish. The initial stages of *Amurotaenia decidua*, which parasitises bullies, occur in *Macrocyclops albidus* (Weekes 1986) and planktonic copepods are secondary hosts in the life-cycle of *Ligula intestinalis*, the pleurocercoid of which infests both rainbow trout and bullies (Weekes & Penlington 1986).

Copepods can be disease vectors for human parasites in tropical climates. But conversely they can also carry the fungi or sporozoans that parasitise



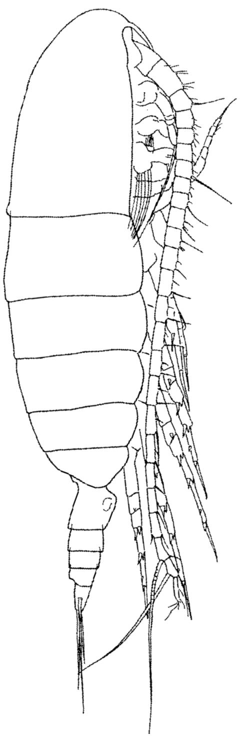
Abergasilus amplexus.
From Jones 1981.

malarial mosquitoes. Copepods have been implicated in the spread of viruses through fish populations (Mulcahy et al. 1990). Freshwater copepods of the genera *Mesocyclops* and *Macrocyclops* have been used for control of the container-breeding mosquito species of *Aedes*, *Anopheles*, and *Culex*. So far, no examples of these kinds of relationships have been noted in New Zealand.

Zoogeography of the New Zealand copepod fauna

Marine plankton

Very few marine planktonic copepods are endemic to the New Zealand region. The distribution of pelagic Copepoda (Bradford & Jillett 1980; Bradford *et al*. 1983; Bradford-Grieve 1994, 1999a) in the region appears to be maintained by a combination of factors probably related to their occurrence in water masses in some way or other. The physiological requirements of a species (temperature tolerances, ability to breed in differing temperature regimes, nutritional requirements for growth and breeding) and their behaviour (vertical migration in relation to particular water masses or physical-oceanographic phenomena) all contribute to the patterns we observe. An additional factor (plate tectonics) was probably important in the occurrence of some neritic plankton species in the New Zealand region.



Calanus australis (female)
From Bradford-Grieve 1994

Some species have a clearly coastal distribution. Among the New Zealand epipelagic calanoids, only species of Acartiidae, Calanidae, Centropagidae, Clausocalanidae, Paracalanidae, Pontellidae, and Temoridae contain coastal forms that are rarely encountered in oceanic waters. Endemic coastal species such as the calanoids *Acartia ensifera, A. jilletti, A. simplex,* and *Centropages aucklandicus* and the poecilostomatoid *Corycaeus aucklandicus* are confined to New Zealand waters, whereas *Gladioferens pectinatus*, *Labodocera cervi*, and *Sulcanus conflictus* are confined to Australia and New Zealand. *Calanus australis* is found in at least New Zealand and southeastern Australian coastal waters, where it is essentially restricted to the mid-shelf (Bradford 1985). It seems possible that many of these species had common ancestors with close relatives in other temperate neritic parts of the world as far back as the Oligocene, when equatorial sea temperatures were low (Bradford 1979). *Paracalanus indicus* is restricted to coastal waters, with maximum concentrations occurring close to shore (Bradford 1985), although this species possibly has a broad tropical/subtropical distribution. *Clausocalanus jobei* and *Temora turbinata* also have a tropical/subtropical distribution whereas *Drepanopus pectinatus* has a coastal distribution around subantarctic islands.

Relationships to water masses are most clearly seen among oceanic epipelagic species. Nevertheless, in the New Zealand region some oceanic species are capable of responding rapidly to the heightened productivity of coastal waters and may attain maximum numbers close to the coast, obscuring their oceanic affinities. Examples of this type of distribution are seen in the calanoids *Nannocalanus minor* and *Clausocalanus ingens* and the cyclopoid *Oithona similis*.

Warm-water (tropical) oceanic epipelagic species usually have a cosmopolitan distribution if they are able to breed at a range of latitudes extending to 40° S, whereas those with breeding ranges restricted to lower latitudes (e.g. *Euchaeta rimana*) are not circumglobal in their distribution because of the geographical barriers (South America and Africa) presented to their distribution. In tropical or subtropical waters, epipelagic calanoid species with distributions extending to 40° S and sometimes as far as the Subtropical Front are *Aetideus giesbrechti*, many *Calocalanus* species, *Clausocalanus arcuicornis*, *C. lividus*, *C. parapergens*, *C. paululus*, *C. pergens*, *Eucalanus hyalinus*, *Mecynocera clausi*, *Nannocalanus minor*, *Neocalanus gracilis*, *Pareucalanus sewelli*, *Pareuchaeta acuta*, *P. media*, *Rhincalanus nasutus*, and *Subeucalanus crassus*. Species with a warm-temperature (transition zone) Southern Hemisphere distribution include *Aetideus pseudarmatus*, *Clausocalanus ingens*, *Pareucalanus langae*, and possibly *Neocalanus tonsus* and *Calanoides macrocarinatus*. Species with subantarctic distributions include *Cala-*

nus simillimus, Clausocalanus brevipes, *Neocalanus tonsus*, and *Subeucalanus longiceps*. Species with Antarctic–subantarctic distributions include *Aetideus australis*, *Clausocalanus laticeps*, and *Rhincalanus gigas*.

Marine sediments

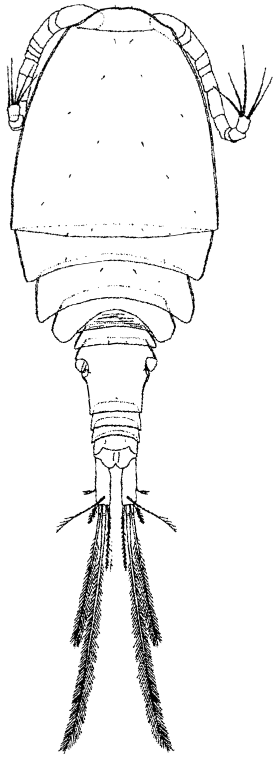
Throughout the world the copepod fauna of marine sediments (predominantly harpacticoids) is well known only for the intertidal and shallow sea areas. Detailed data are available for only a few sites of more than a few metres in depth, mostly in Europe, although scattered information is known for all depths down to almost the bottom of the deepest trenches. Even for intertidal and sublittoral areas, most of the world outside Atlantic Europe, the western Mediterranean, and a few locations on the eastern coast of the Americas is poorly known or even totally unknown. A reasonably comprehensive survey of the North and South Islands of New Zealand has been carried out, but the results have yet to be fully published and many species remain unnamed. Furthermore, assessment of the zoogeographic relationships of the New Zealand fauna is made impossible by the almost complete absence of information from Australia and New Caledonia. All that can be said at this time is that it seems unlikely that New Zealand will harbour many endemic genera (though that will depend on the attitude of future taxonomists towards taxon definitions).

Freshwater plankton

In New Zealand, most freshwater calanoids (eight species of *Boeckella* and one of *Calamoecia*) belong to the family Centropagidae, the non-marine members of which are mainly confined to Australasia, the subantarctic, the Antarctic Peninsula, and parts of South America (Bayly 1992). Only three of these species are found only in New Zealand (Jamieson 1998); the others also occur in Australia. A further four species are considered to be resident natives (*Boeckella dilatata*, *B. propinqua*, *B. triarticulata*, and *Calamoecia lucasi*) whereas *B. minuta* and *B. symmetrica* may have invaded New Zealand since European colonisation (Banks & Duggan 2009). Recently, the diaptomid cross-hemisphere invaders *Skistodiaptomus pallidus* and *Sinodiaptomus valkanovi* have been recorded in constructed water bodies (Duggan et al. 2006; Banks & Duggan 2009; Makino et al. 2009).

Bayly (1995 and references therein) concluded that the present-day distribution of freshwater and brackish Centropagidae can be interpreted as being a result of the colonisation of southern-hemisphere inland waters from marine and then brackish-water ancestors at a time when Australia, New Zealand, and South America were still linked to Antarctica, and Africa, Madagascar, and India had already drifted northwards. The absence of the Diaptomidae from New Zealand, most of Australia, and all of Antarctica also appears to be related to the timing of the separation of these landmasses from Pangaea in relation to the evolution of this family.

The distribution of calanoids in the major lakes is probably well known (Chapman & Green 1987; Jamieson 1988, 1998; Bayly 1992; Banks & Duggan 2009) but has yet to be fully examined in smaller habitats, especially ephemeral pools and the less-accessible high-country tarns. Most species show relatively clear habitat segregation. *Calamoecia lucasi* is widespread in northern, central, and western parts of the North Island, where it is found in streams, ponds, and large rivers. It also lives in a few small lakes in Northern Nelson. *Calamoecia ampulla*, a widespread species in Australia, is known only from one unverified South Island record (Bayly pers. comm.). Of the *Boeckella* species, *B. minuta*, *B. symmetrica*, and *B. tanea* have restricted distributions in the North Island. *Boeckella tanea* is found only in Northland, *B. symmetrica* in a pond near Auckland, and *B. minuta* in the Waikato River hydroelectric reservoirs and water-supply reservoirs in Wellington. It has been suggested that *B. symmetrica* and *B. minuta* may be



Abdiacyclops cirratus, an endemic cyclopoid genus andspecies from a subterranean well in Canterbury.
From Karanovic 2005

recent immigrants from Australia (Chapman & Green 1987) and this may apply to *C. ampulla* too. *Boeckella propinqua* occurs mainly in central and northern areas of the North Island but, like *C. lucasi*, its distribution also extends to the tip of the South Island. *Boeckella hamata* occurs throughout the southeastern part of the North Island, the eastern part of the South Island, and southern Westland, mainly in reservoirs and coastal lakes. *Boeckella triarticulata* has a similar distribution but apparently does not co-occur with *B. hamata*. It is found mainly in ponds and reservoirs in eastern parts of the South Island from Canterbury to Otago, with one record from Hawke's Bay in the North Island. *Boeckella delicata* has a disjunct distribution, occurring in Northland and the Waikato region of the North Island and also on the west coast of the South Island. *Boeckella dilatata* occurs only in the South Island, mainly in glacial lakes and in associated reservoirs. It also has a disjunct distribution and is found only in northern and southern areas of this island. Unlike the usual situation elsewhere in the world, co-occurrences of two or more species of calanoids in one lake are rare, and most lakes have only one calanoid. In the North Island, there are a few co-occurrences of *C. lucasi* and *B. delicata, C. lucasi* and *B. propinqua*, and *C. lucasi* and *B. minuta*, and in the South Island *B. triarticulata* and *B. dilatata*, *B. triarticulata* and *B. hamata*, and *C. lucasi* and *B. propinqua* in a few habitats (Chapman & Green 1987; Jamieson 1998; Banks & Duggan 2009).

Various attempts have been made to explain the distributional patterns of the New Zealand freshwater calanoids (summarised by Jamieson 1998) and, until recently, most of these used dispersalist biogeographical ideas. Banks and Duggan (2009) have highlighted the role of constructed lakes and ponds in facilitating inter-and intracontinental invasions of calanoid species. Maly (1984) suggested that distributions resulted from probabilities of immigration and extinction that were assessed from clutch sizes and the likelihood of predation by fish. Maly (1991) modified these ideas to include the number of existing populations and concluded that dispersal was probably not important over long distances but may be important at local scales. Jamieson (1988) explained the distribution of *Boeckella dilatata*, *B. hamata*, and *B. triarticulata* by relating differences in their ecological requirements and dispersal abilities to vicariant events. More recently, Jamieson (1998) has provided a convincing explanation for the distribution of these three species and *B. delicata* based on panbiogeographic methods. She showed that their distributions are correlated with the three principal pre-Late Cretaceous technostratigraphic terranes that, over the last 150–200 million years, have come together to make up New Zealand. *Boeckella dilatata* and *B. delicata* occur in lakes and ponds on the Tuhua and Caples Terranes and *B. hamata* and *B. triarticulata* on the Torlesse Terrane. The species overlap at the terrane margins. The present-day disjunct distributions of *B. dilatata* and *B. delicata* are thus thought to result from tracks arcing out to sea.

The species pairs on the different terrane groups are thought to differ in ecology; in particular *B. delicata* and *B. hamata* are suggested to have a higher salt tolerance than either *B. dilatata* or *B. triarticulata*, thus enabling sympatry. Localised dispersal presumably explains the overlap of species at the terrane margins. Jamieson's panbiogeographic approach would seem to have considerable potential for explaining distributions of the remaining calanoids. It is clear, however, that ecological information remains important for explaining distributions of sympatric species. Ecological studies of life-histories and food requirements have been made of some species (e.g. Green 1975; Forsyth & James 1984; Jamieson 1986; Chapman & Green 1987; Burns 1988; Jamieson & Burns 1988; Xu & Burns 1991; Burns & Xu 1990; Twombly et al. 1998; Couch et al. 1999), but much more remains to be done. The effects of post-European colonisation, with altered fish communities and changing trophic status of lakes, on distributional patterns are not known.

The cyclopoid copepod fauna is very poorly known taxonomically and ecologically. A few cyclopoids are found in the lake plankton, but their populations are usually either sparse or seasonal and little is known about them. There are no equivalents of the large-bodied *Cyclops* (in the strict sense) of many Northern Hemisphere lakes.

Mesocyclops leuckarti has been recorded from various North Island lakes (Green 1974, 1976; Jamieson 1977; Chapman & Green 1987; Greenwood et al. 1999), but it is likely that these records were not of the nominate species as *M. leuckarti* does not occur in the Southern Hemisphere (Kiefer 1981). Bayly (1995) has suggested that its correct identity is possibly *M. australiensis*. *Macrocyclops albidus* occurs in low numbers in the Rotorua and Taupo lakes (e.g. Chapman 1973; Forsyth & McCallum 1980), in the lakes of the Waitaki River system, and in other South Island lakes (Stout 1978; Burns & Mitchell 1980). *Eucyclops serrulatus* is found in the plankton of Lakes Hayes and Johnson (Burns & Mitchell 1980) and *Acanthocyclops robustus* in the plankton of Lake Mahinerangi (Mitchell 1975). It still can be concluded that, until a revision is made of the freshwater cyclopoids, no valid assessments of biogeographical relationships can be made. Nevertheless, Karanovic (2005) held it to be highly likely that the cosmopolitan cyclopoids *Acanthocyclops robustus*, *Diacyclops bisetosus*, *Eucyclops serrulatus*, and *Paracyclops fimbriatus* were accidentally introduced to New Zealand by early European settlers in barrels of fresh water. Jamieson (1980a, b) conducted experimental studies of predatory feeding and development rates of *Mesocyclops* sp.

Plant associates

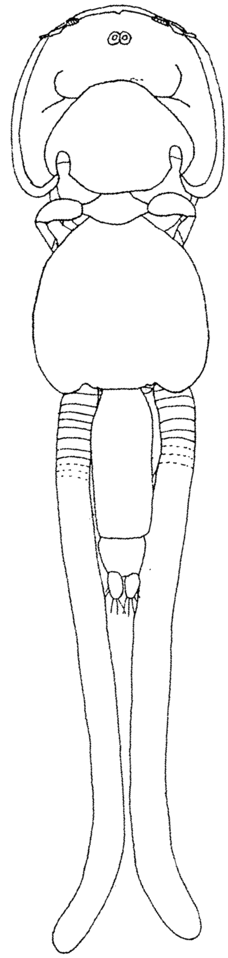
In marine systems the term 'plant associates' means the fauna associated with macroalgae and sea grasses and is usually called the phytal habitat. In addition, a few species have been found associated only with decaying wood (from wharf piles to driftwood dredged from depths of 1100 metres). These perhaps should be included in the phytal fauna as it is most probable that the role of the living or dead plant is primarily as a substratum for the copepods' food supply, namely bacteria, fungi, and microalgae attached to the plant. However, in this regard the phytal fauna is little different from the true benthos, which relies on these food sources attached to particles of the sediment.

Most of the species do not show obvious morphological adaptations to the phytal habitat. In those that do, the adaptations are usually to enable the animal to attach itself more effectively to the plant. Very few species seem actually to damage the plant or to be directly feeding on its tissues. Many genera that contain species found among algae have other species living on or in the adjacent benthic sediment. Many species are found equally often among algae and in sediments without associated plant growth. Also, it is known that many of the species washed from samples of macroalgae and sea grasses are actually associated with the sediment and detritus that becomes trapped in the interstices of the plant and thus are really part of the sediment fauna. Even many of the truly phytal species that do show adaptations to that environment have been shown to leave the plant for mating; this may partially explain the relative rarity of males in collections of these species.

In the marine system, about 45% of the described phytal species are endemic. Only a few undescribed species currently exist in collections, which may partly be a consequence of inadequate collecting and cataloguing. Notwithstanding, the phytal fauna is quite well known ecologically (e.g. Hicks 1977, 1988b) and, while it is very probable that many species remain to be discovered, the main outlines of the fauna are well known. Unfortunately, the phytal fauna of adjacent marine regions is as poorly known as their sediment fauna and similar remarks about understanding zoogeographical relationships apply. The comments below on endemism in the sediment fauna apply equally to the phytal but the lack of regional collecting makes it futile to try to estimate the true level of endemism.

The situation in freshwater and terrestrial systems is much the same. Some copepods (cyclopoids and harpacticoids) probably use plants mainly as the substratum on which their food grows, but much less is known about

Goniocyclops silvestris (female).
From Karanovic 2005



The fish parasite *Caligus pelamydis*, from barracouta.
From Hewitt 1963

their ecology. Certain copepods are found associated with aquatic vegetation in lakes and ponds, and with mosses (Harding 1958; Chapman & Lewis 1976). In semiterrestrial situations such as mossy banks and the edges of waterfalls or in damp forest litter and decaying wood, some copepods (such as *Goniocyclops silvestris* and a variety of harpacticoids) are found; most are apparently endemic but this fauna has still to be properly examined (Chapman & Lewis 1976).

Animal associates

It is difficult to make any definitive statement about the zoogeography of animal associates because the commensal and parasitic copepod fauna of marine invertebrates in New Zealand and neighbouring seas is very poorly known. For example, known New Zealand siphonostomatoid species diversity is only 29% of that in European seas, and even less for cyclopoids and harpacticoids, whereas, based on what is known for well-studied high-level Animalia taxa in both regions, New Zealand species diversity matches or exceeds that in European waters (Gordon et al. in press). The end-chapter checklist of New Zealand species in these copepod orders is annotated to indicate the type of relationship and host.

Species identifications of parasitic copepods from fishes of neighbouring seas are, in many cases, awaiting critical review. For example, *Trifur lotellae* in New Zealand would appear to be identical to *Trifur physiculi* from Australia. There are many other such examples. Also, the parasitic copepod fauna of marine invertebrates in New Zealand and neighbouring seas is almost totally unknown. Nevertheless, Jones (1988b) examined the then known parasitic copepod fauna and concluded that endemism on teleosts at the generic level was very low (2%) and there were no endemic genera on elasmobranchs (sharks).

The freshwater parasitic copepod fauna consists of only three species – *Abergasilus amplexus* and two very rare or extinct species, *Thersitina inopinata* and *Paeonodes nemaformis*. *Abergasilus* is an endemic estuarine genus common in, and known only from, Lake Ellesmere and the Chatham Islands lagoon. It has close affinities with South American genera. *Thersitina* has been found only once, in a plankton sample from Lake Poerua (Percival 1937). *Paeonodes nemaformis* has been found only twice, both times in South Westland on introduced salmonids (Hewitt 1969). The genus has also been found in Africa and is apparently closely related to *Mugilicola*, found in South Africa, India, and Australia (Boxshall 1986). The native hosts of *Thersitina* and *Paeonodes* are unknown, despite extensive searching. It is concluded that the parasitic copepod fauna of marine vertebrates is derived from the wandering of host fishes and reflects the strong links with Australia and the island chains to the north (Jones 1988a,b).

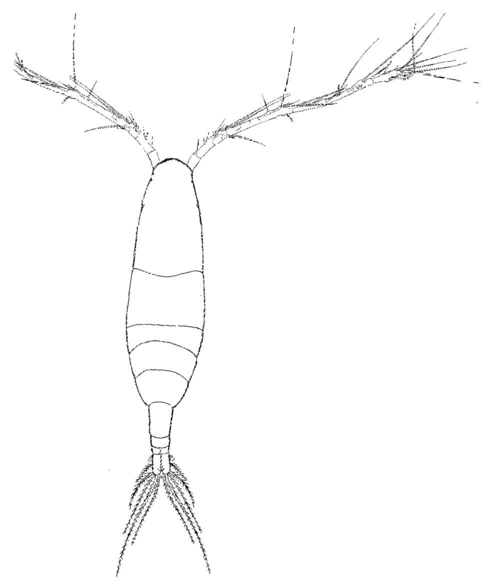
Endemism

One key element in the occurrence of endemism in New Zealand is the paleogeography of the region. The freshwater, brackish, and inshore copepod faunas illustrate the key elements of such reconstructions (Lewis 1984; Bayly 1995). The absence of the calanoid family Diaptomidae and presence of freshwater species of Centropagidae in Australia, New Zealand, South America, and Antarctica indicates that the period when these land masses were still linked but already separated from Africa, Madagascar, and India (120–80 million years ago) is crucial in reconstructing the evolution of *Boeckella*, *Calamoecia*, and *Gladioferens* in New Zealand and other southern hemisphere regions. These events, and the subsequent submergence of New Zealand in the Oligocene (35 million years ago) were probably responsible for speciation and the currently observed endemism (Bayly 1995).

The connection between New Zealand and Antarctica was broken during the Late Cretaceous. Three of eight New Zealand species of *Boeckella* are endemic to New Zealand (Maly & Bayly 1991) and it is likely that this genus inhabited the fresh waters of the ancestral landmass when it separated from Antarctica.

By the Late Oligocene, nearly all of the New Zealand landmass (possibly all of it according to Landis et al. 2008) was submerged. Significant extinctions will have occurred at this time, accounting for the relatively impoverished fauna of New Zealand compared with that of Tasmania. On the other hand, the multiple vicariant events associated with the production of a diminishing New Zealand archipelago in the Oligocene might have been expected to result in some speciation and the currently observed endemism if not all of the landmass was in fact submerged.

We predict that a higher degree of endemism than is currently recorded will be discovered amongst freshwater and benthic copepods when the less well-known groups are revised. But we need to introduce here a note of caution in this discussion of endemism. While the number of endemic species indeed reflects the evolutionary history of a particular fauna, in practice the number of such species recognised by past and present taxonomists depends on the interpretation of morphological variability within a species, especially where there is discontinuous distribution and not enough morphomolecular information for phylogenetic analysis.



Acartia ensifera.
After Bradford-Grieve 1994

Marine plankton

Very few marine planktonic species are endemic to New Zealand. The main reason for this is that most species are oceanic and are relatively widespread in a global sense, ranging from circumglobal subantarctic and Indo-Pacific to distributions encompassing all the world's oceans. Only a few coastal calanoid or cyclopoid species are endemic to New Zealand waters (*Acartia ensifera*, *A. jilletti*, *A. simplex*, *Centropages aucklandicus*, and *Corycaeus aucklandicus*). The cyclopoid *Corycaeus aucklandicus* is endemic to coastal waters of northern New Zealand.

Freshwater plankton and benthos

Only three freshwater calanoid species are endemic – *Boeckella dilatata*, *B. hamata*, and *B. tanea*; the other seven species also occur in Australia. Only two (*Metacyclops monacanthus*, *Paracyclops waiariki*) of the 19 cyclopoid species are known to be endemic to New Zealand. All others are supposedly cosmopolitan or Australasian. Notably, several genera recorded from Australia, some with multiple species (*Apocyclops*, *Australocyclops*, *Ectocyclops*, *Mixocyclops*, *Neocyclops*, *Thermocyclops*), have not yet been recorded from New Zealand. Some studies (see Bayly 1995) have shown much greater degrees of differentiation and endemicity than previously recognised in microcrustaceans, and it is evident that more stringent resolution of morphotypic variation of the New Zealand freshwater cyclopoids is required before their status can be assessed. Presumed 'cosmopolitan' species may be so only because of widespread and indiscriminate misuse of authoritative (?northern hemisphere) taxonomic references. As noted earlier for *Mesocyclops leuckarti* (discovered to be a species complex by Kiefer (1981) and not represented by the nominate species in the Southern Hemisphere), comparable species groups may be found in other 'cosmopolitan' species. An on-going global revision of the Cyclopoida (e.g. Dussart & Defaye 1995; Einsle 1996) will help resolve some of the problems. This series should be consulted as a guide to the global literature on cyclopoid genera and families, and in particular for the accepted modern level of taxonomic discrimination.

Marine sediments

Approximately 50% of the described harpacticoid species are endemic, but at least three times as many species remain undescribed in collections, and it is reasonable to estimate that at least 75% of these will prove to be endemic new species. It would seem, therefore, that the rate of endemism in New Zealand is high compared, for example, to the British Isles (as an example of another island group of comparable size), where probably it is less than 10%. But this comparison is meaningless. The British fauna has been investigated for much longer and at much greater intensity. As a result, it is known to contain at least four times as many species. Further, and very importantly, the British Isles are close to the shores of northwestern Europe, where the fauna is also very well known and shares many species with Britain. New Zealand is distant from its nearest neighbours. This, and its geological history since separation from the rest of Gondwana, may well have increased the level of endemism, but the lack of data from Australia (where the fauna is very poorly known) undoubtedly inflates the current estimates.

The limited amount that is known about the benthopelagic calanoid fauna indicates that there may be some degree of endemism (e.g. Bradford 1969; Bradford-Grieve 1999b) in the New Zealand region. Nevertheless, in the deep sea the perception of endemicity may reflect the paucity of sampling of near-bottom faunas worldwide.

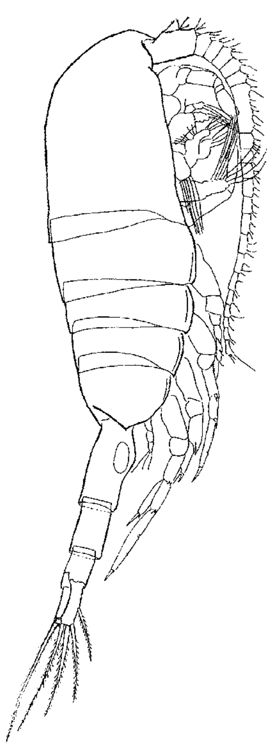
Cryptic habitats

Freshwater harpacticoids in New Zealand have been collected mainly from clumps of moss or liverworts or similar vegetation in streams, the littoral of ponds and lakes, or from wet banks close to water bodies and in damp forest in leaf litter. Of the 19 named species in the end-chapter checklist, 17 are endemic, but relatively little collecting has been carried out and large areas of the country remain unexplored. The total fauna is likely to be many times the recorded number of species, but it is probable that a very high level of endemism, and of localised distribution of species, may be found. It will be interesting to see if their distribution supports the panbiogeographic explanation for the distribution of freshwater planktonic Calanoida (Jamieson 1998). The presence of small cyclopoid species has also been noted, but only one has been identified to species and the true extent of this fauna cannot be estimated at this time (Chapman & Lewis 1976).

Gaps in taxonomic knowledge of copepods and scope for future research

Platycopioida

This order is not known in the New Zealand region. It is possible that platycopioids will be found when the benthopelagic realm is properly sampled, because they have been found in other temperate, shallow-water, near-bottom habitats. Other genera have been found in marine caves in Bermuda so their relatives might not be expected to occur in New Zealand.



Metridia lucens (Calanoida).

From Bradford-Grieve 1999

Calanoida

The marine pelagic calanoid copepod fauna of New Zealand is fairly well known, mainly from the work of Janet Bradford-Grieve. The end-chapter crustacean species list incorporates results from Bradford and Jillett (1980), Bradford et al. (1983), and Bradford-Grieve (1994, 1999a,b). Their data are augmented by information in the revisions of the Aetideidae (Markhaseva 1996) and Euchaetidae (Park 1995). All these works incorporate other records of 19th- and 20th-century workers.

A number of calanoid families have not been recorded in the New Zealand region. This may partly reflect lack of extensive sampling. For example, the poor sampling of benthopelagic habitats at all depths is probably responsible for the absence of the Diaixidae, Discoidae, Hyperbionychidae, Mesaiokeratidae, Parkiidae, Pseudocyclopiidae, Ridgewayiidae, and Ryocalanidae, although it is likely that the New Zealand fauna does include some species from a number of these families. The apparent absence of isolated marine (anchialine) caves in New Zealand probably explains the absence of the Boholinidae, Epacteriscidae, and Fosshageniidae.

Species of Parapontellidae have been recorded only from the North Atlantic

Ocean and from deep waters of the Malay Archipelago, so this rare family may not occur in the New Zealand region.

Other families are absent from the New Zealand fauna for paleogeographic reasons. The Diaptomidae are known from fresh waters in most of the world apart from New Zealand, most of Australia, and all of Antarctica (Bayly 1995). Pseudodiaptomids are brackish to marine species, widespread in other parts of the world but present in the Australasian region only in northern Australia.

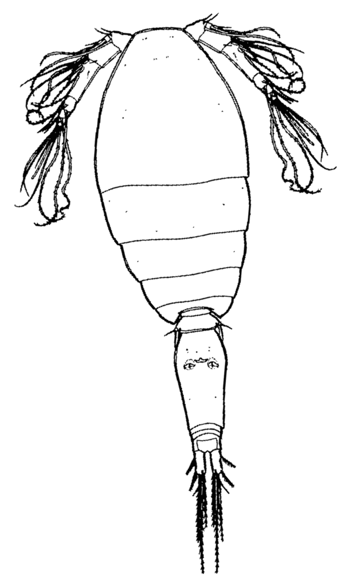
The taxonomy of the freshwater planktonic calanoids is reasonably well known (Chapman & Green 1987), although genetic studies using modern techniques are required to assess whether there has been cryptic speciation in any of the geographically widespread and disjunct species and in those shared with Australia (cf. Boileau 1991). Ecological studies are still in their infancy, and for all species much more needs to be known about autecology (e.g. growth and reproduction, feeding rates, behaviour, life-history strategies, population dynamics, etc.), and contributions to community and ecosystem dynamics (e.g. competitive interactions, predation effects, production rates, contribution to food chains, nutrient cycling, etc.).

Misophrioida

Members of this order have not been recorded from New Zealand. It is possible that they might be found when marine benthopelagic habitats are more extensively sampled.

Cyclopoida

This order now includes the Poecilostomatoida (Boxshall & Halsey 2004). Cyclopoids have been relatively little studied in New Zealand – knowledge of the marine, freshwater, and brackish non-parasitic Cyclopoida is very scattered and inadequate.



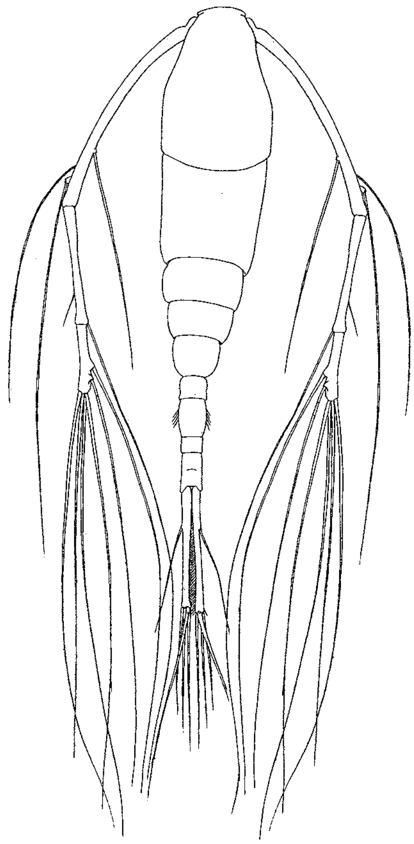
Oncaea media (Cyclopoida).
From Heron & Bradford-Grieve 1995

Early records of freshwater Cyclopoida were summarised by Hutton (1904) and amplified by Chapman and Lewis (1976). The synonymies and taxonomic arrangement given by Dussart and Defaye (1985) in their checklist of the world free-living Cyclopoida were taken into account in compiling the New Zealand list. In addition, the revision of the *Paracyclops fimbriatus* complex (Karaytug & Boxshall 1998) and the records of Roper et al. (1983) were noted. The commoner New Zealand taxa in ponds and lakes are known but both their generic and species status need re-examination in view of the recent taxonomic revisions of supposedly cosmopolitan genera (Morton 1985; Dussart & Defaye 1995). The underground and cryptic fauna is unknown taxonomically apart from *Goniocyclops silvestris* in forest litter (Harding 1958), and genera and species described by Karanovic (2005), but other undescribed species are known. Entries in the end-chapter checklist accompanied by a question mark are doubtful old records that need further investigation.

Checklists entries of the free-living marine planktonic families Oithonidae, Corycaeidae, and Sapphirinidae of the New Zealand region are based on the unpublished records of Janet Bradford-Grieve; the identities of the species need more detailed study. The species of Oncaeidae are known from the work of Heron and Bradford-Grieve (1995).

Another group of families comprises mainly marine parasites or associates of other animals. For example, *Hemicyclops* (a near relative has been discovered in New Zealand but is undescribed) has a typical cyclopoid body form and lives in loose associations with other marine organisms (e.g. polychaetes), sharing their burrows. There has been some work on fish parasites in New Zealand but the fauna is essentially unknown or undescribed – an extensive collection of *Sarcotaces* spp., made by Jones in the 1980s and 1990s from around New Zealand, remains in the Auckland Museum collection awaiting description.

The parasitic families Archinotodelphyidae, Chordeumiidae, Cucumaricolidae, Mantridae, Ozmanidae, and Thespesiopsyllidae and the marine benthic



Mormonilla phasma (Mormonilloida).
After Giesbrecht 1893

family Cyclopinidae are not known from New Zealand. The freshwater parasitic family Lernaeidae is represented by only *Lernaea cyprinacea*, which was introduced with ornamental fish (Boustead 1982). The commensal Ascidicolidae and Notodelphyidae, living in association with tunicates, are known from only two collections (Schellenberg 1922a, b; Jones 1974, 1979). It is certain that many more cyclopoid associates of marine invertebrates remain to be found and described.

Data on the occurrence of commensal and parasitic forms have been collated here using the works of Thomson, Hewitt, Jones, Pilgrim, and Ho as described above. In general, we can say that the symbiotic copepods of New Zealand are very poorly known, particularly those occurring in association with marine invertebrates. Certainly, those parasitic on marine fishes are better known than those parasitic or commensal on/in other hosts, but we still cannot say that fish copepods are well known in New Zealand. There is currently nobody working on symbiotic copepods in New Zealand.

Gelyelloida
The two known species of this order are found in subterranean waters of France and the order is unlikely to be found in New Zealand.

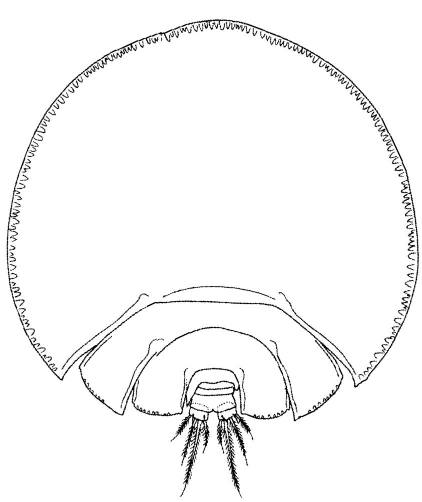
Mormonilloida
This order contains only two species that are usually found at mesopelagic depths. *Mormonilla phasma* has been recorded off the east coast of northern New Zealand.

Harpacticoida
Early contributions to knowledge of New Zealand's fauna were made by Thomson (1878a,b, 1882), Brady (1899), Sars (1905), Brehm (1928, 1929), Farran (1929), Lang (1934), and Harding (1958). More recent additions to the fauna have been made by Barclay (1969), Hicks (1971, 1976, 1986, 1988a,c), Lewis (1972a,b; 1984), Wells et al. (1982), Hicks and Webber (1983), and a number of other authors. Hicks has also contributed a body of ecological and biological information on the phytal harpacticoid fauna. Included herein are unpublished records of freshwater species from Dr Maureen Lewis, and marine species from Drs John Wells and Geoff Hicks. When the presently undescribed species in existing collections are worked up, our knowledge of the sediment-dwelling harpacticoids of seashores will be reasonably good, but much work still needs to be done on the marine phytal fauna (mainly nationwide collecting to establish distributional patterns). As is common worldwide, there is very little knowledge of the sediment or phytal faunas of the sublittoral and deeper.

Lack of extensive exploration may be responsible for the absence of some families. It is highly probable that Argestidae, Cerviniinae (Aegisthidae), Cletopsyllidae, and Nannopodidae will be found in shelf and deep-water sediments and Longipediidae and Metidae associated with seashore plants and algae. On the other hand, the absence of the Parastenocarididae may be for geological reasons.

Only a fraction of New Zealand's freshwater and damp terrestrial locations has been surveyed. It is to be expected that the number of species in the fauna will be at least tripled, and New Zealand's geological history makes it likely that a number of intriguing questions of zoogeography and phylogeny will arise as a result. The harpacticoid fauna of New Zealand's ground waters is completely unknown, yet cave systems exist that are comparable to the species-rich karst formations of Europe.

Of particular note is the paucity of information on the fauna of the far offshore islands from the Kermadecs to the Chathams and subantarctic islands.



Artotrogus gordoni (Siphonostomatoida).
From Kim 2009

Siphonostomatoida
All Siphonostomatoida are parasites or associates of other animals and the order is mainly marine. Most work has been done in New Zealand on the parasites

of fish, but this work is nowhere near complete. Almost nothing is known of the vast proportion of this order likely to live in association with marine invertebrates. We estimate that there are many species waiting to be discovered in the New Zealand siphonostomatoid fauna. There is currently nobody working on symbiotic copepods in New Zealand.

Commensal and parasitic forms have been collated here using the works of Thomson, whose major work was published in 1890 and whose collection is still housed in the Otago Museum (Thomson 1890). Gordon Hewitt also published extensively in the 1960s (Hewitt 1963, 1967, 1968, 1969) and, later, one of his students, Brian Jones, continued (1979, 1981, 1985, 1988b, 1991); his collection, including many undescribed species, is now in the Auckland Museum. A large collection was amassed at Kaikoura by students of the University of Canterbury under Bob Pilgrim (Pilgrim 1985) and some of that material was worked up by Ju-Shey Ho (Ho 1975, 1991; Ho & Dojiri 1987). The compilation given in the end-chapter crustacean species is based on the parasite list of Hewitt and Hine (1972), Pilgrim (1985), and the unpublished collection records of Jones.

An unidentified species of *Monstrilloida*.
Geoff Read

Monstrilloida

All Monstrilloida have internal parasitic naupliar and early postnaupliar stages and free-swimming, non-feeding adults. The known hosts are polychaete worms and prosobranch molluscs. Members of this order have been noted in the New Zealand fauna although there are no published records and descriptions.

Conclusions

There are few copepod taxonomists in New Zealand and none is able to work full-time on the subject. The greatest gaps in our knowledge copepod diversity are in the orders Cyclopoida, Harpacticoida, Siphonostomatoida, and Poecilostomatoida, especially concerning copepods as symbionts and parasites. These can be filled only by sampling little-studied environments, namely phytal, freshwater, deep-water, damp-terrestrial groundwater, and offshore islands. Sampling of benthopelagic and deep-sea habitats will yield records of hitherto undiscovered families and orders.

Because copepods are ecologically and economically so important, there is tremendous scope to understand the roles they play in the different ecosystems that they occupy, and to understand their impact on the other organisms with which they live in association, some of which are directly exploited by humans.

Class Ostracoda: Seed shrimps, mussel shrimps

Hemicytherura pentagona (Pleistocene).
Stephen Eagar

Ostracods are tiny bivalved crustaceans that are widely distributed in the oceans, in fresh waters, and, rarely, in terrestrial situations. Food-mediated seasonal blooms in some freshwater habitats can result temporarily in vast numbers. Their shape confers on them the common name seed shrimps or mussel shrimps. Species subclass Podocopa range from 0.2 to 1.5 millimetres in length, while modocopids are often much longer, reaching an extreme of 30mm in *Gigantocypris*. Their shells, strengthened by deposition of calcium carbonate amongst the layers of cuticle, also fossilise well; in fact, ostracods are the most abundant arthropods in the fossil record, with a body plan that has been conserved at least since the Silurian. The shells can be brightly coloured and highly sculptured, making them attractive creatures to study, especially with a scanning electron microscope. They have an indistinctly segmented body like most arthropods, with paired appendages that are adapted for a variety of functions. Their identification is normally a specialist occupation.

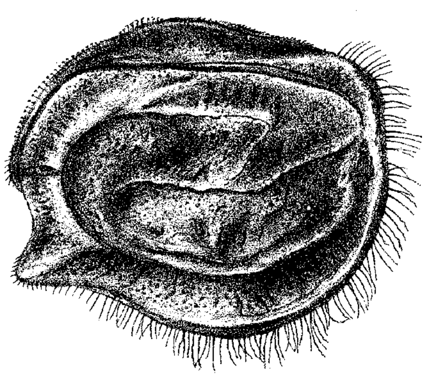
They are very useful organisms, as knowledge of their taxonomy and distribution can be applied to studies of ecology and to environmental monitoring in relation to water quality, water depth, salinity levels, and temperature, as well as in stratigraphy. The number of specialists studying this group of animals is declining even though there is great potential for their usefulness. There are approximately 22,000 living and fossil species in the Catalog of Ostracoda published by the American Museum of Natural History and estimates of likely global diversity suggest more than 62,000 species in total. Of the described living species, 7000 belong to subclass Podocopa and 600 to subclass Myodocopa (Cohen 1998). There are many more species yet to be found in New Zealand, both living and fossil, in all environments.

Ostracods live in most aquatic environments and even, in the case of one New Zealand species – the bright yellow *Scottia audax* – in the damp leaf litter of the forest (Chapman 1961). Freshwater species live for between one season (as ponds dry) and three years. Marine species similarly live for one season to two years. Many marine planktonic ostracods constitute food for fish and species of one family (Entocytheridae, represented in New Zealand by a single species) are commensal on fish and other arthropods. Some myodocopids are bioluminescent but none have yet been found in New Zealand.

The first description of an ostracod, by Carl Linnaeus (1746), was very generalised. A figure was published in 1753, but the 'father' of the study of ostracods is regarded as O. F. Müller who, in a 1785 monograph on Entomostraca from Denmark and Norway, produced good descriptions and figures of freshwater ostracods.

History of study in New Zealand

Currently, the New Zealand living ostracod fauna stands at 442 species (including 86 undetermined), mostly marine but also comprising 37 freshwater and one terrestrial species. This tally is the product of many zoological studies since 1843; actual descriptive taxonomy has proceeded in pulses. The first species to be studied, by William Baird, was a relatively large (1.94 millimetres body length) freshwater species (*Candonocypris novaezelandiae*), often found in ponds and drinking troughs for farm animals (Baird *in* White & Doubleday 1843). It was collected by naturalist-explorer Ernst Dieffenbach. Baird (1850) was also responsible for describing the large (6.5 millimetres) marine species *Leuroleberis zealandica* sent to him by Rev. Richard Taylor of Waimate, one of the early settlers. George M. Thomson, teacher, Member of Parliament, and an amateur naturalist, produced the first locally published paper on ostracods from the Dunedin district in 1879. The first global oceanographic voyage of HMS *Challenger* (1873–1876) brought the ship into New Zealand waters and into Wellington Harbour for sampling. The results were published by Brady (1880). With the general establishment of the New Zealand colony, there was by the end of the 19th century an exchange of information between naturalists in New Zealand and Europe who were keen to document the fauna. So material was sent away for identification. Norwegian G. O. Sars (1894) published on freshwater species contained in dried mud and Brady (1898), living in Newcastle, England, received some marine specimens from New Zealand. Owing to the paucity of New Zealand ostracod taxonomists, this practice continued well into the 20th century with Brehm (1929) in Austria, Kornicker (1975) in the USA, and Hartmann (1982) in Germany providing identifications. One consequence is that many of the type specimens of New Zealand species reside in overseas institutions.



Cymbicopa hanseni.
From Brady 1898

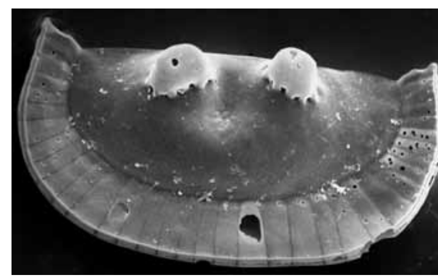
The freshwater ostracod fauna was reviewed by Chapman (1963) and Chapman and Lewis (1976), and Scarsbrook et al. (2003) briefly summarised the ecology of New Zealand groundwaters in which ostracods occur but which are poorly known.

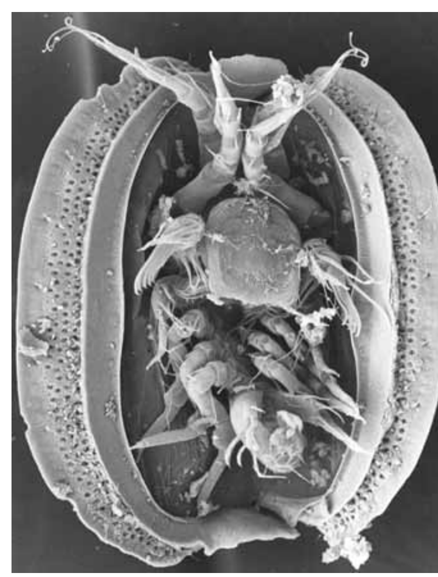
The podocopids and platycopids from the shallow intertidal to outer shelf have been the most intensively studied ostracods because they are also the most accessible (e.g. Morley & Hayward 2007). As mentioned above, ostracods are useful for environmental monitoring. They are sensitive to small changes in salinity and water quality and respond negatively to pollution. One study of a New Zealand waste outfall has shown the effects of sewage on a coastal ostracod fauna (Eagar 1999).

The planktonic myodocopids, which require specialist zoological knowledge, has been treated in monographs by Poulsen (1962, 1965) and Kornicker (1975, 1979) and in research studies by Deevey (1982). The first halocyprids were not recorded until Barney (1929). This group, together with the deep-sea podocopids, had received the least attention, but the recent study by Jellinek and Swanson (2003) has significantly increased knowledge of the latter.

Fossil species have followed a similar pattern of study. The earliest paper was by Jones (1860) on some tertiary species from Orakei. A bulletin by Chapman (1926) was issued by the New Zealand Geological Survey for Cretaceous and Tertiary species, but he used European names. His records are therefore not explicitly included in the following checklist, but the species are probably still represented there as synonyms of other workers' identifications. Benson (1956) recorded the occurrence of ostracods in late Middle Cambrian rocks from New Zealand, based on F. H. T. Rhodes's identification of their remains in a limestone. The preservation did not permit accurate identification. Simes (1977) recorded a phosphatic or phosphatised specimen from the limestone of the Upper Cambrian Anatoki Formation, and silicified ostracods were recorded by Marden et al. (1987) from the Triassic (Norian age). No other records whatsoever are available for any specimens from the Ordovician to the Jurassic.

Good fossil faunas are now known from sediments of Cretaceous age at several localities and these have been published recently (Dingle 2009). There have been a large number of papers on the systematics and paleoecology of New Zealand region Tertiary Ostracoda from the mid-1950s onwards (Swanson, 1969; Ayress 1990, 1991, 1993a,b,c, 1995, 1996; Ayress & Warne 1993; Ayress *et al*. 1994, 1995, 1997, 1999; Ayress & Drapala 1996). These faunas are rich, easily obtained, and interesting as they can be tied into other paleontological work. Most of the ostracod species in the end-chapter fossil checklist are therefore Tertiary species. The first publications to illustrate New Zealand ostracods using scanning electron microscopy came later (Swanson 1979a,b, 1980). The end-chapter checklist following builds on the one published by Eagar (1971).





Lateral view of valve of *Puncia* sp. (upper) and ventral view of *Manawa staceyi*, both from Cavalli Islands.

Kerry Swanson

Features of the New Zealand ostracod fauna

Many Cenozoic marine species are endemic, long-ranging, and even still living. Presuming that they have not evolved a tolerance to changed ecological conditions, it can be assumed that the paleoeviromental conditions in which they lived were the same as now. Of particular interest are species of the endemic living-fossil genera *Manawa* and *Puncia* (Punciidae). Similar in shape and ornamentation to some Paleozoic genera, they are found living in shallow water off the north and east coasts of New Zealand. They provide insight into the soft-part anatomy of a group of ostracods (order Palaeocopida) that has otherwise been extinct for a long time (Hornibrook 1963; Swanson 1990; Horne et al. 2005).

Freshwater species are rare as fossils. Many species are swamp- or pond-dwellers and are not found on lake margins; inasmuch as ostracod shells are very soluble in the acid conditions of swamp deposits, their chances of preservation there are small. Further, most of New Zealand was submerged by the Late Oligocene and there were relatively few lakes, along with limited means of dispersal, available in the geological past (Hornibrook 1955; Eagar 1995a). Once colonisation from Europe was established, trout, salmon, and carp were introduced from Europe via Australia and it is likely that ostracod eggs travelled as hitchhikers to New Zealand on the damp media used to transport the fish (Eagar 1994). There is one non-marine saline species – *Diacypris thomsoni* (see Bayly & Williams 1973) – from Sutton, Otago, in salinity conditions of up to 15 parts per thousand. Guise (2001) discovered in the Avon-Heathcote Estuary, Christchurch, a new endemic genus of brackish-water ostracod (*Swansonella*) that tolerates higher salinities.

There are now more opportunities for introducing ostracods into New Zealand. Resting eggs that can withstand desiccation may even be transported by aircraft on footwear and camping gear. In addition to European freshwater species, several other species have an Australasian distribution. One marine species discovered close to shipping ports in the North and South Islands may have been brought in ballast water (Eagar 1999).

Few studies have been made of the anatomy of New Zealand ostracods. These were mostly on myodocopids (Poulsen 1962, 1965, Kornicker 1975, 1979) and to a lesser extent to the freshwater species (Podocopida: Cyprididae) (Chapman 1963; Eagar 1995b; Rosetti et al. 1998), with a few ventures into the marine podocopids (e.g. Brady 1902; Swanson & Ayress 1999).

Class Malacostraca

This class contains more than half of all known species of crustaceans, including the aristocrats – the giant spider crabs of Japan with their 3-metre leg span (vying with fossil eurypterids as the largest of all arthropods) and the New Zealand packhorse rock-lobster (*Sagmariasus verreauxi*) at 20 kilograms – and krill, one of the most ecologically critical malacostracans in marine food webs, slaters, and tiny sand-hoppers. Malacostracans are very unevenly divided into three subclasses – Phyllocarida, Hoplocarida, and Eumalacostraca.

Levinebalia fortunata.
From Wakabara 1976

Subclass Phyllocarida: Phyllocarids

Order Leptostraca

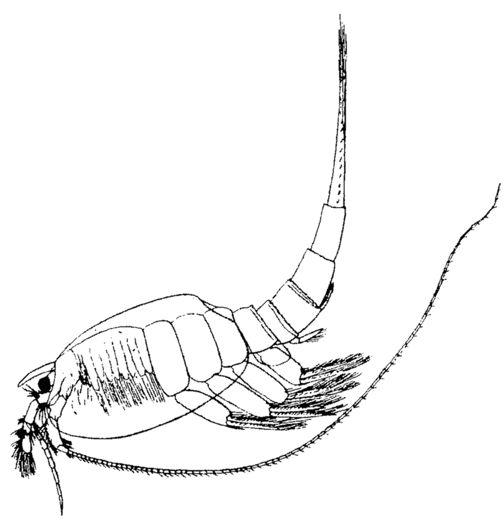
The Leptostraca is the sole living order of the Phyllocarida, a group of Crustacea with a long geological history (Rolfe 1969), possibly extending back as far as the Cambrian, some 600 million years ago (Briggs 1992). Despite new conclusions from DNA analyses as to their place in crustacean evolution (Spears & Abele 1999), the Leptostraca may still be regarded as 'living fossils' indicative of the times and conditions in which the so-called primitive arthropods lived (Hessler & Schram 1984; Dawson 2003b). They are known from the New Zealand Ordovician (Chapman 1934), and the presence of several living species of Leptostraca in the region is of considerable interest. Using the small-subunit 18S ribosomal-DNA gene of 10 representative foliaceous-limbed Crustacea, Spears and Abele (1999) concluded that the Phyllocarida are true malacostracans, which diverged fairly early from the main lineage. This result is consistent with the pioneer work of Claus (1888) and Calman (1909) and with Manton's (1934) study of embryology, and also corroborates the views of Dahl (1987, 1991) of the Leptostraca as an early offshoot.

The late British zoologist Sir Alistair Hardy (1956) vividly recalled the excitement of his first encounter with one of the little crustaceans, *Nebaliopsis typica*, found in great depths but rarely collected, and then usually dead and very damaged. It had only ever been seen alive on one occasion – on the Swedish Antarctic Expedition in 1904 – until a second specimen was collected from the *Discovery II* fifty years later. The Leptostraca, wherever they have been found subsequently, have continued to excite and interest zoologists and paleontologists alike.

A paleontological summary of the Phyllocarida was made by Rolfe (1969). Monographs on the Leptostraca as a whole have been made by Claus (1888) and Cannon (1960), and these still have their usefulness, but a new and compact text has been produced (Dahl & Wägele 1996). More recently, the relationships of the leptostracan genera were examined by Olesen (1999) and by Walker-Smith and Poore (2001), who revised the families and genera. The latter authors also provided a complete listing of all species of Leptostraca together with keys to the families and genera. Some 42 species of living Leptostraca are recognised at present, divided into three families – Nebaliopsidae (genera *Nebaliopsis*, *Pseudonebaliopsis*), Paranebaliidae (named only in 2001, containing *Paranebalia*, *Levinebalia*, and *Saronebalia*), and Nebaliidae (with five other genera). Many species of *Nebalia* and *Paranebalia* remain undescribed as yet (Dahl & Wägele 1996).

Leptostracans are small, usually 4–12 millimetres in length although one species, *Nebaliopsis typica*, can exceed 35 millimetres. They are characterised by the possession of a relatively large, bivalved carapace, hinged on the midline and held together by an adductor muscle. The carapace loosely covers the abdomen and part of the thorax, and is attached by a hinged rostral plate covering the head and closing the anterior gap of the carapace itself. Long anteriorly projecting antennae are used for swimming, the antennal flagellum in males being as long as the body. There are eight pairs of foliaceous, leaf-like thoracic limbs that also provide a feeding mechanism and may be modified in the female in the form of a fan of plumose setae forming a basket-like chamber for brooding eggs between the ventral regions of the valves of the carapace. The first four pairs of pleopods are well developed and biramous whereas the 5th and 6th pairs are small and uniramous. The abdomen ends in two characteristic long and articulated tail spines or furci. In contrast with all the six abdominal segments possessed by all other Malacostraca, the Leptostraca have a 7th segment and this lacks any appendages. The telson may be considered an 8th segment.

Relatively little is known of the life-history, growth rates, or physiology of most leptostracans. Useful observations have been made by Cannon (1927), Rowett (1943, 1946), Martin et al. (1996), Vetter (1996a), and Wägele (1983). Manton (1934) worked on the embryology of *Nebalia bipes*, helping to elucidate phylogenetic relationships of the Phyllocarida (Dahl 1987; Spears & Abele 1999). Linder (1943) described some larval stages, which could be useful for recognition in sorting plankton samples. Leptostracans play a significant role in benthic production (Rainer & Unsworth 1991; Vetter 1996a,b; MacLeod et al. 2007). The unusual marine rotifer *Seison* is often found epizoic on leptostracans. None has yet been discovered in New Zealand but it would be worth checking local *Nebalia* to ascertain their presence or absence.



Nebalia longicornis.
From Thomson 1879

Leptostracans are widely distributed as a group. Individual species may be limited or widespread in depth range and geographically, but taxonomic caution needs to be observed in the case of the purportedly wide-ranging species. Dahl's (1990) analysis of the *Nebalia longicornis* complex showed that it comprised at least 10 different species. Walker-Smith (1998) reviewed the genus *Nebaliella*, describing the first known Australian species. In her unpublished Honours thesis, she recognised six new species and a new genus of Leptostraca from Australia (Walker-Smith pers. comm. 2000).

Present-day leptostracans live in a variety of habitats, including under intertidal stones, with decaying seaweed or dead shell, in crab pots, on mangrove shores and coral reefs, and in subtidal sandy plains or muddy sand. A non-New Zealand species, *Speonebalia cannoni*, is the only leptostracan to be recorded from a groundwater habitat. *Nebalia hessleri* lives in enriched sediments and detrital mats with low oxygen levels in submarine canyons off southern California. Here they form the highest density ever reported for a macrofaunal assemblage, namely 1.5 million per square metre. In northwestern Spain, Moreira et al. (2009) reported six species of leptostacans in subtidal sediments, the largest number of species recorded in a single area. *Dahlella caldariensis* occurs among mussels and vestimentiferan worm tubes, swimming above clumps of animals at hydrothermal vents.

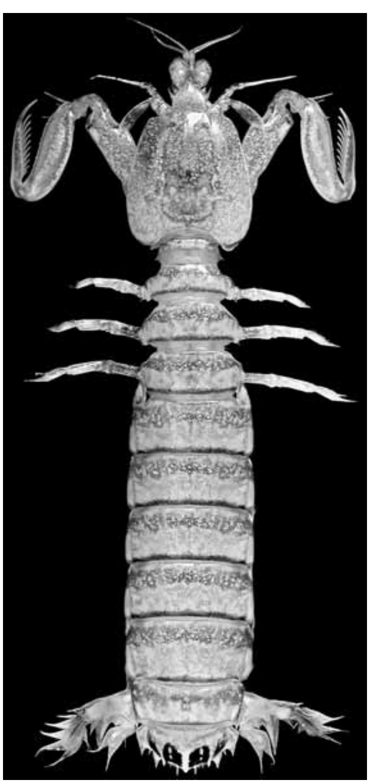
The New Zealand leptostracan fauna

The New Zealand fauna currently consists of five species in four of the 10 known genera. Unfortunately, little is known of the true numbers of taxa represented in any one geographic area, but the indications are that New Zealand could well be shown to have a higher diversity.

The first to be recorded and named in New Zealand was *Nebalia longicornis*, based on a single mature male collected in Otago Harbour (Thomson 1879a). It was subsequently described in more detail, based on records from 8–10 metres depth in Dunedin Harbour and 20 metres at Stewart Island (Thomson 1881). This later paper by Thomson (with its slightly different figure) appears to have been overlooked by all subsequent authors. *Nebalia longicornis* was inadequately described and illustrated according to Dahl (1990), and great taxonomic confusion subsequently resulted from attempts to apply this name to later records of *Nebalia* from other parts of the world. Since Thomson's type specimen could no longer be found, Dahl redescribed the species based on a female collected from Otago Harbour in 1965, thereby fixing *Nebalia longicornis* Thomson, 1879a as a member of the New Zealand fauna. Thomson (1913) noted his *Nebalia longicornis* as found in Otago Harbour and frequently taken outside the Otago Heads in trawl-nets.

Thiele (1904) reported a specimen of what he considered to be *Nebalia longicornis* from Akaroa Harbour. Dahl (1990) examined this specimen and found it to be a species of *Nebalia* (then in his genus *Sarsinebalia*) but in too damaged a condition to be able to describe further. Thiele had also recorded juvenile *Nebaliella antarctica* from Akaroa Harbour but apparently this specimen has not been re-examined.

In 1907, W. Benham collected a juvenile *Nebalia* from Musgrave Harbour on the Auckland Islands that Chilton (1909) attributed to *N. longicornis* as then understood. Another specimen was taken at Port Ross, Auckland Island, in 1914 during the Mortensen Expedition (Stephensen 1927). Calman (1917) reported two immature specimens of Leptostraca collected in 1911 at *Terra Nova* Stations 130 and 135 off Three Kings Islands and in Spirits Bay [given incorrectly by Dahl (1990) as Stns 10 and 15]. Dahl (1990) has since examined these specimens, concluding that one is a *Nebalia* and the other a *Sarsinebalia*.



Mantis shrimp *Heterosquilla tricarinata*.
Shane Ahyong

Morton and Miller (1968) described a *Nebalia* as a member of the protected sandy-beach fauna, one of the small filter-feeding Crustacea that live in the fine sands of the lower beach. They also illustrated it as the prey of the small shallow-water cephalopod *Sepioloidea pacifica.*

The only other work on New Zealand leptostracans has been the description of *Levinebalia fortunata* (Wakabara 1976, as *Paranebalia*) based on 16 females collected by trawl nets at 420–660 metres depth in canyons off Otago Peninsula, representing a marked extension to the known bathymetric range of the genus. Apart from Prof. John Jillett at Otago (see Dahl 1990) no-one has conscientiously searched New Zealand habitats for leptostracans. It is likely that deliberately intensive collecting will reveal not only great extensions of the range of the already listed forms but undescribed species as well. Morton (2004) suggested searching for leptostracans in black anaerobic sediments with decaying algae and carrion-baited traps may also be useful (Lee & Morton 2005), especially for assessing population densities.

Chapman (1934) described several species from Ordovician rocks in Fiordland, based on numerous specimens. They have never been studied since and are listed in the end-chapter checklist of fossil New Zealand Crustacea under the generic names recommended by Rolfe (1969).

Subclass Hoplocarida

Order Stomatopoda: Mantis shrimps

Mantis shrimps are among the most aggressive and behaviourally complex crustaceans. All are active predators and mark one of the very few radiations of obligate carnivores within the Crustacea. The general morphology of mantis shrimps has been described by Holthuis and Manning (1969), and characteristic features are the triflagellate antennules, well-developed stalked eyes, and the greatly enlarged, raptorial second maxillipeds. The name mantis shrimp stems from these large and powerful raptorial claws. Prey is captured by 'spearing' or 'smashing', depending on whether the dactyl of the raptorial claw is extended or kept folded during the strike. (Think of the dactyl as a finger, opposing the thicker 'thumb' of the claw.) Hence the two modes of prey-capture define the 'smashers' and the 'spearers' among mantis shrimps (Caldwell & Dingle 1976). The strike of the raptorial claw is among the fastest known of animal movements, being completed in 3–5 milliseconds, and the strike of large species of 'smashers' may break aquarium glass.

Vision in mantis shrimps is strongly developed. In most species, the cornea is divided into two halves by a midband of ommatidia, enabling binocular vision with each eye. Additionally, the midband ommatidia in many families enable colour vision and detection of polarised light (Marshall 1988).

Most stomatopods live in temperate or tropical shallow marine habitats, but several species also range into subantarctic waters, and a few tropical species may occur in brackish water. Seven superfamilies are recognised: Bathysquilloidea, Erythrosquilloidea, Eurysquilloidea, Gonodactyloidea, Parasquilloidea, Lysiosquilloidea, and Squilloidea. Most members of the Gonodactyloidea occur on coral reefs where they shelter in or under boulders and coral. The bathysquilloids are known only from deep outer-shelf waters. Members of other superfamilies generally burrow in flat sandy and muddy harbour bottoms and sea-floors.

Pterygosquilla schizodontia.
Shane Ahyong

The Stomatopoda comprises the only living order of Hoplocarida, two other orders (Aeschronectida and Palaeostomatopoda) being known only as fossils. Compared with other major crustacean groups such as the Decapoda, the fossil record of the Hoplocarida is relatively poor but it appears that the hoplocarids originated in the Devonian and the Stomatopoda proper first appeared during the Carboniferous. Recognisably modern stomatopods, with well-developed raptorial claws, did not appear until the Mesozoic (Holthuis & Manning 1969; Hof 1998; Hof & Schram 1998).

Over the past three decades, the taxonomy of the Stomatopoda has been extensively revised, largely through the work of the late R. B. Manning, who recognised five living superfamilies (Manning 1995). Ahyong and Harling (2000) provided the most recent phylogenetic study. At present, more than 450 species in more than 100 genera, 19 families, and 7 superfamilies are recognised.

The stomatopods of the Atlantic have been monographed and are well known (Manning 1969, 1977), while those of the eastern Pacific were treated relatively comprehensively by Schmitt (1940) and Hendrickx and Salgado-Barragán (1991). Stomatopod diversity in the Indo-West Pacific region, however, is more poorly known. The most important major works for this region are those of Kemp (1913) on the Indian fauna, Manning (1995) on the Vietnamese fauna, and Ahyong (2001) on the Australian fauna. The Indo-West Pacific fauna has been extensively studied in the past decade (e.g. Ahyong 2002a,b,c; Ahyong & Naiyanetr 2002; Ahyong et al. 2008).

The New Zealand fauna

New Zealand's mantis shrimps are known from only a few studies, the most important of which are those of Miers (1876), Chilton (1891, 1911a) and Manning (1966). Manning (1966) recognised three species from New Zealand and its offshore islands: *Pterygosquilla schizodontia*, *Heterosquilla tricarinata*, and *Acaenosquilla brazieri* (as *Heterosquilla brazieri*). He also remarked that *Squilla tridentata* Thomson, 1882, synonymised with *H. tricarinata* by Chilton (1891), was probably a distinct species. Ahyong (2001) recognised Thomson's species as distinct under the combination *Heterosquilla tridentata*. Other additions to the

New Zealand stomatopod fauna are *Hemisquilla australiensis* (Stephenson 1967), *Odontodactylus brevirostris* (Manning 1991), and the striking 30-centimetre-long, scarlet deep-sea species *Bathysquilla microps* (O'Shea et al. 2000). Therefore, seven species are presently recorded from New Zealand.

The commonest species are *Heterosquilla tricarinata* (known around both main islands and Chatham, Stewart, Campbell, and Auckland Islands, generally in intertidal sand or mudflat burrows) and *Pterygosquilla schizodontia* (central New Zealand to the Auckland Islands, burrowing in subtidal sand and mud). Their biology has received little scientific study. Larval development of *Pterygosquilla schizodontia* was studied by Pyne (1972). Several studies have been conducted on *H. tricarinata* including those of Fussell (1979), Greenwood and Williams (1984), and Williams et al. (1985).

The New Zealand stomatopod fauna is relatively small, and this is consistent with the primarily tropical distribution of most species. Neverthless, low diversity may also reflect low collecting effort. Study of collections from northern island groups in New Zealand territorial waters should reveal numerous additional faunal records. The Japanese mantis shrimp *Oratosquilla oratoria* has become established in some North Island estuaries and is the first exotic species of Stomatopoda to be detected in New Zealand waters. New species and numerous additional distribution records will be reported in a forthcoming revision of the New Zealand Stomatopoda by Shane Ahyong.

Subclass Eumalacostraca

Superorder Syncarida

Orders Anaspidacea, Bathynellacea

The Syncarida constitutes a group of tiny crustaceans that may be regarded as living fossils, with a geological history extending as far back as the Carboniferous (Dover 1953; Drummond 1959; Brooks 1969; Schram & Hessler 1984; Uhl 1999, 2002; Jarman & Elliott 2000; Dawson 2003a). They are little known to most biologists, the exception being the large-sized *Anaspides*, found in Tasmania, which has attracted much interest and attention largely because of its accessibility in open waters rather than the subterranean habitat in which most syncarids live.

The Syncarida were first made known to science by the report of a fossil species, *Uronectes fimbriatus*, in Europe. Their relationships and place in the crustacean hierarchy remained a matter of contention until Packard (1885, 1886) gave them separate status as the Syncarida. Much later, Brooks (1962, 1969) finally settled the status of the fossil as one of three orders constituting the superorder Syncarida, and Schminke (1975) related them to the living orders. Schram (1984) subsequently reviewed and revised the fossil species, which range in time from the Early Carboniferous (Uhl 2002) to the Early Permian in Europe and North America, the Late Permian of Brazil, and the Triassic of Australia, corresponding to the former landmass of Laurentia prior to the formation of Pangaea.

New Zealander George Malcolm Thomson, a noted amateur scientist, teacher, and politician, is generally credited with the discovery and description of the first living syncarid – *Anaspides tasmaniae*, which he discovered when visiting Tasmania in January 1892. He was of the opinion that his discovery was a schizopod shrimp (Thomson 1894). However, Calman (1896) said this new crustacean was no schizopod and supplemented Thomson's description in some detail, comparing *Anaspides* with fossils from Illinois and Germany that Packard (1885) had already placed in his new group, Syncarida. Calman concluded that *Anaspides* was, in fact, a living representative of primitive malacostracans that had flourished widely in Paleozoic times

Ironically, however, living syncarids had in fact been discovered some years previously when Vejdovský (1882, 1889) published a description of the tiny *Bathynella* that he had found two years earlier in a well in Prague. Calman (1899) subsequently recognised *Bathynella* as a syncarid, but little more was known until 1913 when Chappuis (1915) found more specimens in a well near Basle. He placed them in a new taxon, Bathynellacea. Syncarids were soon found to occur in many places throughout Europe, in wells, springs, or streams in caves (Chappuis 1939) as well as in Australia, New Zealand, Japan, North and South America, and elsewhere.

Although Thomson turned out not to be the first discoverer of a living syncarid, the finding of such an ancient form of crustacean living in Tasmania did excite many subsequent workers (up to the present day), resulting in a substantial number of publications on aspects of their morphology, development, ecology, and relationships – and even a poem in the style of Longfellow dedicated to *Anaspides* (Mesibov 2000). In essence, there have been two approaches to the study of the Syncarida, one concentrating on the relatively tiny subterranean and interstitial forms (basically the order Bathynellacea), and the larger, open-water taxa of Australia (order Anaspidacea, which also includes the subterranean Stygocarididae). General accounts of the Syncarida can be found in Siewing (1959), Noodt (1964), McLaughlin (1980), Schminke (1982), Schram (1986), and Coineau (1996, 1998).

Within the Eumalacostraca, the Syncarida are distinguished by the absence of a carapace, an elongate body form (more or less cylindrical in the subterranean forms), with a thorax consisting of seven or eight segments, the first segment being fused to the head in some groups. The abdomen consists of six segments and a telson, or five segments followed by a pleotelson formed from the fusion of the 6th segment with the telson.

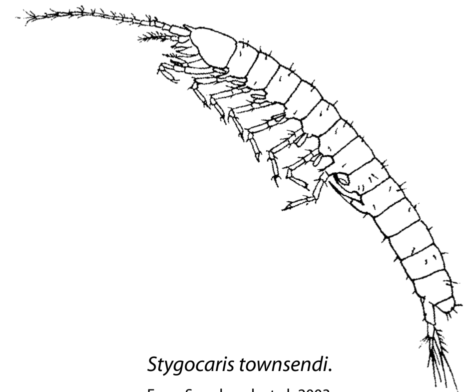
The order Anaspidacea contains four families: Anaspididae, Kooningidae, Psammaspididae, and Stygocarididae. Only the last of these has been found in New Zealand. They include the largest of the syncarids, with a body length ranging from about 1 to 50 millimetres. The Bathynellacea contains two families, the Bathynellidae and the Parabathynellidae, which are both represented in the New Zealand fauna as it is presently known. They are very much smaller in size than the anaspidaceans, ranging from about 0.4 to 3.5 millimetres.

The body form of syncarids is reflected in the habitats in which they are found: the tiny forms, with slender, cylindrical bodies, devoid of pigment and eyes, are found in caves and underground waters, whereas the much larger forms, such as *Anaspides*, found in surface waters are shrimp-like.

Living syncarids comprise more than 200 species worldwide (Camacho & Valdecasas 2008), although fresh explorations and more refined collecting techniques are already increasing this number. There are many species of syncarids collected from eastern Australian caves and karst areas awaiting identification and description (Thurgate et al. 2001) and such may be the case for New Zealand.

Syncarids have the reputation of being rare animals, although the pioneer investigations by Chappuis (1943) on *Bathynella* in Hungary showed that numerically rich collections could be made at individual sites. Much of the alleged rarity is a consequence of their small size (which is why early investigators in New Zealand such as Chilton did not find them) and their largely subterranean habits. Schminke (1986) has said that those who know how to sample their habitats 'today have lost the impression of dealing with rare animals.' Syncarids are globally widespread; Schminke (1986) listed all the species then known, with their locations. New taxa continue to be described Camacho 2005a,b; Cho 2005; Cho et al. 2005, 2006; Camacho et al. 2006; Cho & Schminke 2006).

While some Syncarida inhabit open- and surface-water habitats (Camacho & Valdecasas 2008), it is acceptable to say that syncarids are characteristic of subterranean habits throughout the world, whether groundwater (as revealed by sampling wells, springs, and gravel river margins), or caves with streams and sandbanks providing living space in the interstitial spaces between sediment grains.



Stygocaris townsendi.
From Scarsbrook et al. 2003

Syncarids have been recorded from springs in Australia (Knott & Lake

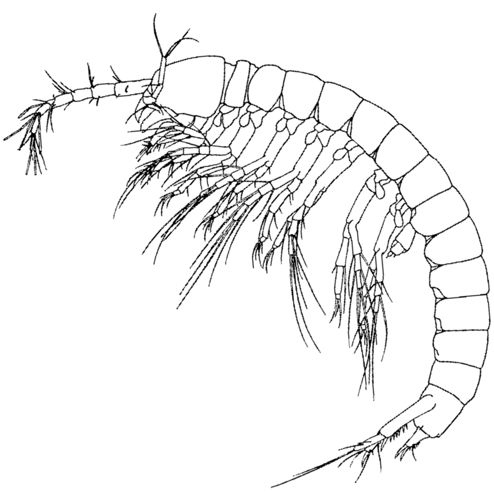
(1980), and in New Zealand they occur in similar situations as well as from groundwater in wells (Scarsbrook et al. 2003), just as did the first-discovered European living syncarids. Many syncarids have been collected from caves, although in New Zealand only *Stygocaris townsendi* has been described from such a habitat (Morimoto 1977). Karst landscapes throughout the world provide habitats for syncarids.

Information on the development, life-history, and habits of syncarids is still quite limited. So far as the Anaspidacea are concerned, most of the developmental studies have been done on *Anaspides tasmaniae*, by Hickman (1937), with other aspects covered in other studies, for instance Dohle (2000). The biology of bathynellaceans is less well known, but what is known has been summarised by Coineau (1996). In feeding, *Anaspides* has a filtering mechanism, used in conjunction with collecting particles by scraping detritus with its limbs. Smith (1908) noted that *Anaspides* was an omnivorous feeder, eating dead insects as well as each other, but mainly feeding on algal slime and submerged mosses and liverworts. The habitat of Tasmanian anaspidaceans, notably *Allanaspides hickmani* and *A. helonomus*, is under continuing threat (Driessen et al. 2006).

Compared to the amount of information regarding the general biology and ecology of the anaspidacean syncarids, there is virtually nothing recorded about the lifestyle and habits of the Bathynellacea. What is known has been summarised by Coineau (1996), and Camacho (1992) has outlined the abiotic characters of the subterranean environment in which most of bathynellaceans live.

Camacho (2006) noted 256 species and subspecies of extant Syncarida, 95% of which are subterranean in habitat. In addition to the two living orders is the order Palaecaridacea, which is entirely fossil.

The order Anaspidacea comprises five families, of which three are confined to Australia. These include: Anaspididae, with five genera – *Allanaspide*s, *Anaspides*, *Paranaspides*, *Anaspidites* (Triassic, Australia), *Koonaspides* (Lower Cretaceous, Australia); Koonungidae, with two genera – *Koonunga*, *Micraspides*; Psammaspididae, with two genera – *Eucrenonaspides*, *Psammaspides*; and Stygocarididae, with four genera – *Oncostygocaris* (Chile), *Parastygocaris* (Argentina), *Stygocarella* (New Zealand), and *Stygocaris* (Australia, New Zealand, Chile). The 21 living species of Anaspidacea are confined to the Southern Hemisphere. *Anaspides tasmaniae* is of particular interest in the context of mitochondrial DNA studies, in which it has been demonstrated that there may be at least three cryptic species (Jarman & Elliott 2000).



Notobathynella longipes.
From Schminke 1978

The order Bathynellacea comprises two families, both distributed widely throughout the world, totaling 66 genera an 219 species: Bathynellidae, with more than 20 genera (including *Bathynella*, of which there are New Zealand representatives) and more than 80 described species; and Parabathynellidae, with about 32 genera and more than 90 species (also recorded from New Zealand in the genera *Atopobathynella*, *Hexabathynella*, and *Notobathynella*). As discussed by Camacho et al. (2002), there have been two contrasting views as to the systematic position of the bathynellids as being either within the superorder Syncarida or as a separate suborder Podophallocarida in infraclass Eonomostraca. These Spanish researchers' molecular studies in Spain on a cave-dwelling bathynellid, *Iberobathynella* (*Espanobathynella*) *magna*, have now provided a nucleotide sequence that supports a basal position for the Bathynellacea with a clear distinction from the Syncarida, placing them in the Podophallocarida but retained in the Eumalacostraca.

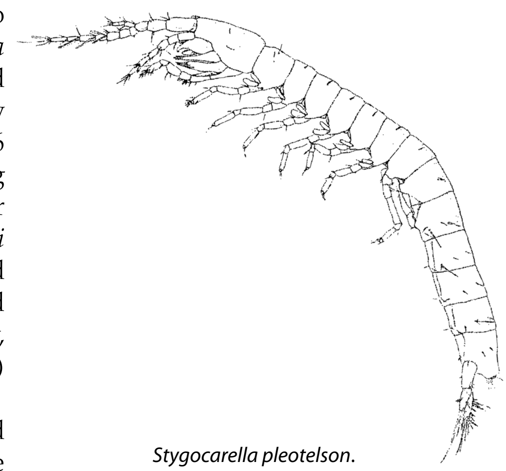
Schminke (1986) postulated that the Syncarida originated in the marine environment from whence they invaded freshwater by two independent lines, living first in surface waters and then invading the groundwater habitat. He developed the 'zoea' theory (Schminke 1981b) in which it was suggested that the Syncarida originally passed through a series of larval stages and through neoteny reached sexual maturity at a stage corresponding to the zoea larva of the penaeid prawns (Decapoda). Schminke (1972) had previously demonstrated, by a study of all the then-known species of *Hexabathynella* (but which did not include the subsequently discovered *H. aotearoae* of New Zealand), all of which were known to occur close to the sea, that syncarids did not invade the freshwater interstitial habitat from sandy marine beaches. Presumably, some of the more recently discovered occurrences of *Hexabathynella aotearoae* indicate secondarily derived habitats. This species is closest evolutionarily to Australian *H. halophila* (Camacho 2003).

Biogeographically, the breakup of the ancient supercontinent Gondwana has been invoked to explain some of the distributions between northern and southern hemispheres and within the austral landmasses (Schminke 1973, 1974, 1975, 1980, 1981a; Williams 1986). Subsequent information about the distribution and phylogeny of the various syncarid groups can be found in Coineau (1996), Camacho and Coineau (1989), Camacho *et al*. (2000), and Guil and Comacho (2001).

The New Zealand fauna

In 1967 and 1968, visiting German scientist Kurt Schminke searched for syncarids quite widely throughout New Zealand, taking almost 200 samples from interstitial freshwaters at 11 different localities (Schminke & Noodt 1968; Schminke 1973). Of these, 36 yielded syncarids in the families Bathynellidae, Parabathynellidae, and Stygocarididae. In his unpublished thesis, Schminke (1971) included two new forms of *Bathynella*, a species and its subspecies (as yet not formally described), collected from the Tauherenikau River in the Wairarapa and from the Orari River in South Canterbury. In his major work on the evolution, taxonomy and biogeography of the world fauna of the Parabathynellidae, Schminke (1973) listed his collecting locations in New Zealand with descriptions and distribution maps of four new species from New Zealand: *Atopobathynella compagana*, *Hexabathynella aotearoae*, *Notobathynella chiltoni*, and *N. hineoneae*.

Schminke (1978) subsequently reported on a collection, made by by G. Kuschel of the former DSIR Entomology Division, which included a female bathynellid from a bore in Nelson, and two females of *Notobathynella*. He also noted two more specimens of *Atopobathynella compagana* and described *Notobathynella longipes* from wells at Motueka. In the Anaspidacea, Schminke (1973) mentioned at least three unidentified New Zealand species of Stygocarididae in one new genus, later describing *Stygocarella pleotelson* (Schminke 1980) and noting 16 localities from which other unidentified specimens had been collected. During a brief trip to New Zealand in 1975, Morimoto (1977) collected syncarids at four South Island locations, finding three species of *Stygocaris*, of which *S. townsendi* was described as new. More recently, in a NIWA study of the New Zealand groundwater fauna (Scarsbrook et al. 2000), syncarids appeared to be widespread in interstitial habitats in alluvial groundwaters in Hawkes Bay and Canterbury, both within the margins of gravel riverbeds and in the deeper (10–20 metres) ground water.



Stygocarella pleotelson.
From Schminke 1980

Thus, the New Zealand syncarid fauna, as presently known from limited sampling, consists of at least four species of Anaspidacea – *Stygocaris*, and one or possibly more species of *Stygocarella*. The Bathynellacea is represented by what appear to be quite abundant and widespread species of Bathynellidae (*Bathynella*), none formally described, and three genera of the Parabathynellidae – *Atopobathynella* and *Hexabathynella* (each with one described species), and *Notobathynella* (at least four species, three of them named). It is highly likely that the New Zealand syncarid fauna will be found to be much more extensive, if only in terms of the distribution of the already described species, all of which are endemic.

Gaps in knowledge of Syncarida

Not only is taxonomic knowledge of the New Zealand Syncarida incomplete; even less is known about their ecology and special adaptations to the several kinds of habitats in which they occur. It is apparent that a geographically widely distributed syncarid fauna exists in New Zealand's ground waters. The brief venture into cave collecting by Morimoto (1977), taken with what is known of the distribution of syncarids in Europe and Australia, suggests the prospect of further exciting discoveries locally in this particular habitat. Cave systems and karst-type landscapes with sink holes and sunken streams are common in many parts of New Zealand (Crossley et al. 1981), and there is a very strong fraternity of recreational cavers, some of whom have already contributed to scientific knowledge of cave life. There is a real challenge to use the technical expertise of such people to look for these fascinating 'living fossils'; a preliminary guide to promote such work was issued by the New Zealand Department of Conservation (Hunt & Millar 2001). The results of a 15-year study of Spanish cave fauna by Camacho (2000) shows what could be achieved by a systematic approach towards elucidating New Zealand's subterranean syncarid fauna.

There is a growing appreciation worldwide of the importance of groundwater organisms as environmental indicators of water quality, not to mention the scientific interest of these organisms in their own right (Danielopol 1992; Marmonier et al. 1993; Danielopol et al. 2000; Gibert et al. 1994; Jones & Mulholland 2000; Scarsbrook et al. 2000, 2003) and the need to understand karst landscapes and their fauna from a conservation perspective (William & Wilde 1985) and cave life in general (Vandel 1964; Ford & Cullingford 1976; Sasowsky et al. 1997; Culver 1982; Camacho 1992; Juberthie & Decu 1994–2001). 'Living fossils' carry appealing overtones in the public imagination (Dawson 2003a), so the demonstration of the existence even of such tiny forms as the syncarids could be another highlight to make known.

An estuarine species of *Tenagomysis*.
Stephen Moore

Orders Lophogastrida and Mysida ('Mysidacea'): Opossum shrimps

The Mysidacea are shrimp-like but have a number of characters, including a 'brood pouch', that distinguish them from other crustaceans of similar appearance. They are mainly marine, living in all oceans from great depths to brackish coastal waters, and there is a small number of freshwater species. They are of limited commercial importance and therefore not as familiar as the decapod shrimps and prawns. Mysidacea may, however, be very common, particularly in estuaries and coastal waters, where they often congregate in large swarms, and are of considerable importance as primary consumers and as food of fishes.

Historically, the Mysidacea comprised a single order with two suborders – Lophogastrida and Mysida. The two groups differ in important ways and there is now debate over whether they are mono- or polyphyletic (having one, or more than one, ancestor). Some workers question whether the Mysida, which contains the great majority of Mysidacea, even belongs in the large malacostracan superorder Peracarida, with the Lophogastrida; see Martin and Davis (2001) for a discussion of mysid classification. These authors discarded the Mysidacea, raising the two suborders to ordinal status, a decision followed here. Even so, the two groups have many characters in common and, since relatively few species (24) have been recorded from New Zealand waters, are discussed here collectively.

Historical studies

Mysidacea have been recognised since the late 18th century. The taxonomic literature is scattered and deals mostly with northern hemisphere faunas and least with that of the Indian Ocean and Australasia. Major contributors include Tattersall and Tattersall (1951), Gordan (1957), Mauchline and Murano (1977), Mauchline (1980), and Müller (1993).

The history of New Zealand mysidacean taxonomy is brief. The first published record is that of Thomson (1880), who described *Siriella denticulata*.

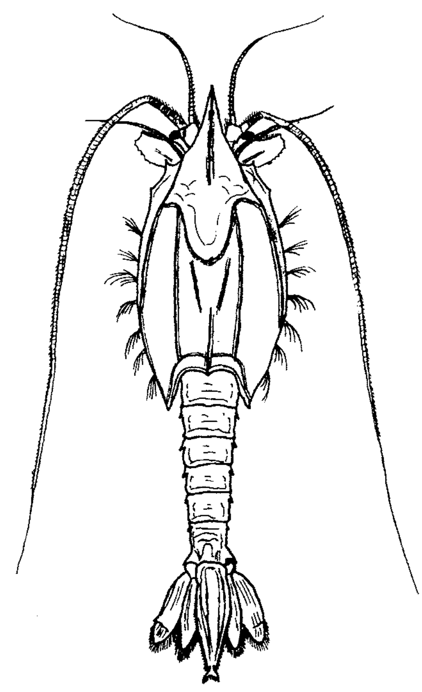
Kirk (1881) described *Mysis meinertzhagenii,* but the type and further evidence of its existence have not been found since. Thomson (1900) described *Tenagomysis novaezealandiae* from brackish water near Dunedin, and Calman (1908) attributed an immature mysidacean specimen to the genus *Pseudomma*, apparently not identified since. *Tenagomysis tenuipes* Tattersall, 1918, from Carnley Harbour, Auckland Islands, brought the early list of mysidaceans known with certainty to occur in New Zealand to three. Next, Walter Tattersall's (1923) report on the Mysidacea of the 1910 *Terra Nova* Expedition to Antarctica and the Southern Ocean added 12 species. Eight were new, seven of which belonged to *Tenagomysis*, and the remaining species was named *Gastrosaccus australis*, the first and so far only named species of the genus from New Zealand. New records for New Zealand of previously described species of Mysida included *Euchaetomera oculata*, *E. typica*, and *Siriella thompsoni*. Chilton (1926) presented an overview of New Zealand Mysidacea to that date. Later, Olive Tattersall (1955) identified *Boreomysis rostrata* and *Euchaetomera zurstrasseni* from New Zealand waters and Hodge (1964) redescribed *Tenagomysis chiltoni*. The most recent addition to the fauna was that of *Tenagomysis longosquama* (Fukuoka & Bruce 2005).

Walter Tattersall (1923) appears to be the first to have recorded a species of Lophogastrida, *Paralophogaster glaber,* in New Zealand. Apart from a record of *Lophogaster* sp. from Te Papa (Museum of New Zealand) collections, the remaining records are from Fage (1941) reporting on mysidaceans caught by the 1928–30 *Dana* Expedition, all in the family Gnathophausiidae: *Gnathophausia elegans*, *G. zoea*, *Neognathophausia ingens*, and *N. gigas*.

Clearly there are more mysidacean species to be described from New Zealand. Small numbers of specimens have been collected, with most material in New Zealand held at the University of Otago and Auckland University of Technology (Jocqué & Blom 2009).

Morphology, species, and endemism

The carapace is well developed in Mysidacea and covers the thorax, as it does in euphausiids and decapod shrimps, but is fused with the anterior three or four thoracic segments only; the back of the carapace can simply be lifted to expose the posterior four or five thoracic segments. They have a shrimp-like abdomen with fully developed or reduced pleopods, and the telson and paired uropods form a tail fan. Mysidacean eyes are compound and stalked although in a few deep-water species they are reduced to immovable plates. The antennules are always biramous and most have an antennal scale. Of the eight pairs of thoracic appendages, the first one or two are modified as maxillipeds. The remaining six or seven pairs form legs and generally bear swimming exopods. A feature of female mysidaceans is their large leaf-like oostegites, on the inner side of some or all of the legs, which overlap to form a brood chamber or marsupium (recalling the name opossum shrimp) beneath the thorax, in which eggs are laid and the young develop. Both orders have all these characters in common.



Female *Neognathophausia ingens* (Lophogastrida).
From Sars 1885

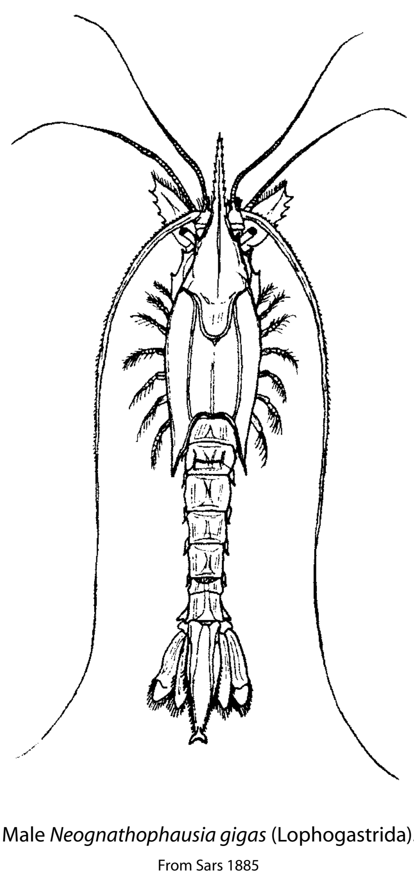
In the Lophogastrida, however, gills are present on some or all of the legs, pleura ('side plates') are present on the abdominal segments, and the pleopods are well developed and usually unmodified in both sexes. Lophogastrids also have seven pairs of oostegites but lack statocysts in the endopods of the uropods. All species of Lophogastrida live offshore in meso- and bathypelagic habitats, with many being hyperbenthic (living close to the bottom) in deep water. The largest mysidaceans belong to this order and most occur throughout the world's oceans but are less often seen than species of Mysida, because of their oceanic existence.

A characteristic of the Mysida (excluding all 33 species of the Petalophthalmidae) is the presence of a pair of balancing organs or statocysts, in the telson. Situated near the base of each uropodal endopod, statocysts are an obvious feature, distinguishing mysids from similar animals such as euphausiids (krill). Mysids also lack gills and the pleopods of females are reduced or rudimentary;

those of males are variously modified. Like the lophogastrids, many mysids have seven pairs of oostegites, but there are fewer pairs in some subfamilies of the Mysidae, including the Gastrosaccinae, Mysinae, and Siriellinae, which between them contain 16 of the 18 species of Mysida recorded from New Zealand. Mysids occur throughout the marine environment to deep oceanic trenches but are particularly concentrated in coastal regions, and 24 species have colonised fresh waters around the world.

Adult Mysidacea range considerably in size from 2–3 to 350 millimetres long. The largest are in the Lophogastrida but most species belong to the Mysida and are appreciably less than 100 millimetres long. The few species recorded from New Zealand almost cover this range, with mature females of *Tenagomysis macropsis* as small as 3.2 millimetres long (Greenwood *et al.* 1985) and the largest of all mysidaceans, *Neognathophausia gigas*, also being recorded in New Zealand waters (Fage 1941).

Around 1000 species of Mysidacea have been described worldwide, the great majority in the order Mysida, with some 51 in the Lophogastrida. Twenty-four species have been recorded in New Zealand waters, representing both orders (see end-chapter checklist). Of the three lophogastrid families, the Eucopiidae are not yet known here. Of the four families of Mysida, two are found in New Zealand – the Petalophthalmidae (one unnamed species) and Mysidae (all other species). Globally, this is a very large family, with ca. 870 species. Four of the six subfamilies occur in New Zealand.



Male *Neognathophausia gigas* (Lophogastrida).
From Sars 1885

As might be expected in a worldwide group inhabiting a wide diversity of habitats, endemism reflects distribution; no species of the oceanic order Lophogastrida is confined to New Zealand whereas endemism is high in species occupying coastal and littoral waters. Twelve of the 18 species (~67%) of New Zealand Mysida are endemic, including all 10 species of *Tenagomysis* (Müller 1993), but although the genus was first described from Otago (Thomson 1900) it is no longer restricted to New Zealand; five species are known from either Australian or African shores. While *Siriella denticulata* is endemic, *S. thompsoni* is cosmopolitan in its distribution, as one of a minority of epipelagic Mysidacea. The five non-endemic New Zealand Mysida are offshore species, the shallowest among them being *Euchaetomera typica*, another pelagic species, found between the surface and 380 metres. The distributions of the two unnamed species of Mysidacea are not known. Neither *Petalophthalmus* sp. from deep offshore water nor *Lophogaster* sp. in a typically oceanic genus is likely to be endemic.

Ecology and distribution

Distributional records of named New Zealand Mysidacea are, for the most part, far from comprehensive, although there are probably records of littoral species in unpublished environmental reports from various parts of the country. Apparently the only records of *Paralophogaster glaber* are those of Tattersall (1923) offshore of Cape Maria van Diemen and the Three Kings Islands in the far north. Te Papa collections indicate that *Neognathophausia ingens* is common around central New Zealand at least as far south as Banks Peninsula, *N. gigas* is present off the east coast of the North Island, and *Gnathophausia zoea* in the Bay of Plenty and on the outer Challenger Plateau west of Cook Strait. The deepest record of any of the mysidacean species found in New Zealand waters is that of *G. zoea*, at 6050 metres (Müller 1993) at a non-New Zealand locality.

The majority of mysidacean species are found on the inner shelf and in coastal and littoral areas and form an abundant component of estuary zooplankton. Many have very localised distributions and can form dense concentrations among rocks and algal beds. Ingles (1973) encountered *Tenagomysis macropsis* in high numbers in association with red algae in Pauatahanui Inlet. All 10 *Tenagomysis* species in New Zealand are coastal pelagic or littoral, and in some cases freshwater dwellers. *Tenagomysis macropsis* is widespread around New

Zealand, from Spirits Bay eastwards almost to the Chatham Islands (Tattersall 1923) and south to Foveaux Strait although the maximum recorded depth of the species is only 24 metres (Bary 1956). New Zealand's southernmost species, *T. tenuipes*, is so far known only from Foveaux Strait and east of Stewart Island (Bary 1956), and from Carnley Harbour, Auckland Islands.

New Zealand has no strictly freshwater species but *Tenagomysis chiltoni* passes through its life-cycle in at least one completely freshwater locality – Lake Oturi, near Waverley, southwestern North Island (Hodge 1964). Thomson (1900) had originally collected *T. chiltoni* from fresh and saline waters in Otago. Jones et al. (1989) confirmed that this species also frequents saline waters in the Avon-Heathcote Estuary (Christchurch) but is an upper estuarine species and was seldom found in salinities greater than 20 parts per million (ppm). Chapman and Lewis (1976) reported *T. chiltoni* and *T. novaezealandiae* as living in brackish water below the *Paratya curvirostris* (Decapoda) zone in streams. Jones et al. (1989) indicated a salinity-correlated ecological separation between *T. chiltoni* and *T. novaezealandiae* in the Avon-Heathcote Estuary with the former in upper reaches and the latter mid- to upper estuarine. In this study and that of Greenwood et al. (1985), *T. macropsis* was found throughout the estuary and had no linear correlation with salinity range along a transect from 4.1 to 30.1 ppm. In his work in Pauatahanui Inlet, Ingles (1973) found distinct differences in distributions between three species in the Horokiwi Stream – *T. macropsis* occurred in the estuary proper, entering only the mouth of the stream, *T. novaezealandiae* centred around the mouth and lower part of the stream, while *Gastrosaccus australis* was highest upstream, not moving as far as the mouth.

Tenagomysis macropsis, the most abundant species in the Avon-Heathcote Estuary, occurs in greatest numbers at salinities between 16.9 and 19.2 ppm, but it is clearly euryhaline as Bary (1956) found it in great numbers in Foveaux Strait (ca. 60,000 individuals in one plankton tow). The results from overnight surface samples in a tideway, taken during his survey of mysidaceans and euphausiids east and south of the South Island, indicated daily vertical migrations by *T. macropsis* and *T. tenuipes*. The numbers of both species at the surface (including juvenile *T. macropsis*), peaked around 2 a.m. Bary's is the only study published to date on vertical distributions of New Zealand Mysidacea.

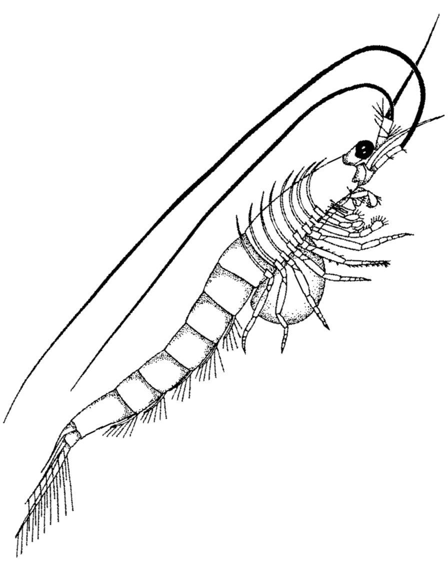
Swarming is characteristic of mysidaceans (though not as densely as euphausiids) and more complex than it may appear. Mauchline (1980) discussed possible reasons for this behaviour. Concentrations probably result when physical and chemical factors in the water make some areas more habitable than others. Salinity, food availability, light or dark, and age class are all components of swarming behaviour. Conditions change regularly in estuaries and dispersed populations can be forced to aggregate in restricted areas at low tide. Ingles's (1973) work on *T. macropsis* in Pauatahanui Inlet suggested a relationship between shoaling and the tidal cycle. Breeding aggregations also take place, probably more so in deep-water species because littoral mysidaceans regularly aggregate for other reasons but breed at the same time. Data gathered by Greenwood et al. (1985) suggested that *T. macropsis* may undertake seasonal migrations, in common with littoral mysids in other parts of the world (Mauchline 1980). Mature *T. macropsis* females move up-estuary with the rise of temperature in spring whereas Roper et al. (1983) found them closer to the estuary mouth in winter. Aggregation of females over the summer breeding season suggests that this is for breeding purposes. Swarming in currents can also lead to the segregation of age classes, which have differential swimming rates. Swarms are of all shapes from globular to elongated and can be very extensive horizontally in the water but only a few centimetres thick (Mauchline 1980).

Reproduction and development

Mysidacea do not have planktonic larvae as most euphausiids and decapods do. Instead, development of embryos and larvae takes place in the marsupium, from which they emerge as juveniles. Mating usually, if not always, involves the male using its fourth pleopods to deposit sperm in the female marsupium (Mauchline 1980) and eggs are fertilised as they are laid in the marsupium. The number and size of resulting embryos depends upon the size of the eggs and the female and on water temperature and season. Meso- and bathypelagic species tend to have larger eggs and produce somewhat fewer young than epipelagic and coastal species, relative to body size.

The embryo (developmental stage 1) grows to some extent in the egg membrane, moults into a stage 2 (eyeless) larva, and passes through a third (eyed) stage to moult into a juvenile ready to emerge from the marsupium. Juveniles grow to become adults without passing through further stages, although the abdomen increases in proportion to the cephalothorax, and the appendages and telson undergo gradual changes as well. Jones et al. (1989) found the sizes of embryos in Avon-Heathcote Estuary species to be in accord with the range generally found for coastal forms. A range of embryo numbers was also carried in the marsupia of the *Tenagomysis* species: 4–25 in *T. macropsis*, 6–19 in *T. novaezealandiae*, and 22–39 in *T. chiltoni*.

In *T. tenuipes* from Foveaux Strait, Bary (1956) found that females (up to 19.9 millimetres long) shed juveniles of 4.2 millimetres length. Those of *T. macropsis* from the same area were about 2.5 millimetres long, mature females of *T. macropsis* being less than half the length of *T. tenuipes*. Greenwood *et al.* (1985) found emerging larvae of *T. macropsis* to average only 1.47 millimetres in length in the Avon-Heathcote Estuary.



Tenagomysis chiltoni.
After Chapman & Lewis 1976

Food and predators

Dietary studies of Mysidacea are limited and none has been carried out on any New Zealand species, although Chapman and Lewis (1976) considered that *Tenagomysis chiltoni* and *T. novaezealandiae* might be detritus feeders. Chapman and Thomas (1998) subsequently reported predatory feeding in *T. chiltoni*. Mouthparts and thoracic appendages are variously modified in relation to diet. Some species are strict filter feeders, some specialise in grazing phytoplankton, and some are carnivores concentrating on certain substrata such as algae, but most are more opportunistic and eat a considerable range of the organic material in their environments. Mauchline (1980) tabulated the diets of 25 species of mainly northern hemisphere mysids. Though by no means comprehensive, his table showed the major importance of organic detritus, significantly supplemented by diatoms, other algae, copepods, and other crustaceans. Probably most New Zealand shallow-water species have similarly generalised diets, but a few specialised feeders are indicated. One of the most extreme modifications of feeding appendages is of the mandibular palp in *Petalophthalmus* species. It is greatly elongated, projecting well beyond the antennae. Carnivorous *Petalophthalmus armiger* pierces its prey and sucks out the internal contents (Mauchline 1980). *Lophogaster typicus* is incapable of filter-feeding, having mouthparts modified to feed on large lumps of food material on the surface of sediments, suggesting that New Zealand *Lophogaster* sp. could have a similar diet.

Filter-feeding is common in Mysidacea and is accomplished using setose mouthparts and thoracic appendages. The animals 'stand on their heads' above soft substrata, creating a current using the thoracic exopods and filtering particles from the stirred-up sediment. In common with euphausiids (see section on Euphausiacea), some Mysidacea employ a 'food basket', formed by the mouthparts and anterior thoracic appendages, in which food items collected using the mandibular palps are retained until they are chewed and swallowed.

Some species follow diel feeding rhythms, with certain species feeding by day, others only at night. *Gastrosaccus australis* individuals caught by Jones et al. (1989) were virtually all taken at night in the Avon-Heathcote Estuary, suggesting that they feed nocturnally instead of competing with the three *Tenagomysis* species by day.

Mysidacea are important links in the food web between primary producers (e.g. bacteria and microalgae) and secondary consumers, especially in coastal waters. They therefore play a critical role in the cycling of energy through the detrital pathway (Jones et al. 1989). Mysids especially are eaten by a very wide variety of fish and also by decapod crustaceans, seabirds, cetaceans, and other predators. Data on predation of lophogastrids is limited because they live offshore but the size and appearance of the largest species facilitates their recognition in stomach contents. Albacore tuna eat *Neognathophausia ingens*. Deep-sea hyperbenthic rattails eat mysidaceans including *N. gigas*, a species also reported in fin whale stomachs (Nemoto 1959 in Mauchline 1980) and *N. ingens* has been found in the stomachs of pigmy sperm whales stranded in New Zealand (Te Papa data). Weddell seals and gentoo penguins are known to eat the Antarctic mysid *Antarctomysis maxima* and, intriguingly, yellow-nosed albatross near Tristan da Cunha have been found with *N. ingens* and *N. zoea* in their guts (Mauchline 1980). It seems these otherwise extremely deep-living lophogastrids may undertake diel migrations near enough to the surface to be captured by albatrosses. Deep benthic and midwater prawns including *Aristaeopsis edwardsiana*, *Pasiphaea tarda*, and *Aristaeomorpha foliacea*, found in New Zealand waters, have also been found to eat mysidaceans.

Mauchline (1980) cited many studies of the diets of coastal fish that indicated the major significance of mysids as food items. He also noted that mysids tended to be underestimated as prey items because their remains were often mistaken for euphausiids. Little information on mysidaceans in the diets of New Zealand fish is apparent, although Griffiths (1976) reported that introduced European perch in the Selwyn River (Canterbury) eat high numbers of *T. novaezealandiae*. Estuaries such as Avon-Heathcote and Pauatahanui are important as fish nurseries and there is little doubt that the mysids that concentrate there are an important part of their diets. In lakes of the Waikato district, mysids are an important part of the diet of smelt (Northcote & Chapman 1999). Along the coast, seahorses (*Hippocampus abdominalis*) ingest *Tenagomysis similis* along with amphipods and the shrimp *Hippolyte bifidirostris* (Woods 2002), all found in the subtidal kelp beds in which seahorses live.

Mysidacea employ defensive strategies to avoid being eaten, including, as in shrimps and lobsters, tail flexing. While transparent and virtually invisible when swimming, mysids have chromatophores – pigment cells – that enable them to adopt camouflage colours and blend with algae, rocks, or sand. Lophogastrids are uniformly bright red, so can avoid detection by exploiting the lack of penetration of red light in sea water, as do many meso- and bathypelagic decapods. Swarming may also confer some protection on mysidaceans by reducing the number of targets apparent to their attackers.

A wide range of ecto- and endoparasites have been reported in Mysidacea. Very common endoparasites are ellobiopsid protozoans (phylum Myzozoa) such as *Thalassomyces fasciatus*, found in *N. gigas*, *N. ingens*, and *G. zoea*. Choniostomatid copepods parasitise mysidaceans, and epicaridean isopods, particularly of the family Dajidae, are common ectoparasites. Juvenile and small male dajids live in the host's marsupium among the developing larvae.

Economic aspects

Mauchline (1980) reported that thousands of tons of *Neomysis intermedia*, *N. japonica*, and *Acanthomysis mitsukurii* are harvested each year in Japan; *N. intermedia* from brackish lakes is the most important of these and is cooked, dried and eaten. There do not appear to be any other major fisheries for Mysidacea but several species are or have been fished in South-east Asia, China, and Korea by local fishers, who net them when they swarm. Some species have been reared successfully in laboratories, and freshwater species have been successfully transferred to other rivers or lakes as food for fish. It is also possible that some Mysidacea have colonised other habitats by transferring there on ships' hulls or in ballast water.

Future work

There is clearly a need for further taxonomy followed by biological research on the Mysidacea of New Zealand before we can gain a reasonable appreciation of their diversity. Historically, New Zealand has never had the services of a mysidacean specialist but the need for such work is surely increasing given the importance of mysids in the marine economy, particularly as a major food of fish. Once Mysidacea currently held in collections are analysed, further assessment of their diversity, numbers, and roles in the region will require sampling gear and strategies appropriate to the collecting of these generally small and easily damaged animals.

The freshwater amphipod *Paracalliope fluviatilis*.
Stephen Moore

Order Amphipoda: Beach fleas, sand hoppers, and kin

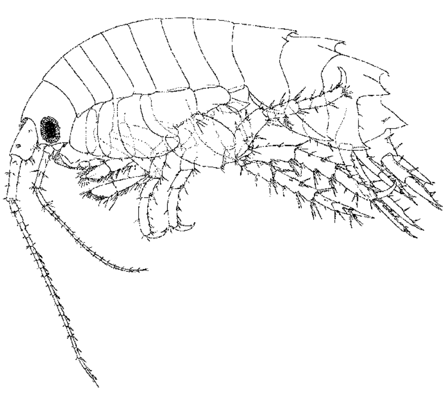
Amphipods are the among the most ubiquitous crustaceans, inhabiting diverse environments from the depths of the oceans' trenches to high altitudes on mountains, living in situations as varied as plankton in the open seas, burrowers in surf beaches, litter-dwellers on forest floors, epizoites on the skin of whales and dolphins, and cryptic inhabitants of subterranean aquifers more than 20 metres below ground level. Amphipods are likely to be found in almost all aquatic habitats, as well as on land wherever water is freely available or humidity is high. In many of these situations, species are numerous and numbers high, frequently overwhelmingly so. It is surprising, therefore, that they have received relatively little scientific attention.

The name of order is derived from two Greek words – *amphi*, both or of two kinds, alluding to the forward orientation of the anterior legs and the backward and/or lateral orientation of the posterior legs (Stebbing 1888), and *podos*, foot.

The relative neglect of amphipods as subjects for scientific study in New Zealand may be because of two related attributes – their biodiversity is bewildering and different species are often not easily distinguished by the untrained eye. The trained worker, on the other hand, finds the myriad variations on the basic morphology fascinating, continually generating questions about relationships between taxa and the selective value of the differences in morphological structures.

The basic amphipod body plan is difficult to define because of the group's diversity. Amphipods are distinguished from other peracarids (malacostracan crustaceans that brood their eggs and young) by the following combination of characteristics: body generally laterally compressed, carapace absent, eyes sessile and usually lacking cuticular facets, pereon (thorax) with seven pairs of unbranched limbs, pereopods (legs) 1–4 orientated anteriorly, pereopods 5–7 directed posteriorly, pereopods 1–2 usually modified as subchelate (grasping) gnathopods, coxal gills present on some pereopods, pleon (abdomen) segments 1–3 with multi-articulate swimming appendages (pleopods), usually biramous, pleon segments 4–6 (urosomites) with stouter, biramous uropods, the final urosomite with a distinct telson.

Some 6000 species in about 120 families are known worldwide (Barnard & Karaman 1991). Estimates suggest that several thousand species await discovery and scientific description, despite more than 100 new species being described annually, on average, during the mid-1980s. The order is divided into three suborders – Ingolfiellidea, Gammaridea, and Hyperiidea; caprellids (formerly Caprellidea) are now regarded as specialised gammarideans.



Paradexamine houtete.
From Barnard 1972a

Historical overview

Knowledge of the New Zealand amphipod fauna began with Dana's (1852, 1853–55) descriptions of a few species, but accelerated with G. M. Thomson's and Charles Chilton's work. Thomson's (1879b) first paper was followed by 14 more over the next 34 years; that of Chilton (1882a) was succeeded by 52 papers by 1926, although not all dealt with New Zealand species. Thomson and

Chilton's (1886) 'Critical list of the Crustacea' contained 71 amphipod species names: 63 gammarideans, four hyperiids, three caprellids, and one cyamid.

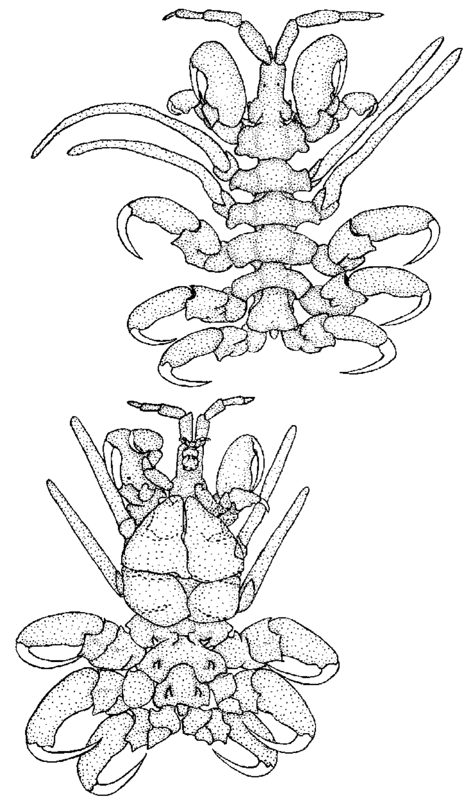
Chilton was the strongest influence on early New Zealand amphipod systematics. He himself was influenced by Della Valle's (1893) attempt to combine many of the world's Gammaridea into fewer species and he treated many New Zealand species as variants of extrinsic taxa (Barnard 1972a). This tendency was exacerbated in his later career by his acquaintance with research on phenotypic variation of amphipods at Plymouth (England). This led him to regard many New Zealand species as phenotypes of sub-cosmopolitan species (Barnard 1972a) or as variants of local species (Fenwick 2001a). Significant contributions were also made by Stebbing (1888, 1910) through his work on local collections made by the *Challenger* and *Thetis* Expeditions. Also notable are Walker's (1908) work on subantarctic material, K. H. Barnard's (1930) studies of *Terra Nova* Expedition collections from the far north of New Zealand, and Stephensen's (1927) and Nicholls's (1938) studies of subantarctic amphipods.

A new phase of New Zealand amphipod systematics began in the 1950s with D. E. Hurley's detailed papers (1954–75) on gammarideans, hyperiids, and cyamids. Several problems were resolved, new species described, and many previously described species clarified. Extensive collections from New Zealand's deep waters were made during the Danish Deep-Sea Expedition, 1950–52, on the *Galathea*. Dahl's (1959) and Barnard's (1961) reports on these collections added considerably to knowledge of our fauna. In none of the preceding investigations, however, was there any attempt to collect amphipods widely in New Zealand waters in order to gain understanding of species' distributions. This, however, was the approach followed by J. L. Barnard during his 1967–68 visit. The resulting monograph (Barnard 1972a) made a preliminary assessment of the biogeography of the New Zealand gammaridean fauna, described numerous new taxa, and provided the most comprehensive guide to date of the fauna (although its focus was algae-living amphipods). Barnard's visit and monograph stimulated much subsequent local interest in the gammaridean fauna (Cooper 1974; Cooper and Fincham 1974; Hurley and Cooper 1974; Fincham 1974, 1977; Lowry 1979, 1981; Fenwick 1976, 1977, 1983; Myers 1981; Lowry and Fenwick 1982, 1983; Moore 1983a,b, 1985; Lowry and Stoddart 1983a,b, 1984).

New Zealand freshwater amphipods were studied by Hurley (1954a, c, f) over this period, as were terrestrial amphipods (Hurley 1955a, 1957a, c). Bousfield (1964) and Duncan (1968) also investigated the terrestrial amphipods. Subsequently, Duncan (1994) substantially reviewed this group, recognising several new genera and species.

Elements of the New Zealand hyperiid fauna were reported by Stebbing (1888) and K. H. Barnard (1930). After about 1950, hyperiids and caprellids were usually investigated and reported separately from gammarideans, with Fage (1960), Shih (1969), and Hurley (1955b) exploring the fauna more fully. Much of this information is brought together in Vinogradov's (Vinogradov et al. 1996) substantial review of the world hyperiids, with Zeidler (2003a, b, 2004a, b, 2006, 2009) refining the group's systematics and adding further new records. The New Zealand caprellids were reviewed by McCain (1969) and he described one new species subsequently (McCain 1979).

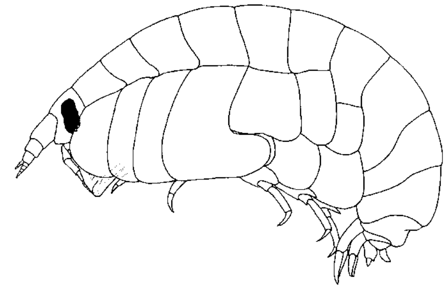
Amphipod diversity in New Zealand currently stands at 500 species, of which 64 are undetermined or undescribed.



Cyamis boopis.
From Hurley 1952

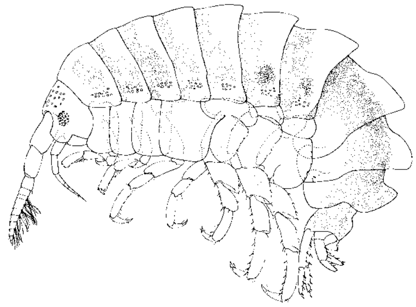
Amphipods in the ecology of New Zealand

The general abundance of amphipods means that, despite their small individual size, collectively they are important in the ecology of many ecosystems, especially as food for larger animals. Huge densities of amphipods are found among New Zealand seaweeds, in which they often dominate the associated fauna (Fenwick 1976; Taylor 1998).



Parawaldeckia angusta.
From Lowry & Stoddart 1983a

Several studies have demonstrated the importance of gammaridean and



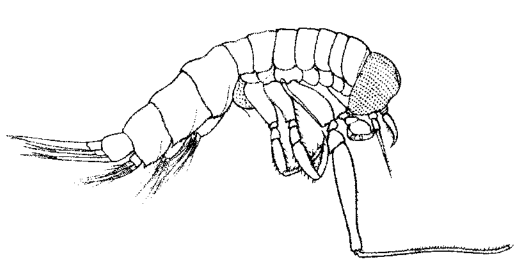
Waitomo manene.
From Barnard 1972a

hyperiid amphipods as food for fish and birds in New Zealand. Amphipods were the most frequently utilised food item among 26 species of common northern New Zealand reef fishes (Russell 1983). Indeed, Jones (1988, p. 454) considered 'the importance of gammaridean amphipods as a food source … startling' for juvenile fish. They were the principal food item for adults of several species and formed important secondary foods for the others (Russell 1983). These amphipods were mostly gammarideans and caprellids but some planktivorous fishes ate a few hyperiids. Small fish species were most dependent upon amphipods for food. Amphipods were eaten by 75–90% of specimens and comprised 40–60% of diet by volume in the various triplefin species (Russell 1983). A few large species also fed extensively on amphipods. Over half of all red moki, blue moki, trevally, goatfish, and juvenile snapper ate gammaridean amphipods, which made up 40%, 38%, 51%, 55%, and 62%, respectively, of their food by volume (Choat & Kingett 1982; Russell 1983). A similar study at Kaikoura (Duffy 1989) confirmed the importance of amphipods as food for fishes and showed their increased consumption by fishes inhabiting brown seaweeds of semi-sheltered, southern shores.

Amphipods are important food for some fishes inhabiting soft bottoms and estuaries also. Adults of nine species of fish in the Avon-Heathcote Estuary all ate amphipods, although they were a common (> 10%) food item for three species only – common sole (13%), cockabully (68%), and common bully (74%) (Webb 1973). Although amphipods were scarce in the diets of yellow-bellied and sand flounders in the estuary (Webb 1973), their juveniles fed almost exclusively (92–96% of food items) on the small tube-dwelling amphipod *Paracorophium excavatum* (Nairn 1998). Offshore, however, larger amphipods were common items (33%) in adult yellow-bellied flounders' diets (Knox & Fenwick 1978).

Fish also eat pelagic hyperiid amphipods. Warehou, banded rattails, javelin fish, black oreos, southern blue whiting, carinate rattails, small-scaled brown slickhead, and small-scaled nototheneids all include amphipods as substantial components of their diets. Many of these fishes fed extensively on amphipods when smaller (up to 37% of food weight and eaten by up to 75% of small fish), with individual fishes taking larger prey as their sizes increased (Gavrilov & Markina 1981; Clark 1985; Rosecchi et al. 1988; Clark et al. 1989). Amphipods were a minor element of the diets of several other deeper-water fishes, notably hoki, smooth oreos, smooth rattails, and orange roughy. Pelagic fishes are the usual predators of these amphipods, but benthic fishes may feed extensively on hyperiids when swarms are carried into shallow water. At The Snares, the demersal telescope fish, as well as spotties, banded wrasse, and benthic nototheneid cod, fed intensively on hyperiids (*Themisto gaudichaudi*, *Hyperietta luzoni*) and krill swarming close to the surface (Fenwick 1978).

The importance of amphipods in freshwater fishes' diets varies with species, amphipod abundance, abundance of other prey items, and fish size. Long-finned and short-finned eels, whitebait (*Galaxias maculatus*), mudfish, common smelt, and brown trout all eat small numbers of the common stream amphipod, *Paracalliope fluviatilis* (McDowall 1968; Eldon 1979; Ryan 1986; Jellyman 1989; Sagar & Glova 1995, 1998; Hicks 1997). Typically, amphipods comprise less than 5% of whitebait food, but more are eaten with increasing fish size (McDowall 1968). Amphipods are commoner in the diets of whitebait closer to estuaries than those further upstream and, in some rivers, amphipods comprise up to 45% of the diet (McDowall 1968). Similar variation in the consumption of amphipods occurs in eels. Amphipods (*Paracalliope fluviatilis* and the brackish *Paracorophium excavatum*) may be a major (70%) or minor (< 0.01%) food for short-finned eels, depending upon the specific habitat, season, and eel size, with amphipods being most important for small eels 100–190 millimetres long. Similarly, juvenile brown trout feed preferentially on amphipods, which make up 80% of food items of trout inhabiting tree-lined sections of some rivers.



Themisto gaudichaudi.
From Stebbing 1888.

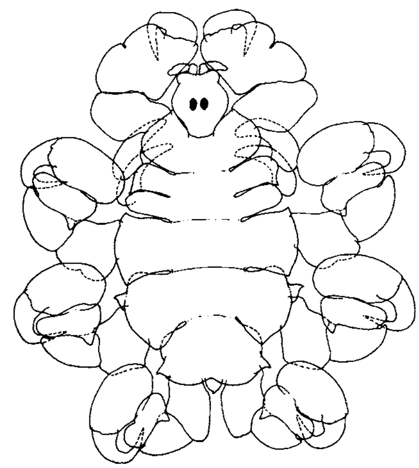
Birds also feed on marine and estuarine amphipods. A number of oceanic birds typically feed extensively on hyperiid amphipods. Red-billed gulls, cape pigeons, Buller's mollymawks, and sooty shearwaters fed on hyperiid swarms at The Snares, with the latter two diving below the surface to catch them at times (Fenwick 1978). Fairy prion chicks are fed a diet comprising 14% amphipods by weight, diving petrels consume 17% by weight of amphipods, and grey-faced storm petrels at the Chatham Islands include four species of amphipods in their diet (Prince & Morgan 1987).

Numerous other New Zealand birds eat amphipods as larger or smaller components of their diets. For example, most penguins are believed to include these crustaceans in their diets (Croxall & Lishman 1987). In North American estuaries, some migratory waders consume 10,000–22,000 corophiid amphipods per day (Wilson 1989). Related species (plovers, dotterels, and wrybills) in New Zealand probably eat appreciable quantities of amphipods. Ground-foraging, insectivorous birds (e.g. robins, fernbirds, tits, and wekas), as well as blackbirds and song thrushes, are almost certain to include land hoppers from among plant litter in their diets. In addition, gulls and other birds probably capture beach-fleas from amongst wrack at times.

Diversity of New Zealand amphipods

Ingolfiellidea

Ingolfiellids are highly specialised, mostly small (< 3 but up to 14 millimetres long), worm-like animals adapted to living interstitially in marine and freshwater sediments, as well as in groundwaters. Marine species occur from the intertidal to the deep sea. Widely regarded as very primitive amphipods, over 30 species are known from two families. They are reported from most continents, including Australia, and two species from New Zealand interstitial marine habitats (Schminke & Noodt 1968) remain undescribed.

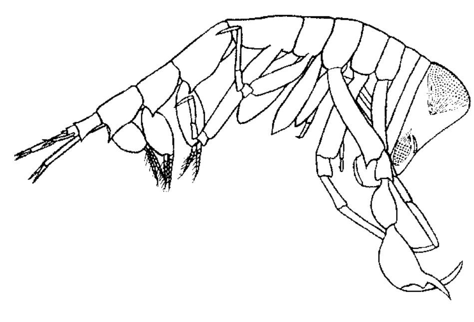


Whale louse *Scutocyamus antipodensis*.
From Lincoln & Hurley 1980

Caprellidea

In a detailed cladistic analysis, Myers and Lowry (2003) demonstrated that caprellids and cyamids are specialised corophiidean amphipods. They are discussed separately here but the end-chapter checklist follows Myers and Lowry. The Caprellidea includes two distinct families, both found worldwide – the skeleton shrimps (Caprellidae) and whale lice (Cyamidae). Whale lice live ectoparasitically on whales and dolphins, whereas caprellids are benthic and often extremely abundant among algal fronds and on bryozoans, hydroids, and sea stars intertidally and on shallow marine bottoms. Each group's body form is very different, although both possess rudimentary abdomens and vestigial abdominal limbs. Whale lice have short, flattened bodies with powerful limbs adapted to grasp their hosts' skin firmly. Caprellids have long slender bodies and their last three pairs of legs, grouped posteriorly, are modified for grasping the substratum, leaving their anterior legs and antennae free for feeding.

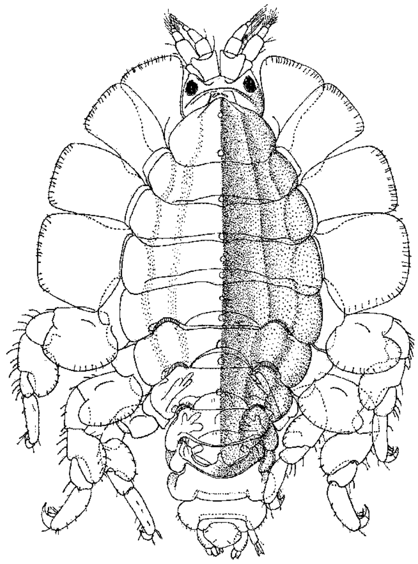
Caprellids are quite diverse, with about 85 genera worldwide (McCain & Steinberg 1970; Laubitz 1993). The New Zealand skeleton-shrimp fauna comprises just eight species in six genera, belonging to two subfamilies (McCain 1969, 1979; Guerra-García 2003). Half (four) of these species are endemic. Eight species of whale lice in four genera are known from New Zealand (Hurley 1952; Lincoln & Hurley 1980), whereas the worldwide cyamid fauna comprises 27 described species in six genera (Martin & Heyning 1999). If, however, cyamids known to occur on whale and dolphin species reported from New Zealand waters are considered, the total cyamid fauna may number some 19 species in all six known genera.



Phronima sedentaria.
From Hurley 1955b

Hyperiidea

Hyperiid amphipods are purely pelagic, living freely in the ocean or associated with other pelagic invertebrates, from the surface to abyssopelagic depths (> 7000 metres) (Vinogradov et al. 1996). Species living near the surface typically



Iphinotus typicus.
From Barnard 1972a

make diurnal vertical migrations from below 200 metres depth to spend the hours of darkness within the surface 50 metres.

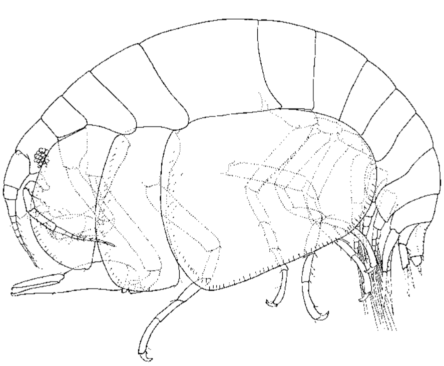
A great variety of body shapes occurs within the hyperiids, making them extremely difficult to characterise. Large eyes and/or an inflated head and variously reduced first thoracic segments or pleon and urosome are common (e.g. Hyperiidae), although the opposite is true in others (e.g. Scinidae). The very compact forms of many surface dwellers (e.g. Platyscelidae) contrast with the needle-like shapes of *Rhabdosoma* species. Lengths also vary widely from 2.5 millimetres (e.g. *Hyperietta luzoni*) to over 150 millimetres for the extremely elongate *Rhabdosoma armatum*.

Some hyperiids live on and within one or a few species of jellyfish, siphonophores, and ctenophores. The relationship between host and amphipod seems uncertain, but the consistent pairings of some species (e.g. *Hyperia macrocephala* is found only on the jellyfish *Desmonema gaudichaudi*) indicate commensalism. Host tissues and other prey items in the guts of these amphipods suggest that the amphipods behave opportunistically, with no obvious advantage to the host. Species of the family Phronimidae apparently eat the viscera of pelagic tunicates, siphonophores, and heteropods and use the prey's transparent covers as a refuge against predators and for rearing their eggs.

Over 240 species of hyperiid in more than 72 genera and 23 families are known from the world's oceans. It is difficult to characterise the New Zealand fauna because of the hyperiid pelagic habitat. Many hyperiids have very wide distributions (Vinogradov et al. 1996), so it seems inevitable that most widely distributed species will be found in local waters eventually (Zeidler 1992), depending upon movements of the specific water masses with which they tend to be associated (Young & Anderson 1987). Thus, New Zealand's hyperiid fauna probably exceeds the reported 94 species in 49 genera reported from our surrounding seas (Hurley 1955b; Kane 1962; Vinogradov et al. 1996; Zeidler (2003a, b, 2004a, b, 2006, 2009) and a total fauna in excess of 100 species seems probable.

Gammaridea

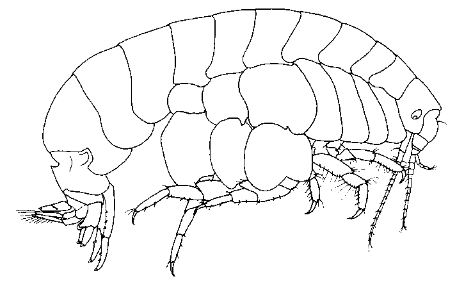
The Gammaridea is the most abundant, ubiquitous, and diverse of the amphipod suborders. More than 5800 species in about 1100 genera are known, some from hadal depths exceeding 10,000 metres (Dahl 1959) and others higher than 4000 m above sea level (Stebbing 1888). Gammarideans range in length from about 2–3 millimetres to a whopping 340 millimetres for the abyssal *Alicella gigantea* (Barnard & Ingram 1986). Large size appears to be associated with higher dissolved-oxygen concentrations in cold-water habitats, and warm-water faunas are dominated by very small species. These amphipods also seem most abundant and diverse in temperate to cool climates, with tropical faunas being relatively inconspicuous, although surprisingly diverse (Thomas 1993). Gammarideans are often referred to as the laterally compressed amphipods. Land-hoppers, beach-fleas, and many aquatic amphipods certainly have the typical shape. However, several tube-dwelling and nestling genera have elongated, more vermiform, shapes. Burrowers in surf beaches (urothoids and some phoxocephalids) are wide-bodied, presumably for stability in high-energy habitats. *Iphinotus typicus* is even more flattened. Its limpet-like shape adapts it for life on the fronds of smooth brown seaweeds on New Zealand's turbulent rocky shores.



Raukumara rongo.
From Barnard 1972a

Marine and freshwater gammarideans are predominantly free-living and benthic. A few are planktonic and others form close associations with algae, hydroids, bryozoans, and a variety of other invertebrates. Members of some families build tubes, nests, or columns from strands of material secreted from glands in their anterior legs, variously incorporating mud, sand, shell, bryozoan fragments, and other particles from their habitats. Species of yet other families characteristically burrow in soft sediments, at times burrowing to more than 200 millimetres beneath the sediment surface. Scavenging, detritivory, and omnivory are the predominant feeding habits, but predation, ectoparasitism on fish, and herbivory also are known (Bousfield 1987; Enequist 1949; Lowry & Stoddart 1983b; Sainte-Marie & Lamarche 1985; Haggitt 1999).

The New Zealand gammaridean fauna (including caprellids and cyamids) comprises 401 species (62 undescribed) in 192 genera (10 unnamed), belonging to 55 families. [Figures below indicate that New Zealand's total gammaridean amphipod diversity is probably 3–4 times geater than the total reported here.] This equates to about 5.6% of the world's described species and 15.8% of world genera, representing over a third of all families. Some 74% of the species (296) are endemic, as are ~29% (55) of the genera. The fauna inhabiting each of three major habitats in New Zealand is discussed separately below.



Paracentromedon? whero.
From Fenwick 1983

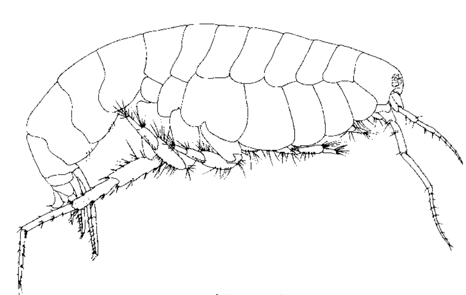
Terrestrial amphipods
All terrestrial species belong to the Talitridae, the only amphipod family to have successfully occupied terrestrial habitats worldwide. These amphipods inhabit gardens, forest floors, and grasslands, where they live in litter, under trees and rocks, or in burrows that they construct themselves. Some 36 species in 10 genera occur in New Zealand (Duncan 1994; Fenwick & Webber 2008). Beach fleas are usually considered with terrestrial species, and 11 species in three genera are known from shore environments, although their revision seems overdue. Most New Zealand talitrids are endemics, but there are at least three aliens. New Zealand species range in length from c. 5–6 to > 50 millimetres for the giant subantarctic *Notorchestia aucklandiae*. Land hoppers and beach fleas occur throughout New Zealand, including the subantarctic islands, from sea level to over 2000 metres.

Freshwater amphipods
Some 53 species (~30 undescribed) in nine named (and 10 additional unnamed new) genera belonging to eight families are reported from freshwater habitats in New Zealand (Fenwick 2001a,b). Several undescribed species from hypogean water (saturated sediments beneath or beside streams and rivers (hyporheic) and groundwater) are currently under investigation and others from epigean (surface) waters await description (Fenwick 2000). Within these habitats, amphipods are often surprisingly abundant, but have received little attention. This relative neglect probably reflects their small adult sizes (3–6 millimetres body length), although two hypogean species (*Phreatogammarus fragilis* and *Ringanui toonuiiti*) grow to over 20 millimetres long. All New Zealand freshwater species, five named genera, ca. 10 unnamed genera, and three families are endemic.

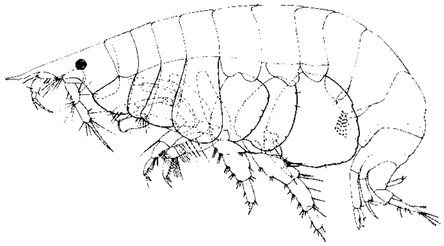
Marine and estuarine amphipods
The New Zealand marine and estuarine amphipod fauna comprises some 365 species. Amphipods inhabit every conceivable habitat in the sea, although few species live in estuaries. They are predominantly benthic, living in and on mud and sand and rocky bottoms, as well as among other invertebrates and algae. The total diversity of the New Zealand marine amphipod fauna is difficult to estimate, but is likely to comprise at least three times the presently known species. Of the known marine fauna, 194 species (~53%) and 35 genera (19%) are endemic.

Special features of the New Zealand gammaridean fauna

Biodiversity and abundance
Amphipods are frequently a major component of marine benthos, especially in cool-temperate to cold-water environments. New Zealand is no exception in this respect. A study of animals inhabiting the green alga *Caulerpa brownii* at



Patuki roperi.
From Fenwick 1983



Ringaringa littoralis.
From Cooper & Fincham 1974

Kaikoura on the South Island east coast revealed a fauna dominated by huge numbers of amphipods – up to 12,000 per 200 grams wet weight (handful) of alga (Fenwick 1976). Some 61 species occurred in this specific habitat. Amphipod abundance increased dramatically with increased exposure to wave action, but fewer species predominated. Thus, the fauna at more sheltered sites comprised lower densities, with more species having more equal abundances.

Shallow sand bottoms at Kaikoura illustrate amphipod abundance in another near-shore habitat. Four species of amphipods and a large myodocopid ostracod comprise most of the fauna in this habitat. Amphipod densities average about 6000 per square metre, fluctuating from a winter low of 4000 to a summer high of more than 12,000 per square metre (Fenwick 1985). Crowding of these crustaceans is reduced by each species occupying a different depth in the sediment (Fenwick 1984) – cryptically coloured, surface-skipping *Patuki roperi* lives in the top 25 millimetres of sand, smaller white *Ringaringa littoralis* dwells at about 40 millimetres depth, bright red *Paracentromedon*? *whero* inhabits mid-depths (50–80 millimetres), and large *Protophoxus australis* overlaps at mostly 65–85 millimetres. *Leuroleberis zealandica*, a very large ostracod, is most abundant at 75–100 millimetres depth. Species' mean depths in the sediment change slightly between sand ripples (150–200 millimetres high) and troughs, as well as with season.

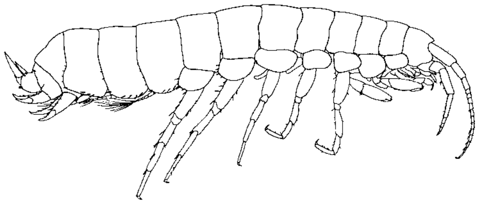
Amphipods are a significant component of surf-zone faunas on New Zealand's exposed beaches, such as in Pegasus Bay (Fenwick 1999). These small, frail-appearing crustaceans not only survive in these highly turbulent situations, but some species are found nowhere else. Amphipod densities peak just outside the zone of wave break, at about six metres depth in Pegasus Bay. Biodiversity of the amphipod fauna changes markedly with depth and, hence, changes in wave-induced turbulence, with most species abundant in only one depth zone. All but one of the abundant inshore (3–10 metres depth) species are free-living active burrowers of the family Phoxocephalidae.

These three studies demonstrate some key aspects of marine amphipod biodiversity. Perhaps most significantly, amphipods are a very important component of faunas inhabiting many of the shallow marine habitats around New Zealand. Not only are amphipods abundant in many of these habitats, but also their biodiversity is high. Individual species of amphipods are very sensitive to small changes or variations in their environments, resulting in marked changes in faunas within and between habitats. Species within some families exhibit very different tolerances of environmental factors, indicating that species or genus may be more useful levels of taxonomic resolution for amphipods in ecological investigations.

New Zealand Phoxocephalidae

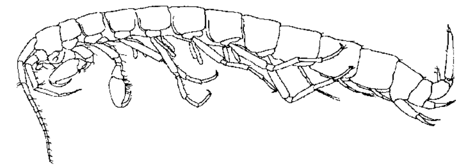
Phoxocephalids are the typical amphipods of the surf beaches and sandy shores that make up so much of New Zealand's coastline. Fifteen (88%) of the 17 phoxocephalid species known from New Zealand are endemic. Eight (53%) of the 15 genera to which these species belong are endemic and monospecific. This generic diversity and endemism is remarkably high. Museum collections indicate that the fauna includes 15 or more undescribed species, indicating over 30 species of phoxocephalids in New Zealand.

The Australian shallow-water phoxocephalid fauna consists of 89 species in 26 genera (comprising 40% of the known phoxocephalid species worldwide), with 23 of these genera endemic (Barnard & Drummond 1978; Barnard & Karaman 1983). Despite the high biodiversities of both the Australian and the New Zealand phoxocephalid faunas, there is little overlap between the two. Only one shallow-water genus (*Booranus*?) seems to be shared between New Zealand and Australia, although three deep-water genera (*Cephaloxoides*, *Harpiniopsis*, *Protophoxus*) and two of their species are found on both sides of the Tasman Sea.



Paracrangonyx compactus.
From Fenwick 2001

Australia is regarded as the epicentre of phoxocephalid evolution because of high diversity of species and genera and high generic endemism (Barnard & Karaman 1983). The subantarctic islands of South America are the only other centre of phoxocephalid radiation, with distinctive attributes present among its species and genera. New Zealand's location between Australia and South America indicates that the New Zealand phoxocephalid fauna is likely to be both diverse and of special biogeographic interest.



Paracrangonyx winterbourni.
From Fenwick 2001

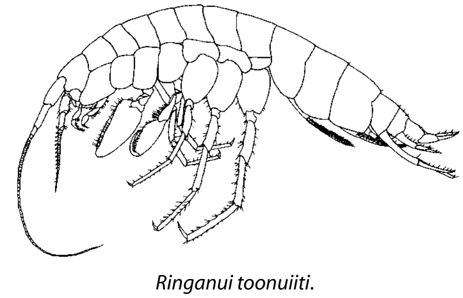
Groundwater amphipods
Late in the 19th century the biological world was intrigued by Chilton's (1882a,b, 1884, 1894) reports of crustaceans living within aquifers of the Canterbury Plains. Following this initial work, the groundwater received scant attention. Subsequent workers, including Chilton himself (e.g. 1912, 1924), apparently assumed no additional species, assigning specimens to known taxa without critical examination.

During the 1970s Guillermo Kuschel of the former DSIR surveyed groundwater faunas by pumping wells throughout the country. Ten new gastropod mollusc, 71 mite, and two water-beetle species were described from these collections (Scarsbrook et al. 2003). The several amphipods from Kuschel's collections await full investigation, but preliminary work (Fenwick 2000) revealed several new taxa. Current collecting effort indicates the existence of a further 20–30 species of groundwater amphipods.

The described hypogean (groundwater) amphipod fauna of New Zealand comprises four species in three endemic genera (two of which have epigean representatives) each belonging to quite different families. Two of the hypogean families are endemic. Given the number of species, this fauna seems remarkably diverse at generic and familial levels. Preliminary work indicates that the New Zealand hypogean amphipod fauna appears dominated by paraleptamphopids and is very different to that of Australia, where hadzioids and crangonyctioids predominate (Bradbury & Williams 1997). Taxonomic work on these collections is required to determine the true diversity, to determine relationships with the Australian freshwater amphipod fauna, and to make the fauna accessible to ecologists.

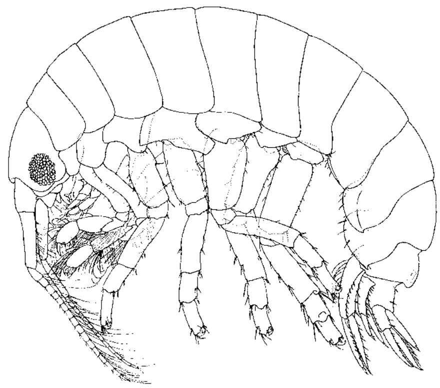
Should we be surprised by a high diversity of groundwater amphipods in New Zealand? Groundwater volumes in New Zealand are huge and probably several times greater than volumes within surface waters (lakes and rivers). For example, the groundwater of the Golden Bay region is estimated to approximate the volume of water in Lake Taupo. There are extensive aquifers beneath most of the Canterbury Plains to depths of 350–550 metres. This is not simply all water, but variably porous gravels with water moving through interstices. Obviously, there is a huge volume of water beneath the plains. Other parts of the country also comprise large plains of porous alluvial gravels (e.g. Waimea Plains around Nelson, the Heretaunga Plains of Hawke's Bay) containing extensive aquifer systems. Given the very large habitable volumes available and the apparent barriers to dispersion between each groundwater system, a high amphipod biodiversity should not be unexpected.

Investigations at one site in Canterbury indicate that groundwater amphipods help to maintain the quality of Canterbury's groundwater (Fenwick et al. 2004). The three known amphipod species, as well as a large subterranean isopod (*Phreatoicus typicus*), congregate at sites of organic enrichment from sewage-oxidation-pond effluent. A series of field and laboratory experiments showed that these animals browse on non-living organic slime layers from sediment and stone surfaces (Fenwick 1987). Extrapolation of experimental results using conservative estimates of crustacean densities indicates that the two dominant amphipods remove large amounts of organic carbon annually in the vicinity of the disposal area.



Ringanui toonuiiti.
From Fenwick 2006

Further understanding of the biology of these valuable groundwater systems depends on documenting and monitoring their biodiversity to facilitate



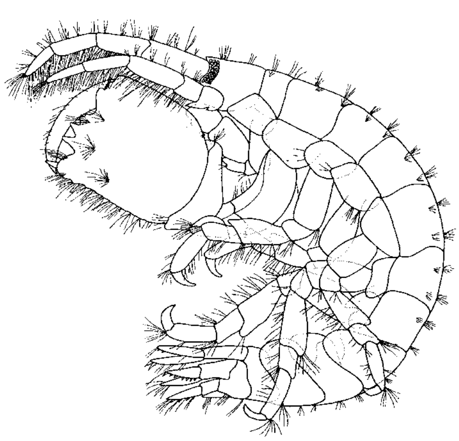
Polycheria obtusa.
From Barnard 1972a

ecological studies for improved policy formulation and management decision-making. Fundamental to this is better taxonomic knowledge of the fauna.

Biogeography of the freshwater fauna
Some New Zealand freshwater amphipods have attracted considerable interest from workers seeking to untangle phylogenies and relationships between faunules of Gondwana and other landmasses. Two endemic genera are of special interest. *Phreatogammarus* was seen as 'an amazing antiboreal morphological counterpart of the Holarctic crangonyctids' (Barnard & Barnard 1983, p. 51), a group now largely confined to North America. This genus was considered to be 'perhaps the most primitive [living] gammarid' (*ibid*., p. 420) that is 'now a perfect relict' (Barnard & Barnard 1982, p. 264). The absence of any significant amphipod fossils increases the significance of *Phreatogammarus* to evolutionary biologists. The morphologies of both *Phreatogammarus* and *Paraleptamphopus*, a modern derivative from a *Phreatogammarus*-like ancestor (Barnard & Barnard 1983), are incompletely known. Thus it is difficult to establish the relationships of these two genera with other genera.

Other New Zealand freshwater amphipod genera are also distinctive and have intriguing faunal relationships. *Paracalliope*, a genus with three New Zealand species and Australian, Philippine, New Caledonian, and Fijian representatives, is calliopiid-like, but sufficiently distinctive to justify placement in a separate family, the Paracalliopiidae, which has one other genus (Barnard & Karaman 1982, 1991). The endemic genus *Chiltonia*, together with the closely related *Afrochiltonia*, *Austrochiltonia*, and *Phreatochiltonia*, comprise the subfamily Chiltoniinae from New Zealand, Australia, and South Africa (Barnard 1972b). Yet another endemic genus poses biogeographic and phylogenetic problems. Bousfield (1977) moved the genus *Paracrangonyx* into his superfamily Bogidielloidea, re-assigned it to the Crangonyctoidea (Bousfield 1978), thence (Bousfield 1982, 1983), along with three other disparate genera, to the family Paracrangonyctidae within his superfamily Liljeborgioidea. Barnard & Barnard (1983, p. 52) placed *Paracrangonyx* among the bogidiellid gammaroids 'for the moment'. Following careful analysis, Koenemann and Holsinger (1999) found the genus to be most closely related to three genera from each of Western Australia, Madeira, and East Africa. After reviewing these placements and rediagnosing the genus, Fenwick (2001b) concluded that the relationship of *Paracrangonyx* to other genera remains uncertain, but that it belongs within the crangonycoid cluster and is close to the Paramelitidae, as well as showing relationships to other genera of Australian hypogean amphipods.

Many of these taxa have not been re-examined since their first collection. The original specimens of some species are in very poor condition and the illustrations and descriptions of some are inadequate. Consequently, many older taxa must be revised before descriptions of new taxa can take place.

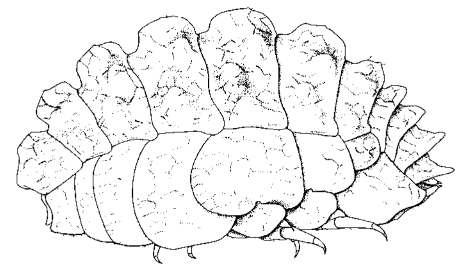


Rakiroa rima.
From Lowry & Fenwick 1982

Special associations
The ecology of New Zealand amphipods is generally poorly known and few associations with other invertebrates are reported. Gammaridean amphipod associations with other crustaceans, ascidians, sponges, hydroids, echinoids, molluscs, and other organisms elsewhere are well documented (e.g. Vader 1978, 1984, 1996) and some New Zealand amphipods probably live in similar associations.

The corophioid amphipod *Pagurisaea schembrii* occurs only on the hermit crab *Paguristes pilosus*, where up to 50 at a time live among the dense setae on the host's chelipeds, walking legs, and carapace (Moore 1983a). The amphipods apparently do not steal their host's food but use their specially modified antennae to capture food particles from the host's respiratory current whilst sheltering within the host's setae and shell.

Some amphipods are found almost exclusively on algae, but the nature of the relationships between amphipods and the algae is uncertain. Many species are found on more than one species of alga, as well as on foliose invertebrates (hydroids, bryozoans). This suggests that many amphipods use their hosts more as a substratum than as a partner in some interdependent association. Species of the tube-building genus *Notopoma* found at Kaikoura illustrate this apparently non-obligate relationship. *Notopoma fallohidea* lives only on the green alga *Caulerpa brownii* at relatively sheltered sites (Lowry 1981). One of its congeners, *N. harfoota*, is extremely abundant on the same alga in more severe wave action, but lives on other algae also. A third Kaikoura species, *N. stoora*, is most abundant on the foliose bryozoan *Costaticella solida*, although a few occur on *Caulerpa*.



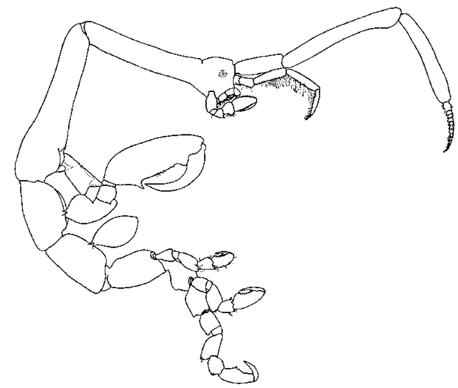
Ocosingo fenwicki (anterior at left, head hidden by large lateral coxae).
from Lowry & Stoddart 1984

Another New Zealand amphipod, *Orchomenella aahu*, bores into stipes of the kelp *Ecklonia radiata* to eat up to 22 milligrams per day of the more palatable (low phenolic content) internal tissues (Haggitt 1999). These amphipods remain within the stipe, reproducing several times. Whole families of as many as 300 individuals, comprising several generations, live within most infected plants. This association seems opportunistic because *O. aahu* is also an active scavenger of animal tissue (Lowry & Stoddart 1983b).

The large subantarctic amphipod *Rakiroa rima* appears to live only within empty sponge-covered shells of a large barnacle (*Megabalanus campbelli*) (Lowry & Fenwick 1982). Similarly, some cryptic species such as *Acontiostoma tuberculata*, *Ocosingo fenwicki*, and *Stomacontion* spp. are known only from among collections of subtidal encrusting sponges (Lowry & Stoddart 1983b). It is uncertain whether these are commensal associations or whether the conditions sought by the amphipods are found coincidentally in close proximity to these other organisms. Some have, however, evolved specialised morphological and reproductive adaptations to their inquilinous life-styles. For example, species of *Ocosingo* and *Stomacontion* have specialised piercing mouthparts (Lowry & Stoddart 1984). *Acontiostoma* and some *Stomacontion* species undergo a sex change to ease the problems of finding a mate; small sexually mature males change into reproductive females as they grow larger (Lowry & Stoddart 1983b, 1984, 1986).

The place of some amphipods in various food-webs makes them ideal intermediate hosts for parasites. The common freshwater amphipod *Paracalliope fluviatilis* is the intermediate host for a parasitic nematode (*Hedruris spinigera*) commonly found in long-finned and short-finned eels, smelt, brown mudfish (Hine 1978, 1980; Jellyman 1989), and whitebait (McDowall 1968). Infection rates of the nematode in these fishes (up to 38% for short-finned and 70% for long-finned eels) are often directly related to abundances of the amphipod and the incidence of *Paracalliope fluviatilis* or smelt in the fishes' diets (McDowall 1968; Hine 1978). This amphipod is also the intermediate host for three additional parasites of freshwater fishes – *Acanthocephalus galaxii*, *Coitocaecum anaspides*, and at least one species of hymenolepid cystocercoid (Hine 1978). Similar amphipod–parasite relationships are almost certain to occur among marine species.

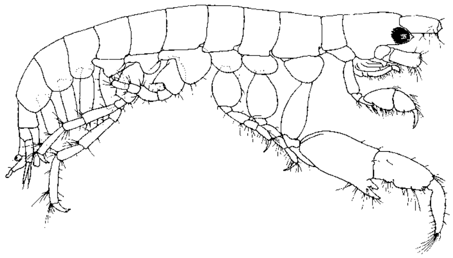
These observations show some of the diverse relationships between amphipods and other organisms. Other relationships, notably those between widely distributed hyperiid amphipods and various other planktonic invertebrates (salps, tunicates, medusae), plus those between cyamids and their cetacean hosts, are not considered. Numerous other relationships between New Zealand caprellid and gammaridean amphipods and various parasites, other invertebrates, and algae are likely to be described in the future.



Caprella equilibra.
From McCain 1968

Alien species

Relatively few invasive amphipods (11 species) have been reported in New Zealand. Among the hyperiids, the potential for a species to invade seems extremely low; ships' ballast water seems the only feasible vector, but the likelihood of hyperiids surviving within ballast water for any appreciable time seems remote. Certainly, exotic species may arrive fortuitously as ephemeral



Ericthonius pugnax (antennae broken).
From Just 2009

transients within water masses not normally entering our region. Such arrivals seem destined to disappear when their water masses are displaced by the more usual regime.

One New Zealand caprellid, *Caprella mutica*, is a very recent invader (Willis et al. 2009), another species (*Caprella equilibra*) is cosmopolitan, and a third (*Caprellina longicollis*) is widespread in southern waters (McCain 1969, 1979). Caprellids' usual association with sessile fouling invertebrates at sites of high water movement suggests that the latter two caprellids could arrive on the fouled hulls of ships and, thus, may be invaders. Equally, several additional cyamids may be found in New Zealand in the future. Whale hosts of several more species are known from New Zealand waters, but these small, apparently rare, amphipods are collected infrequently.

One land hopper, *Arcitalitrus sylvaticus*, has been imported from Australia. It is established in urban and disturbed habitats of northern New Zealand, displacing native land hoppers to become the principal land hopper in domestic gardens in Wellington and Auckland (Duncan 1994). The species has failed to become established in Christchurch, despite at least two separate introductions via potted plants.

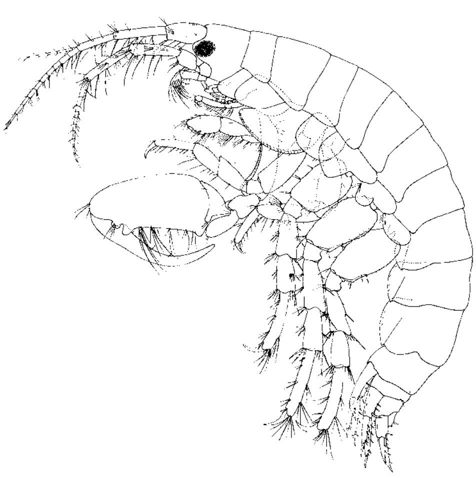
There is no evidence of any exotic amphipods invading New Zealand's fresh waters. A few gammarideans have been introduced to harbours, however, via ships. Two corophioids, *Monocorophium acherusicum* and *Apocorophium acutum*, are cosmopolitan and 'trace out some of the major shipping routes, particularly that from England through the Mediterranean and Suez Canal to South Africa' (Hurley 1954f), indicating that both are invaders. *Ericthonius pugnax*, another tube-building corophioid, is probably another invader because, although its distribution is less readily explained (New Zealand and Indonesia), the species was not discovered in New Zealand until 1923, some 70 years after its original description.

Two additional corophioids have been reported as invaders in New Zealand. *Paracorophium brisbanensis* and an unidentified species of *Corophium* were found in brackish waters of the upper reaches of Tauranga Harbour. Both were regarded as adventives because neither was reported from New Zealand previously, they were not found at any of 92 similar sites surveyed around the country, both Tauranga populations had 'remarkably limited genetic variability', and juveniles dominated their population structures (Stevens et al. 2002).

Another notable alien amphipod, distributed nearly globally, is the wood-boring *Chelura terebrans*. First found in New Zealand in Auckland Harbour (Chilton 1919), this small amphipod bores into most human-made wooden structures around the world (Barnard 1955). *Chelura*, along with *Limnoria* isopods and boring molluscs (*Teredo* species), wreaks havoc on wharf piles, rapidly boring into the timber and weakening any wooden structures. Apart from Chilton's (1919) original records, there appear to be no other reports of this species from New Zealand, although it is certain to be more widespread.

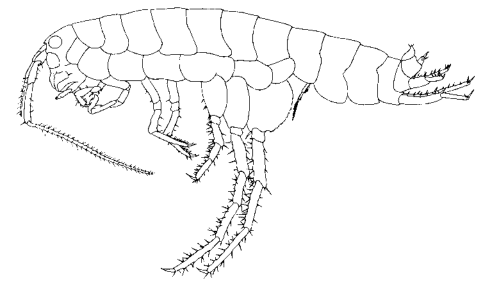
Three additional aliens were found in the sea chest (a large recess in a ship's hull for seawater intake pipes) of a vessel from the tropical Pacific that was slipped at Nelson in September 1999. These were *Stenothoe gallensis* and *Elasmopus rapax*, two known tropicopolitan species, and an unidentified species belonging to the cosmopolitan genus *Podocerus*. The first two species were abundant and included mature males, gravid females, and juveniles. There is no information on whether any of these species has become established in Nelson or elsewhere in New Zealand, despite repeat surveys.

In general, it seems extremely difficult to determine whether marine species with wide distributions are invaders (become established on new shores through dispersal by human activities) or simply arrived by natural dispersal. Several other New Zealand species have variably wide extrinsic distributions, but the ecologies of only a few seem likely to equip them for dispersal on the hulls of ships. Tube-builders and nestlers, especially corophioids, are the most likely candidates. For



Gammaropsis typica.
From Barnard 1972a

example, *Gammaropsis crassipes* was described from shallow bays and harbours in eastern Australia in 1881 but not reported from New Zealand until 1920, suggesting possible introduction. Recent invasions by algae, as well as long-term climatic changes, suggest that the potential for permanent establishment by amphipod invaders will increase in the future.



Puhuruhuru aotearoa.
From Fenwick & Webber 2008

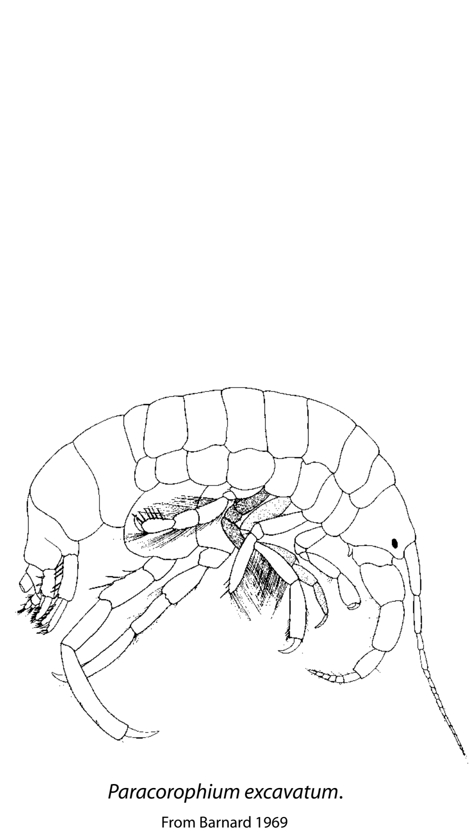
Monocorophium sextonae was considered to be a successful New Zealand invader of European shores (Hurley 1954f), although this has recently been questioned (Costello 1993; Bousfield & Hoover 1997). First described from Plymouth and Wembury in 1937, this amphipod was present, albeit unrecognised, in Chilton's (1921) material (Hurley 1954f). Crawford (1937) remarked that the 'abundance of this species is the more surprising since it is not present in the rich collections of *Corophium* made from the same dredging grounds in 1895–1911. It seems possible, therefore, that it is not indigenous at Plymouth … I cannot guess its original locality'. In revising these species of the family Corophiidae, Bousfield and Hoover (1997) considered that *M. sextonae* 'is almost certainly endemic to the eastern North Atlantic and Mediterranean regions, from whence it has been spread by commerce to world-wide temperate marine waters'.

Amphipods in environmental investigations

Diverse approaches are used to assess and manage human impacts on the aesthetic and life-sustaining qualities of natural environments. Use of plants and animals as bioindicators is increasingly common because of the sensitivities and broad-spectrum responses of some species. Amphipods are ideal bioindicators for shallow marine environments (Conradi et al. 1997) because they are ecologically (trophically) important, tend to be numerically dominant within many habitats, have specific niche requirements, have generally low mobility and dispersive capabilities, and are known to be sensitive to several pollutants and toxicants. Indeed, Thomas (1993) reported that '[a]mphipods are so useful as bioindicators that U.S. Government agencies now require their identification to species in permitting operations such as oil leases and outfalls.' In addition, individual species of amphipods may serve as very useful assays for pollutants (Lamberson et al. 1992). Several US agencies employ amphipods in bioassays to test toxicities and specific contaminant levels independent of chemical analyses and environmental surveys, particularly for marine environments.

Many of New Zealand's estuarine and marine amphipods fulfil all of Thomas's (1993) criteria for effective biomonitors (e.g. Fenwick 1976, 1985; Hickey & Martin 1995; Nipper & Roper 1995; Nipper et al. 1998). This is also true for some terrestrial (e.g. Rainbow et al. 1993) and freshwater species (Hunt 1974). Environmental survey research in New Zealand, however, continues to look at the total fauna and these investigations follow a trend of identifying and enumerating taxa to family level only (Somerfield & Clarke 1995) in attempts to reduce costs by minimising the taxonomic expertise and time required for identifications. Some workers (Thomas 1993; Conradi *et al*. 1997) advocated focusing on the amphipods alone in surveys of shallow marine environments and, certainly, their identification to species seems worthwhile in such surveys. There has been no specific examination of the merits of using amphipods alone for such surveys in New Zealand, and identification tools and knowledge of the group are inadequately developed for this to become a viable, standard approach in the short term.

New Zealand estuarine amphipods (*Paracorophium excavatum*, *P. lucasi*) have been used in bioassays of sediment contamination and toxicity (Nipper & Roper 1995). Additional studies (Nipper et al. 1998; De Witt et al. 1999) revealed the robustness of this assay approach, which is now used extensively. Only recently, however, has the taxonomy of these two species been resolved (Chapman et al. 2002), illustrating that taxonomic knowledge of New Zealand's amphipod fauna is often inadequate for reliable ecological applications.



Paracorophium excavatum.
From Barnard 1969

Gaps in knowledge and future research

New Zealand's amphipod fauna is important ecologically on land, in fresh waters (especially groundwaters), and in marine habitats where species fill vital roles in food-webs and often provide appreciable direct or indirect economic benefits. Amphipods also offer considerable potential as bioindicators of environmental quality in many habitats. Obviously, the potential for ecological and environmental research using amphipods is huge, even when only the more urgent or applied issues are considered. Equally, the scope for academic investigation of amphipods is enormous.

Despite all this, their systematics is very incomplete, hindering attempts to work with the group. Certainly, the land-hoppers appear well known as a result of Duncan's (1994) work, but the beach fleas require equivalent treatment. Freshwater amphipods require urgent attention in view of our scant knowledge of this group and the huge environmental pressures on fresh waters. Known species require extensive redescription and revision to facilitate work on the >50 new taxa in collections. Several other new species exist in other freshwater habitats that await collecting.

The marine gammaridean amphipods of shallow and continental-shelf waters comprise another substantial gap. Collecting has been sparse and the fauna at no one location is well known. Even the distribution of the algal-dwelling species along New Zealand is poorly known, despite Barnard's (1972a) work. Amphipod faunas of shallow soft seafloors are very poorly known. A study in Pegasus Bay showed that 28% of species in the 4–10-metre depth zone are undescribed (Fenwick 1999). Similarly, less than 30% of the 98 species in a series of collections off Kaikoura are known and the unknown ones include several new genera. Also, just 24% (10 of 42 species identified by a leading taxonomist) of amphipods in another study of New Zealand shelf benthos were known to science (Probert & Grove 1998).

Amphipod research in New Zealand thus offers considerable scope for both economically important issues and questions of more academic interest. However, the present status of the group's taxonomy hinders the successful development of this work, as well as discouraging many ecologists from using amphipods as ideal subjects for environmental and ecological investigations. The future, therefore, requires not just more taxonomy, but also the development of interactive guides and keys to overcome these barriers and make the local fauna accessible to non-specialists. This is particularly true for hypogean and other freshwater amphipods, given their role in maintaining the quality of groundwaters and the urgent need for effective management of this economically important resource in the face of increasing demands and human-induced threats.

Fish micropredator
Aega monophthalma (Cymothoida).
From Bruce 2009

Order Isopoda: Slaters, fish lice, and kin

The most diverse range of body plans of all the nine peracaridan orders, if not of all crustacean orders, is shown by the Isopoda, named, however, for the relative sameness of limbs (Greek *isos*, equal, like; *podos*, foot).

Only one of the isopod suborders, Oniscidea, is familiar to most people. The oniscideans are commonly called woodlice, slaters, pillbugs, or roly-polies. However, the order is predominantly marine, being less well-represented in estuarine and fresh waters. There are fewer common names for the marine groups but sea-lice, fish doctors, tongue-biters, and sea-centipedes are applied to some families. No common name, except isopod, applies to all members of the order.

Life-styles vary. Free-living predators, marine filter-feeders, scavengers in forest leaf-litter and on the sea floor, and various parasitic forms are represented in the order. The isopods have succeeded in two unusual habitats besides the shallow marine environments where most crustaceans are typically found. One is the land, where woodlice, slaters, and phreatoicideans are most often the sole crustacean representatives in some habitats, and the other is the deep sea, where the suborder Asellota has radiated into a variety of bizarre forms.

Although they are often said to be 'dorsoventrally flattened' while their close relatives the amphipods are 'laterally flattened,' there are many exceptions; some are cylindrical, others laterally compressed, and others extraordinarily ornamented. The smallest isopod adults are c. 1 millimetre long, many are in the range 4–12 millimetres, and the largest are deep-sea scavengers of the genus *Bathynomus*, growing to an astonishing 400 millimetres!

The only sure way to tell an isopod from an amphipod is that isopods lack strongly chelate first legs and have only one pair of uropods (tail appendages) and a free second thoracic segment. Character interpretation can be difficult, however, because uropods vary considerably. They may be flat limbs that lie in the same plane as the pleotelson, or enclose the pleopodal gills, or have any of several other forms. Technically, Isopoda are defined as follows: eyes sessile (not stalked); carapace absent; one pair of maxillipeds; seven pairs of pereopods (legs), without exopods (an outer branch); abdomen clearly differentiated from thorax and divided into a pleon of five segments (sometimes some fused) and pleotelson (fused pleonite six and telson); pleopods 1–5 similar or anterior pair operculiform, forked; one pair of uropods.

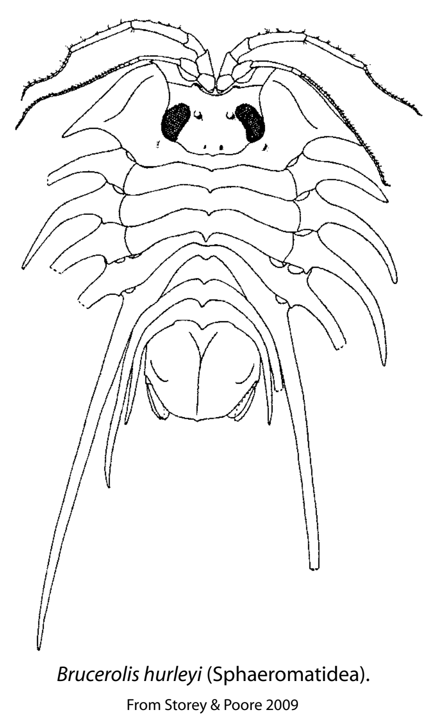
Isopods are of interest to marine biologists because of the important roles they play in ecosystems, especially on the sea floor. Here, species of many families are important scavengers of decaying material. Isopods of the family Cirolanidae are critical in cleaning up decaying dead fish (Bruce 1986a; Brusca et al., 1995; Keable 1995). Fish-lice of the family Cymothoidae are flesh- and blood-feeders that attach to the skin of living fishes. Aegids and juvenile gnathiids are blood-sucking micropredators of fishes, and in the tropics gnathiids can be so abundant that fishes attend cleaning stations where wrasses remove and eat them. Sea-centipedes (Idoteidae) feed on algae. The diverse Sphaeromatidae feed on living and dead material of all sorts. Many isopods are ideal food for many bottom-living fishes such as flounders and skates.

One family of economic significance is the Limnoriidae (gribble). These are wood-borers, formerly of ships but now only of wooden piles and wharves. Like timber borers on land, gribble make galleries throughout the timber and weaken it considerably (Menzies 1957; Cookson 1991). Species of *Sphaeroma* (Sphaeromatidae) behave similarly. Another important group, at least to gardeners, is the terrestrial slaters or woodlice. While most feed innocuously on decaying leaves and wood they can become so abundant as to attack vegetables and other garden plants.

Diversity of New Zealand Isopoda

The world's isopod fauna exceeds 10,000 described species but the actual number of species is certainly several times this. There are big gaps in knowledge of the deep sea, the tropics, and some families with small individuals. The New Zealand fauna totals only 426 living species (and four fossil species) but it appears that few shallow-water isopod groups are well covered taxonomically. It would not be surprising if many species of Sphaeromatidae, Cirolanidae, Gnathiidae, anthuroids, Asellota, and Valvifera remain to be discovered, especially from shelf depths. Even so, the number of already described species (353) somewhat exceeds that of South Africa (cf. 275 species in Kensley 1978) but, not surprisingly, is far fewer than in Australia (1,118 species; Poore 2002, 2005). South African and Australian isopods have attracted greater taxonomic attention than those in New Zealand. As is the case for many marine and terrestrial animals, New Zealand isopods are largely endemic.

The only habitat that is relatively well known is intertidal and subtidal rocky shores, but even here the Asellota have been largely ignored. Museum collections from The Snares (partly described by Poore 1981) contain several undescribed species of small asellotes and more such species could be expected



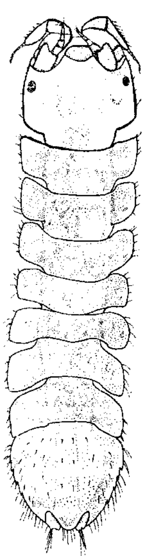
Brucerolis hurleyi (Sphaeromatidea).

From Storey & Poore 2009

throughout New Zealand. While the benthos of the New Zealand continental shelf has been thoroughly sampled, the gear used has not deliberately targeted small invertebrates, and collections available for study seem not particularly diverse for isopods. NIWA collections appear from superficial examination to be far less rich than, for example, those from comparable habitats in Bass Strait at similar latitudes in Australia. Museum Victoria, Melbourne, houses a benthic collection that includes c. 250 species of isopods from sediments (Poore unpubl.). There are even fewer species described from the continental slope. Poore et al. (1994) recognised 359 species, mostly undescribed, from this habitat off the southeastern coast of Australia and a similar number could be expected for the New Zealand slope. Several species from bathyal depths north of New Zealand were described from collections of the *Galathea* Expedition but the rest of the EEZ is virtually unsampled. Another habitat as yet largely unexplored is fresh water in limestone caves; sphaeromatids are known from this environment near Nelson, South Island (Sket & Bruce 2004).

Three species of isopod fossils have been recorded from New Zealand (Grant-Mackie et al. 1996; Hiller 1999; Feldmann & Rust 2006).

Numerous families, 120 at last count in the world fauna, are arranged in a complex hierarchy within suborders (Martin & Davis 2001). Most of the widely used suborders are monophyletic groups, but the one that has traditionally included the most familiar marine species, Flabellifera, is not (Wägele 1989; Brusca & Wilson 1991; Brandt & Poore 2003). Here, Brandt and Poore's (2003) classification is followed and the suborder Flabellifera is superseded by the three suborders Cymothoida, Limnoriidea, and Sphaeromatidea. Three other previously recognised suborders are subsumed within Cymothoida – Epicaridea as superfamilies Bopyroidea and Cryptoniscoidea, Anthuridea as superfamily Anthuroidea, and Gnathiidea as family Gnathiidae. Hurley and Jansen (1977) provided an effective key to identify some families but their classification is now out of date. Modern faunal treatments, also using the older classification, can be found in Kensley (1978) or Kensley and Schotte (1989). Only 49 families have so far been recorded from New Zealand.



Joeropsis sp. (Asellota).
From Hurley & Jansen 1977

Suborder Asellota

Some 93 New Zealand species are known, of which 36 remain unnamed or not fully determined. They have diverse shapes. Diagnostic characters include: coxal plates usually minute; one (rarely two or three) pleonites free, others fused; uropods attached posteriorly. Asellotes are common but small, difficult to find, and even harder to identify. A microscopic examination of tufts of algae from sheltered marine environments will often reveal several species of asellotes, rarely more than two millimetres long. Others live in freshwater streams. Globally, almost 30 diverse families exhibit an exceptional range of form on the floor of the deep sea. Some species are quite bizarre, with extraordinary ornamentation. Several species from the deep sea near New Zealand were described from collections of the Danish research ship *Galathea* (Wolff 1956a, 1962) but only one family from this environment in New Zealand has been treated in detail (Lincoln 1985). The identity of many of the species recorded from subantarctic New Zealand may be in doubt until specimens are compared with those from other islands or continents. Globally, Wilson and Wägele (1994) listed all known asellote species and provided a key to the genera of Janiridae, an important shallow-water family, and Cohen (1998) did the same for Dendrotiidae. The diverse Munnopsididae has been treated in part by G. D. F. Wilson (1989), the Stenetriidae by Serov and Wilson (1995), Pseudojaniridae by Serov and Wilson (1999), Joeropsididae by Just (2001), and Paramunnidae by Just and Wilson (2004, 2006).

Suborder Phreatoicidea

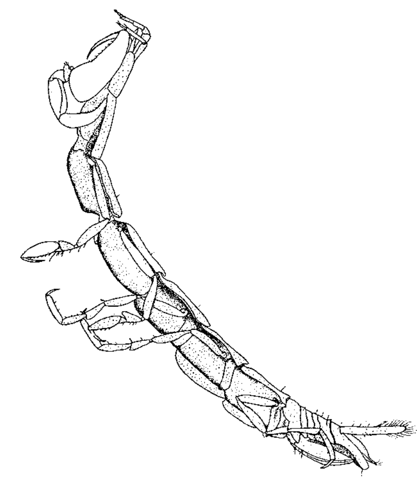
Nine New Zealand species are known, all endemic, and in endemic genera. They are laterally flattened. Other diagnostic characters include: coxal plates extending ventrally; five pleonites free; uropods rod-like and attached posteriorly. Peculiar to southern continents and islands, phreatoicids comprise an unusual group of freshwater and terrestrial species. They superficially resemble amphipods but differ in having only one pair of uropods as well as other isopod features. Most of the New Zealand fauna was dealt with by Nicholls (1944), with one species described in detail by Wilson and Fenwick (1999). The suborder was reviewed by Wilson and Keable (2001).

Neophreatoicus assimilis (Phreatoicidea)
From Hurley & Jansen 1977

Suborder Cymothoida

Comprising sea-lice, fish-lice and other mobile scavengers, predators, and microparasites, 116 described and 16 undetermined New Zealand species are known. Diagnostic characters: usually dorsoventrally flattened but otherwise diverse; mandibular molar blade-like or reduced; coxal plates expanded and free or reduced; five pleonites free or variously fused; uropods usually forming tail fan with pleotelson, rotating in horizontal plane and in broad contact with pleopods. All are marine, but habits and shapes vary. Numerous authors have contributed to knowledge of cymothoidan families in New Zealand, notably the Cirolanidae (Jansen 1978; Bruce 1986a, 2003, 2004a; Svavarsson & Bruce 2000; Keable 2006), Cymothoidae (Bruce 1986b), Gnathiidae (Cohen & Poore 1994; Svarvasson 2006), Tridentellidae (Bruce 1988, 2002), and Aegidae (Bruce 1983, 2004b, 2009a). The suborder contains four superfamilies – Anthuroidea, Bopyroidea, Cryptoniscoidea, and Cymothooidea.

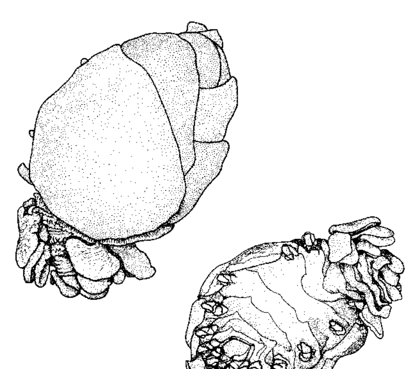
Some 21 described New Zealand species of Anthuroidea are known (in the families Anthuridae, Expanathuridae, Hyssuridae, Leptanthuridae, and Paranthuridae). Diagnostic characters include: shape elongate and cylindrical; coxal plates indistinguishable from pereon wall; pleonites fused or free; uropodal exopod attached proximally on peduncle and dorsally arched over pleotelson. Anthuroids live in sediment and on macroalgae, although the New Zealand species *Cruregens fontanus* is unusual in living in artesian and river waters (Wägele 1982). Very few species had been described until the work of Wägele (1985). The family arrangement follows Poore (2001a), who synthesised many papers and whose earlier work, principally on the Australian fauna, is relevant.



Cruregens fontanus (Cymothoida).
From Hurley & Jansen 1977

The superfamily Bopyroidea comprises parasitic isopods of crustaceans, with 13 described New Zealand species in the family Bopyridae. Diagnostic characters include: individuals sexually dimorphic, females usually asymmetrical, males minute; mouthparts reduced; branchial parasites of crabs, shrimps etc., but also of other crustaceans and some hyperparasites of other bopyroideans. Page (1985) studied New Zealand species. Few modern taxonomists have tackled this confusing group, but Markham (1985) and other papers by this author are a good introduction.

The largest superfamily in New Zealand is Cymothooidea, with 93 species (15 unnamed or not fully determined) in the families Aegidae, Anuropidae, Cirolanidae (with endemic genus *Pseudaega*), Cymothoidae, Gnathiidae, and Tridentellidae. The largest of these, with 37 species, is the recently monographed Aegidae (Bruce 2009a), a family of micropredators mostly associated with fishes. The Cryptoniscoidea has just five species in New Zealand, in the families Crinoniscidae and Hemioniscidae (Hosie 2008).



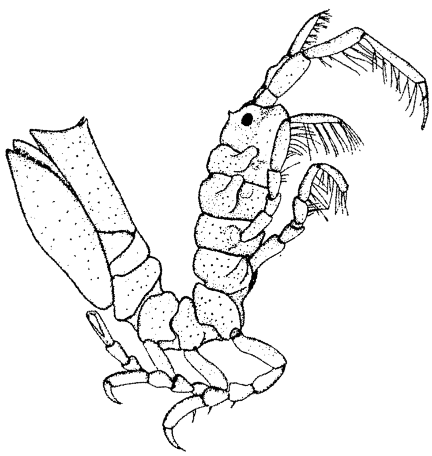
Dorsal (upper) and ventral (lower) views of *Athelges lacertosi* (Cymothoida), a parasite of the hermit crab *Lophopagurus lacertosus*.
From Pike 1961

Suborder Limnoriidea

These are wood-boring isopods, sometimes called gribble, with nine New Zealand species all in a single family, Limnoriidae, reviewed by Cookson (1991). Mandibles are specially modified, the body is cylindrical, and pleonites are free. Wood is not their only target in New Zealand. *Limnoria limnorum* caused the 1916 failure of the Cook Strait submarine cable when some individuals bored through the gutta-percha that was around the inner cable core.

Suborder Sphaeromatidea

These comprise marine pillbugs in general, with 81 described New Zealand species known, including 61 species of Sphaeromatidae. Diagnostic characters: usually dorsoventrally vaulted, occasionally flattened, sometimes able to enroll; coxal plates well developed; pleonites variously fused; uropods usually forming tail fan with pleotelson, rotating in vertical plane and excluded from branchial cavity. All are marine, but habits and shapes vary. Notable taxonomic contributions include those on the Sphaeromatidae (Hurley & Jansen 1977) and the enigmatic, sometime sphaeromatid, genus *Paravireia*, herein placed as *incertae sedis* (Jansen 1973; Brökeland et al. 2001). A sphaeromatid species is host to a fecampiid flatworm, *Kronborgia isopodicola*, described from Kaikoura, the adults of which live in the body cavity of *Exosphaeroma obtusum* (Blair & Williams 1987; Williams 1988).



Pseudarcturella chiltoni (Valvifera)
From Hurley & Jansen 1977

Suborder Valvifera

These include the so-called sea-centipedes and other bizarre forms, comprising 25 described New Zealand species. The form of the uropods, as long plates attached to the side of the abdomen and tightly enclosing all the pleopods, defines the valviferans. Most are marine, but the three species of *Austridotea* are among the few freshwater members of the suborder (Chadderton et al. 2003). Some forms are ornately decorated. The only family-level reviews are by Poore and Lew Ton (1990, 1993) and Poore and Bardsley (1992). The family arrangement follows Poore (2001b).

Suborder Oniscidea

These are the land-dwelling woodlice, slaters, and pillbugs, with 72 described New Zealand species known. Four species are naturally occurring non-endemics and six others are introduced. Diagnostic characters: usually flattened but sometimes able to roll up; five pleonites usually free; pleopods highly modified for air-breathing. Oniscideans are exclusively terrestrial and are the only crustacean group to compete successfully with other arthropods on land. Seven pairs of legs immediately reveal that they are not insects or millipedes. There are examples high up on the seashore but none is truly marine. Although damp places, and under leaves and decaying logs, are favoured habitats, some overseas species are known from deserts. Like all isopods, oniscideans rely for respiration on their pleopods, which are kept damp with a variety of water-conservation measures. Most species are scavengers on dead plant litter but some can be pests in gardens. There are numerous families including five genera and many species endemic to New Zealand. But the most commonly seen species are introduced from Europe. The New Zealand fauna was reviewed by Hurley (1950) and one family revised by Green (1971). Some of the names listed by Hurley are now out of date and the present review follows the taxonomy of Green et al. (2002).

Historical overview of isopod studies

The first scientific collection of isopods in New Zealand was made by the French biologists J. R. C. Quoy and J. P. Gaimard when the *l'Astrolabe*, captained by Dumont d'Urville, visited in 1826. They discovered two shallow-water sphaeromatids from algae, described 13 years later as *Isocladus armatus* and *Cassidina typa* in a significant publication on isopods by H. Milne Edwards (1840). Earlier publication dates appear in the New Zealand checklist but these are of species either introduced to the country or of species described from elsewhere. Later, the United States Exploring Expedition visited New Zealand on its 1838–42 round-the-world voyage, and numerous species of marine animals were described by its chief scientist, James D. Dana. Among these are 19 species of isopods (Dana 1852b, 1853–55). The first review of the New Zealand crustacean fauna (Miers 1876) listed 28 isopod species in 16 genera. When a second review was completed 10 years later by Thomson and Chilton

(1886), 60 species of isopods had by then been described, many by these two authors. A third checklist and key (Hurley 1961) listed 168 species; the increase in the intervening years was contributed largely by results from foreign deep-sea expeditions like the British HMS *Challenger* (1873–76) and Danish *Galathea* (1952). By 2009 the number had grown again, largely as a result of the work of New Zealand-based taxonomists Desmond Hurley and Peter Jansen in the 1970s and Niel Bruce in the 2000s, as well as overseas workers with an interest in specific families (J. Just, R. Lincoln, G. C. B. Poore, and J.-W. Wägele).

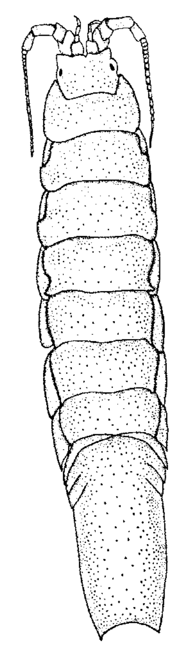
Special features of the New Zealand isopod fauna

Some 38 isopod families have marine representatives in the New Zealand fauna. Gaps can be explained by inadequate collecting. For example, it is safe to say that most deep-water asellote families will be recorded once appropriate sampling is done. It is possible that the Ancinidae and Corallanidae might one day be found in New Zealand. Four small families from the southwestern Pacific (Bathynataliidae, Hadromastaciidae, Keuphyliidae, and Phoratopodidae) are so far not recorded from New Zealand. The Serolidae, rich in species in shelf environments in Australia (Harrison & Poore 1984; Poore 1985, 1987), the southwestern Pacific (Bruce 2009b), and Antarctica (Brandt 1988; Wägele 1994), is represented in New Zealand by only a relatively small number of deep-water species, several of which have been described (Bruce 2008; Storey & Poore 2009).

The Gondwanan affinities of the fauna are evident in the largest families, Sphaeromatidae and Cirolanidae, where genera found in other Gondwanan continents dominate. This is clear too in Plakarthriidae, a family known only from three species, one each in South America, New Zealand, and southern Australia (Poore & Brandt 2001). The same is true for the terrestrial families, with many Palaearctic oniscidean families absent and strong radiation of southern ones. The Phreatoicidea is a typical high-level Gondwanan taxon, being confined to New Zealand, Australia, and India.

New Zealand isopods are largely endemic – 100% of freshwater species, 86% of terrestrial species, and almost 77% of marine species. The endemicity of some taxa reflects the long isolation of the fauna from Australia, the continent from which it last separated 85 million years ago. Close relatives (perhaps sister species) of New Zealand species are found in Australia within several families, e.g. Austrarcturellidae, Idoteidae, Leptanthuridae, Phreatoicoidae, Plakarthriidae, and Sphaeromatidae. Much less is known about relationships among other apparent endemics. Many species from the shelf and deep sea are known only from type specimens from a single sample, so their true distribution is unknown. But even here evidence is emerging that endemism is truly high. For example, none of the anthurideans or haploniscid and dendrotiid asellotes described from New Zealand occurs in Australia (Cohen 1998; unpublished material and catalogues).

Non-endemic species fall into two groups – those apparently naturally widespread, and those thought to be introduced. The idoteids *Batedotea elongata* and *Paridotea ungulata* have been identified from algal communities in New Zealand and Tasmania and another, *Idotea metallica*, is cosmopolitan on oceanic algal wrack (Poore & Lew Ton 1993). Several other species may occur naturally in New Zealand and Australia and sometimes also elsewhere, e.g. *Natatolana pellucida* (Cirolanidae), *Limnoria rugosissima*, *L. tripunctata* (Limnoriidae), and *Cymodoce convexa* (Sphaeromatidae). Several species of aegid micropredators of fishes and at least three species of cymothoid fish ectoparasites seem widespread in the Tasman Sea (and sometimes beyond), as are their host species. A deep-sea gnathiid, *Bathygnathia vollenhovia*, which occurs on both sides of the Tasman Sea (Cohen & Poore 1994), is certainly naturally distributed. For other seemingly widespread species, identifications are suspect until type material has been compared. Specimens of the New Zealand sphaeromatid *Pseudosphaeroma campbellense* identified from Australia (Harrison 1984) may be specifically



Paridotea ungulata (Valvifera).
From Hurley & Jansen 1977

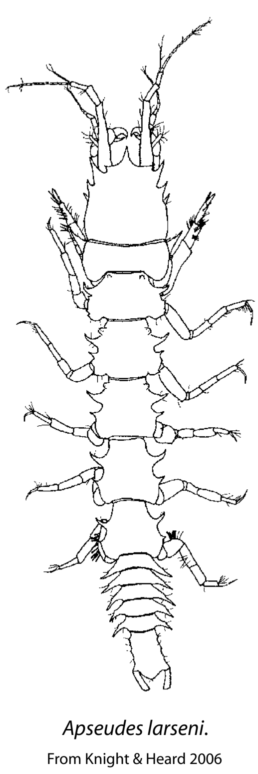
different (Poore 1994; Bruce & Wetzer 2008). This suspicion is especially valid for some species recorded from the New Zealand subantarctic but whose type locality is elsewhere, e.g. the sphaeromatids *Exosphaeroma gigas* and *Cymodocella tubicauda* (Hurley & Jansen 1977; Brandt & Wägele 1989).

The most familiar isopods of gardens and farmland, the woodlice and pillbugs, are definite imports from Britain or continental Europe, namely *Armadillidium vulgare*, *Porcellionides pruinosus*, and *Porcellio scaber*. They arrived with garden plants or simply as stowaways with the first Europeans. An export of a slater has occurred, too – the styloniscid *Styloniscus otakensis* to Australia's Macquarie Island (van Klinken & Green 1992).

Alien marine isopods

For marine isopods the presence in New Zealand of exotics is ambivalent, although the ability to be transported to and from New Zealand with fouling on ships is certain. Cranfield et al. (1998) recorded three isopods as potentially introduced to New Zealand. The first, Australian species *Cymodoce tuberculata* (Sphaeromatidae), recorded by Chilton (1911b) from a plank of the ship *Terra Nova* in Lyttelton, seems not to have become established in New Zealand. The second, a species of wood-boring gribble, *Limnoria tripunctata* (Limnoriidae), has potentially been distributed by shipping between widespread localities around the world but its origin is unknown (Cookson 1991). The third, *Limnoria rugosissima*, is a borer of algal holdfasts, not of timber, so is more likely to be distributed between southern Australia and New Zealand by drifting kelp. On the other hand, *Limnoria quadripunctata* (not listed by Cranfield et al. 1998) was first described from Europe and now globally recognised; its origin is more probably Southern than Northern Hemisphere (Cookson 1989; Poore & Storey 1999). Likewise, *Sphaeroma quoianum* (Sphaeromatidae), another wood-borer and its commensal, *Iais californica* (Janiridae), could have been distributed similarly. *Eurylana arcuata* (Cirolanidae) is possibly a New Zealand species introduced to Australia (or vice versa) and to North America (Bowman et al. 1981).

The affinities of the New Zealand fauna can only be understood if the taxonomy is accurate. Two species of *Phalloniscus* (Oniscidae) erroneously recorded from Australia, *P. kenepurensis* and *P. punctatus*, were excluded by Bowley (1935) and Green (1961). *Deto marina* (Scyphacidae), recorded from New Zealand by Schultz (1972), is endemic to Australia.



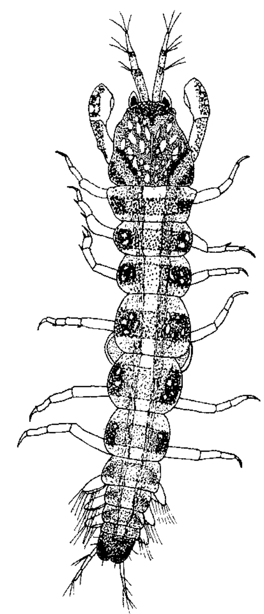
Apseudes larseni.
From Knight & Heard 2006

Order Tanaidacea: Tanaids

Tanaids (there is no common name) are very small, shrimp-like creatures. They are mostly in the 2–5 millimetre range but adults of a few species can be as small as half a millimetre or as long as 75 millimetres (Gamo 1984). There are three living orders, the members of which exhibit characteristic morphologies and, to some extent, lifestyles. Species of Neotanaidomorpha are free-living surface dwellers, while those of Tanaidomorpha are largely tube dwellers and the Apseudomorpha are mostly burrowers or crawlers. The first two segments of the thorax are covered by a carapace forming, with the head, a cephalothorax. The first thoracic segment supports a small pair of maxillipeds, the second a distinctive pair of chelipeds, and each of the third to seventh segments bears a pair of pereopods. The first pereopod may be adapted for burrowing in the suborder Apseudomorpha, equipped with spinning glands for tube construction in the suborder Tanaidomorpha, or may be a simple 'walking leg' in the suborder Neotanaidomorpha. Sexual dimorphism is often evidenced in the chelipeds and the claw of the left cheliped can be greatly enlarged in the males of some species of Apseudomorpha. Each of the first five abdominal segments normally carries pleopods but these may be absent in many deep-sea species. The final pleonal segment is fused with the telson (forming a pleotelson) and carries a pair of uropods. Respiration takes place over the inner surface of the carapace.

As with other peracarid crustaceans such as isopods, amphipods, and cumaceans, tanaids carry their fertilised eggs and mancae (post-larval juveniles) within a ventral marsupium. In most groups this is formed out of four pairs of oostegites, attached to the first four pairs of pereopods. This is not the case in the Tanaidae, examples of which that are common in intertidal habitats; in this family the marsupium is seen as a ventral pair of elongate sacs (or sometimes just one sac). Similarly, species of Pseudotanaidae, common in the deep-sea, have only a single pair of oostegites arising from the fourth pair of pereopods. There is also some evidence to show that in some burrowing-tubicolous groups (such as the Typhlotanaidae) the female constructs a mucous brood pouch in which she and her young live (G. Bird unpubl.).

Tanaids are usually detritivores or grazers but some taxa are filter-feeders and opportunistic predation on smaller invertebrates (such as foraminiferans or juvenile echinoderms) may be common. Only a few species are considered to be parasitic but none are obligate parasites. Tanaids are preyed upon by a large number of other organisms including polychaetes, other crustaceans, migratory birds, and a large number of juvenile and adult fish such various rat-tails and grenadiers in the deep sea (Bird unpubl.)



Sinelobus stanfordi.
From Chapman & Lewis 1976

Identification of tanaids is notoriously difficult, complicated by their small size and sexual and developmental variation (Larsen 2005) along with widespread and intense convergent evolution. So far, 25 families, more than 200 genera, and more than 1000 species have been described, but it is estimated that the order contains several thousand undescribed species, most of which are suspected to live in the deep sea. Tanaids live almost exclusively in marine or brackish habitats, with just a few species in fresh water. They occupy a wide range of depths. Marine species can be found intertidally among coralline algae, crevices, holdfasts, and in rock-pools. Shallow-water and shelf forms can be found in sand and mud, although tanaid sand-faunas are typically sparse. Tanaids are very common and species-rich in deep-sea oozes and some live in deep-ocean trenches to hadal depths exceeding 9000 metres (Kudinova-Pasternak 1972).

Apart from those species that are attached to floating objects, all tanaids are benthic, but some have short-lived males that can be found swimming above the seafloor in their search for females. Tanaids are free-living, tube-dwelling, burrowing, or live in association with other organisms in a variety of relationships. Some live as epifauna on solitary corals (Sieg & Zibrowius 1988), colonial corals and hydroids (Bacescu 1981), live scallops (Brown & Beckman 1992), oysters (Bamber 1990), barnacles (Reimer 1975), and even sea turtles (Caine 1986). Some species are true symbionts, living together with gastropods (Howard 1952), tube-dwelling sea cucumbers (Larsen 2005), in the canals of sponges (Hassack & Holdich 1987), and as cleaning commensals on mobile bryozoan colonies (Thurston et al. 1987). Tanaids may also have their own epifaunal associates such as stalked protozoans (Gardiner 1975) or bivalves (Warén & Carrozza 1994) and deep-sea species can carry foraminiferans embedded in the cuticle. They may be parasitised internally by nematodes and externally by copepod-like tantulocarids (Larsen 2005).

The New Zealand fauna is so poorly known that even an approximate assessment is difficult but, if comparison is made with a similar area and range of habitats, based on the Rockall-Biscay region of the Northeast Atlantic (G. Bird unpubl.), then 250–300 species are possible. The cryptic habits of the group and the small number of active specialists globally and in New Zealand suggest that this state of affairs may continue for some time although progress is now being made. Knowledge of the New Zealand fauna is still largely based on the older published records of Chilton (1882c, 1883), Thomson (1880, 1913), Stephensen (1927), Wolff (1956b), and Lang (1968). As a consequence, there are only about 20 authoritative records among the species in the end-chapter checklist. The remainder are unpublished records or undescribed species based on studies by Graham Bird, Elizabeth Hassack and the late Jürgen Sieg. Amongst these records are a number of undescribed species (indicated in the end-chapter checklist by bracketed numbers) and several new genera, the family affiliation of which is not currently available. This list is a snap-shot view and highly provisional. A few old records have been reappraised in the light of current tanaid taxonomy (Larsen & Wilson 1998, 2002; Knight & Heard 2006; Bird 2008). The New Zealand fauna also contains one of the few known freshwater tanaids – *Sinelobus stanfordi* from lakes in the Rotorua district.

Order Cumacea: Comma shrimps

The common name for cumaceans alludes to one of their distinctive features, i.e. resemblance to a comma when preserved. That is, they have an enlarged front section (head and part of the thorax) followed by a rather narrow posterior section (remainder of thorax and abdomen).

Comma shrimps live on the seafloor with their bodies generally slightly submerged in the sediment. They feed on diatoms, pieces of seaweed, foraminiferans, and detritus, which they collect from the sediment surface. For the most part, they will stay hidden in the sediment during the day, and some will make extended trips into the overlying water after sunset. The reasons for these excursions are not precisely known, but include moulting and searching for mates. In fact, in some cumacean families, the body morphology of the mature male is completely modified for swimming, suggesting that at that stage the animal rarely visits the sediment. Swimming cumaceans are vulnerable to fish predation, and mature males are commonly found in fish stomachs.

The cumacean body is one of the more modified of the higher crustaceans. Anteriorly, the head and three segments of the thorax are covered with a carapace. As a result, the normal feeding appendages of the head are augmented by three thoracic appendages (known as maxillipeds) that are also used for feeding. The first of these is also highly modified for respiration. That is, the epipod, which is not present in amphipods and is reduced in isopods, is greatly enlarged in cumaceans as a branchial lobe. Respiration occurs as the branchial lobe is moved back and forth underneath the sides of the carapace.

The remaining thoracic segments bear appendages that function as walking legs. In some cases, especially in mature males, these legs will also have an outer branch, the exopod, that is used to aid in swimming. The abdomen is generally long and thin. Abdominal appendages are either pleopods, if they occur on one or more of the first five segments, and uropods when present on the last segment. Pleopods are not present in the females of species that occur in New Zealand, and may or may not be present on some or all segments in the males. A final, post-abdominal segment, the telson, may be present as a separate structure, or it may be fused to the last abdominal segment.

Cumaceans are rare in the fossil record. There are two species known from the Jurassic, but they are more or less similar to a modern cumacean family, suggesting that the group as a whole is quite old. On the other hand, cumaceans are among the last of their line to have evolved, so it possible that all peracarids were present by the end of the Paleozoic.

As with other members of the superorder Peracarida, cumaceans carry their young in a brood pouch, with the young hatchling looking like a miniature version of the adult minus the last pair of thoracic legs. Because of this direct development, cumacean species are generally not very widespread, and some genera are restricted to individual continents or ocean basins. Some families, such as the Bodotriidae and Nannastacidae, are primarily warm-temperate to tropical, while others such as the Lampropidae and Diastylidae are most diverse in colder oceans. All families are represented in the deep sea, but lampropids show the greatest diversity in that environment.

New Zealand Cumacea

The first cumaceans known from New Zealand were described by George Thomson (1892), who had spent a couple of days dredging in the Bay of Islands in 1883. Not being able to sort the material for some time, his two species went undiscovered for several years. It would be another decade before Zimmer (1902) would describe an additional two species, collected by Prof. Dr Thilenius from the Bay of Plenty and deposited in the Berlin Museum. The biggest contribution, to this day, of our knowledge of New Zealand cumaceans was made by W. T. Calman, who, over a 10-year period (Calman 1907, 1908, 1911, 1917), described 17 species from material sent to him by G. M. Thomson and Henry Suter. Norman Jones, a prolific cumacean worker, described a new species and added a new record from the Chatham Islands area (Jones 1960). He added five new species and two new records to the New Zealand fauna in his now classic monograph covering material in the collections of the former New Zealand Oceanographic Institute (now part of NIWA), the Zoology Departments of Auckland and Canterbury Universities, and the then Dominion Museum, Wellington (Jones 1963). A further eight deep-water species were described by Jones (1969) from material collected in the Tasman Sea by the *Galathea* Expedition.

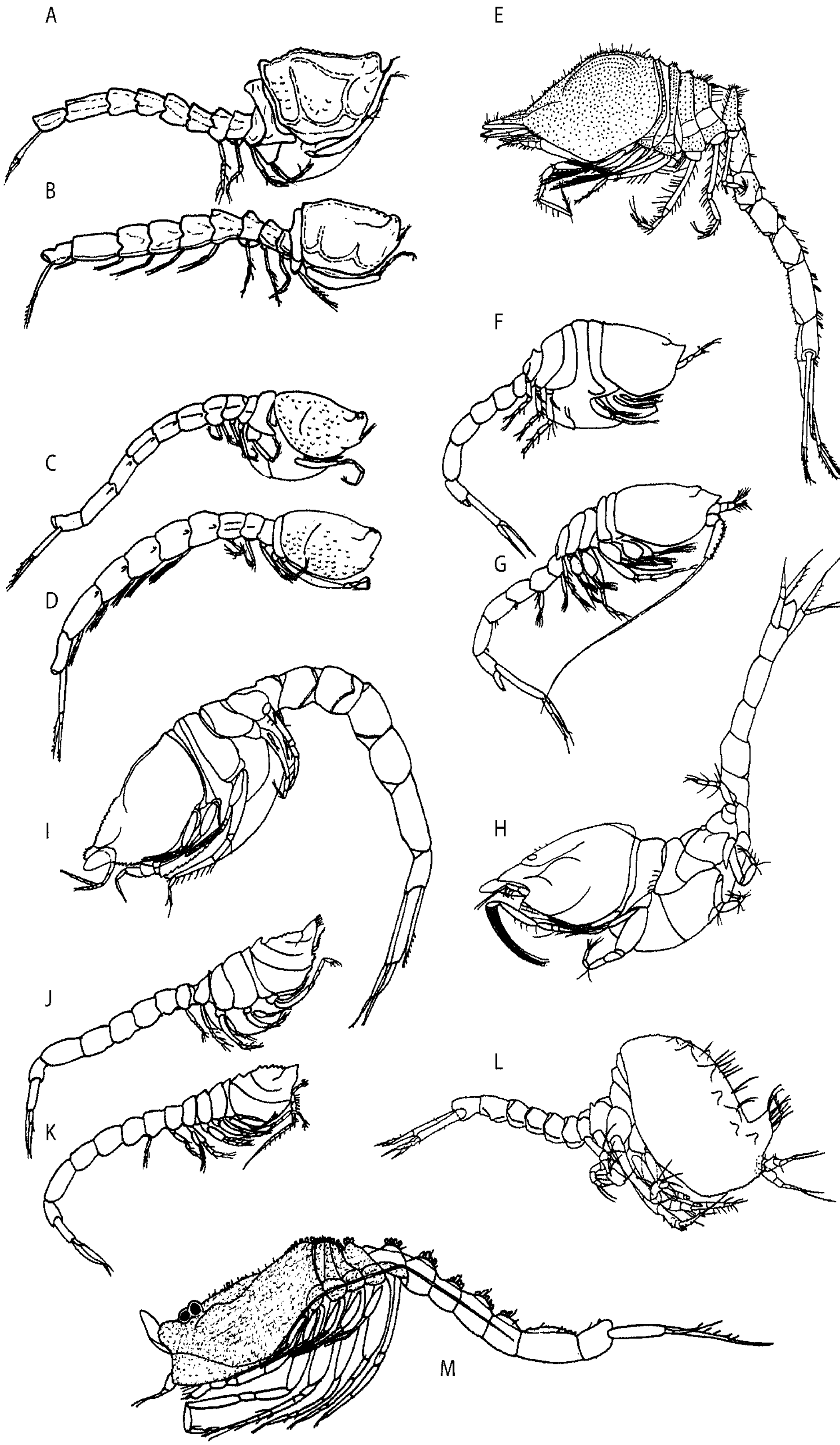
Over the intervening 31 years, many samples containing cumaceans have been taken in the waters of New Zealand's EEZ and stored in the NIWA Invertebrate Collection, Wellington. Until this present review, no one had taken the challenge of working up this material. Most of the new material examined was collected in the deep waters of the New Zealand microcontinent and contains much that is new, both at species and genus levels. From these collections, four new species of Gynodiastylidae were found and described in a recent monograph of the family by Gerken (2001). Several other new taxa have been sorted from the collections and will be described in future papers.

Of the eight currently recognised cumacean families, only six are represented in New Zealand waters. (The Ceratocumatidae is known only from abyssal depths in the Atlantic and Indian Oceans and the Pseudocumatidae are so far exclusively Eurasian–Atlantic in distribution.) The Gynodiastylidae is the smallest of the families represented in New Zealand, with only seven species, and the Diastylidae the largest, with 19 species formally known (and at least another six species remain to be characterised). Some remarks are now offered for each family, based on historical records as well as new findings from NIWA material.

Family Bodotriidae: Subfamily Bodotriinae. Members of this subfamily occur in all oceans, primarily in shallow water, but also in the deep sea. New Zealand is quite unusual in having only one (*Cyclaspis*) of the 13 genera represented in its fauna. This is most likely because the other genera are primarily warm-water and have invaded temperate waters only at the edges of their distributions. Because of the long isolation of the New Zealand microcontinent, temperate-water invasion would have been difficult. On the other hand, *Cyclaspis* is found in tropical to cool-temperate shelf waters as well as the cold waters of the deep sea, so its radiation in New Zealand waters might be expected. The level of endemicity is high in absolute numbers, but species in this genus are usually found in one, maybe two, zoogeographic provinces. Few new species are likely to be found in shelf waters, with most additions to the fauna coming from bathyal depths. If another genus is to be added, it will most likely be something completely new.

Family Bodotriidae: Subfamily Vaunthompsoniinae. This subfamily is largely austral in its distribution and is found from tropical-shelf habitats to cold bathyal waters. Only one New Zealand shelf species is known, and it is not endemic. One of the two bathyal species is endemic, as are both abyssal species. It is unlikely that more than one or two additional shelf species will be found, but the deep-water fauna could continue to contribute new genera and species.

Family Diastylidae. Of the seven genera represented, one (*Colurostylis*) is



Some New Zealand representatives of cumacean families.
Bodotriidae: A (female), B (male), *Cyclaspis elegans*; C (female), D (male), *Cyclaspis thompsoni*.
Diastylidae: E (female), *Diastylis acuminata* (Diastylidae); F (female), G (male), *Colurostylis pseudocuma*.
Gynodiastylidae: H (female), *Gynodiastylis milleri*. Lampropidae: I (female), *Hemilamprops pellucida*.
Leuconidae: J (female), K (male), *Paraleucon suteri*. Nannastacidae: L (female), *Campylaspis rex*; M (male), *Nannastacus pilgrimi*.
A–K, M, from Jones 1960; L, from Gerken & Ryder 2002

endemic. The others are broadly distributed in the colder waters of the world ocean. The genera *Makrokylindrus* and *Vemakylindrus* are exclusively bathyal or deeper. Specific endemicity is very high (18 of 19 known species) for this family considering the widespread nature of the genera. In addition, diastylids are very abundant and at least one or two individuals can be found at any benthic sampling station.

Family Gynodiastylidae. This is a predominantly southern hemisphere family (but ranges as far west as the Persian Gulf and east to Japan) and exhibits its greatest radiation in southern Australia. There are seven endemic species in New Zealand shallow waters, of which three are in the widespread genus *Gynodiastylis*. One of the new species, in the genus *Allodiastylis*, was found at bathyal depths.

Family Lampropidae. The lampropids are a worldwide, cold-water, primarily deep-sea group. The taxonomy of the family is in need of serious revision, so some of the species found in the current study may be assigned to new endemic genera when revision is completed. Prior to this study only one lampropid, *Hemilamprops pellucidus*, was known from New Zealand. It is a widely distributed southern hemisphere species. Bathyal waters, however, have so far produced eight new species and one new genus (Gerken 2010), suggesting that the Chatham Rise and Campbell Plateau have much higher-than-average lampropid diversity.

Family Leuconidae. This family has very high generic endemicity (three of six genera) in New Zealand, especially in shelf waters. Further, the endemic genera are morphologically advanced within the family, anchoring a group (clade) where the male second antenna becomes reduced in length and modified so it can be used to grasp the female during mating. This trend continues in other eastern Pacific genera, with the second antenna possessing a more complete grasping structure in one Japanese genus and finally culminating in a western North American slope-dwelling genus where the grasping structure is all that is left of the appendage. All species of leuconids are endemic, with the single exception of *Eudorella truncatula*, which is surely an introduced species, broadly distributed in the North Atlantic and North Pacific. This family does not seem to be well represented in New Zealand bathyal samples, in contrast to what is seen in northern hemisphere waters.

Family Nannastacidae. There are two groups of genera in this family in New Zealand – deposit-feeding *Cumella* and its relatives and carnivorous *Campylaspis* and its relatives. Of the deposit-feeders, only one genus, *Scherocumella*, has been found in shallow waters, and two genera were found in the bathyal samples. This group seems to be under-represented in New Zealand. In contrast, there are at least six species of the carnivorous genus *Campylaspis* and two of *Procampylaspis*. The radiation within these genera is typical of that seen in other shelf and slope cold-water environments in both northern and southern hemispheres. All species in this family are endemic. The finding of a species of *Styloptocuma* extends the range of this genus into the Pacific.

In summary, there are two groups of cumaceans in the New Zealand fauna – the highly endemic species and genera of shallow water and the continental shelf, and the bathyal and abyssal species that belong to genera and families that are widespread throughout the cold deep waters of the world. Notably, within one family, the Leuconidae, there has developed a specialised morphology among the males that seems to have spread northwards in the eastern Pacific, culminating in advanced forms in Japan. Finally, New Zealand lacks representatives of many warm-temperate genera, even though it has a warm-temperate zoogeographic province and the Kermadec Islands within its EEZ. This may be a consequence of the geological history of the microcontinent, which, after it became isolated, went through a cooling period, thus eliminating resident warm-water species.

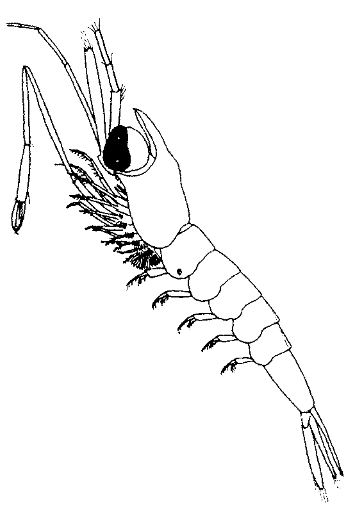
Gaps in knowledge of New Zealand Cumacea

The cumacean fauna of New Zealand's EEZ currently comprises 31 genera (two not yet named) and 74 species, not all formally named. Of these, about half, i.e.

15 genera and 37 species, are from shelf waters. In 1999, a brief collection by Les Watling in a few areas of the North and South Islands produced one new species of *Colurostylis*. Additional collecting is probably not likely to result in the addition of more than 10 new species from shelf depths, with the possible exception of Stewart Island and the subantarctic islands, which so far remain unexplored with respect to cumaceans. The relatively few samples (ca. 15) obtained by Watling have so far yielded 31 new species and two new genera, with the Diastylidae still to be studied in detail. None of the species in the new NIWA and Watling samples can be matched to the eight species Jones (1969) described from the Tasman Sea, suggesting either that there is a high level of endemicity between the east and west deep waters of New Zealand or that the deep-water fauna is very diverse. Neither of these hypotheses is unlikely. Because they brood their young, cumacean species are highly restricted to zoogeographic provinces in shallow water, and may well be restricted to individual tectonic plates in deep water. Since cumacean diversity is generally highest in the Southwestern Pacific, one might expect the overall diversity of bathyal waters to be much higher, at least by a factor of two, than that which has been observed to date. In addition, the lack of correspondence between the shallow New Zealand and southern Australian faunas lends credence to the fact that there is little natural water-borne transport of cumaceans. Most likely the shelf-dwelling cumaceans of New Zealand evolved in situ from whatever stock was present after Zealandia (the New Zealand continental mass) separated from Antarctica about 56 million years ago.

Order Euphausiacea: Krill

We've all heard of 'krill', shrimp-like crustaceans congregating in vast swarms in cooler latitudes of both hemispheres, and famous as whale food. The term krill was originally used by Norwegian whalers for the northern hemisphere cold-water euphausiids *Meganyctiphanes norvegica* and *Thysanoessa inermis* (Mauchline & Fisher 1969) but is now applied to all species of the order Euphausiacea. 'Euphausiids' is itself an unusual word because the ending '-ids' is commonly reserved for family names, not orders. But all except one species of Euphausiacea belong in just one family, the Euphausiidae and, based on long-term use, 'euphausiids' is here to stay. The Euphausiidae contains 85 species and the Bentheuphausiidae one species.



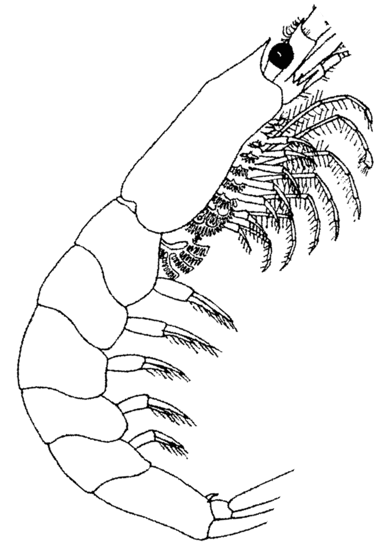
Stylocheiron abbreviatum.
After Sars 1885

The Euphausiacea is notable among the crustacean orders because all the species have conceivably been described. One or two new species may yet be discovered, but only eight have been added in the last 50 years, two in the last 30, with the very deep-water *Thysanopoda minyops* Brinton, 1987, the most recent. However, in some species, particularly in the genus *Stylocheiron*, up to six distinct 'forms' are recognised (Brinton et al. 1999). A few species such as *Euphausia similis* and *E. similis* var. *armata* are also extremely similar. In some cases these forms and species are geographically separate and in others overlapping. It is unclear what the taxonomic significance of the forms is, but new taxonomic techniques such as gene-sequence analysis may resolve this problem. If so, it seems likely that any future changes in the number of euphausiid species are more likely to result from redefinition of current taxa than from new discoveries. There is a further, informal subdivision of the family Euphausiidae, with Brinton et al. (1999) listing several 'species groups' within five of the larger genera based on morphological similarity. The 19 species found in New Zealand waters are named in one or another of these groups.

Krill are of great importance in the marine economy because of their vast numbers. They constitute a major proportion of oceanic biomass, are major grazers of phytoplankton and consumers of small zooplankton, and are themselves essential in the diets of whales, fish, seals, seabirds, and even people.

Morphology and distinguishing characters of krill

Krill are rather uniform in appearance and easily distinguished from other crustaceans. Their morphology is well illustrated and described in several publications, including Baker et al. (1990), who gave a particularly clear overview of their structure, and Brinton et al. (1999). Only the more distinctive characters are described here. Typical of shrimp-like crustaceans, krill are adapted to a natant (swimming) life-style, having an elongate body with the cephalothorax covered by a carapace, a six-segmented abdomen, and a telson with uropods that form a tail fan. They also have moveable eyes, biramous first and uniramous second antennae, and, behind the mandibles, two pairs of maxillae. There are eight pairs of thoracic limbs. Each has a two-segmented outer exopod and a five-segmented inner 'leg' but the posteriormost pair of limbs (eighth pair) is reduced to lobes in all but *Bentheuphausia amblyops*. The form of the seventh pair of limbs also varies between genera. While the first pair of limbs is used in the manner of maxillipeds they are similar in form to those behind. Abdominal segments 1–5 bear a pair of pleopods, the first pair in males being modified to form a handlike copulatory organ (petasma). This is used to transfer sperm packages to a midventral female structure (thelycum). The petasma and thelycum are diagnostic of species although they can be difficult to examine and other, more accessible, structures are generally used for this purpose if they are present and undamaged. Of particular use in this respect are the proximal three segments of the antennule (the antennular peduncle), which may bear a lappet having a characteristic shape or number of spines. The peduncle is usually present in collected specimens and used in combination with other characters.



Thysanopoda acutifrons.
From Holt & Tatersall 1906

Krill are easily distinguished from other shrimp-like crustaceans in having the gills exposed below the edges of the carapace, rather than covered by it. Euphausiid gills stem laterally from the first (coxal) segment of the thoracic limbs and become larger, more branched, and more obvious posteriorly.

A second distinctive character is the presence of movable light organs called photophores (the name Euphausiidae indicates they emit 'true light'), which are distributed in the same pattern throughout the order. Only the two very deep-water species *Bentheuphausia amblyops* and *Thysanopoda minyops* lack photophores; all others have a photophore on the carapace beneath each eyestalk and two pairs ventrally on the thorax, adjacent to the second and seventh limbs. Most also have four single photophores ventrally on abdominal segments 1–4, but in species of *Stylocheiron* only one abdominal photophore is present, on the first segment.

The cuticle is thin, flexible, and mostly smooth, with a small spine behind the eye and one or two pairs of denticles (tiny spines) on the sides of the carapace in some species. The front is rounded or produced into a simple sharp rostrum that is small in comparison to many other shrimp-like crustaceans. Some species have a keel behind the rostrum, there may be low-profile dorsal spines and keels on the third to sixth abdominal segments, and, in a few species, some characteristic sculpturing of the abdominal pleura (side-plates). Krill otherwise lack the variety of rostra, spines, and keels found in many decapod shrimps and mysidaceans but they still have rather unusual, distinguishing characters.

Two groups of the Euphausiidae can be distinguished by the shape of the eyes, which are round or almost so in one group and divided by a constriction into upper and lower lobes in the other (Baker *et al.* 1990). The genera *Euphausia*, *Meganyctiphanes*, *Nyctiphanes*, *Pseudeuphausia*, and *Thysanopoda* have round eyes, while *Nematobrachion*, *Nematosceles*, and *Stylocheiron* have bilobed eyes. One genus, *Thysanoessa*, has a mixture of both eye types. There is also a consistent relationship between eye shape and the form of the thoracic limbs (Baker et al. 1990) – species with bilobed eyes have one or two pairs of thoracic limbs greatly elongated while round-eyed species do not. *Stylocheiron* eyes are the oddest of all – four New Zealand species have eyes with enlarged crystalline cones making them tube- or pear-shaped. While lacking obvious cones, the eyes of *S.*

abbreviatum are also pear-shaped and those of *S. maximum* dumbbell-shaped.

Fully grown krill range in length from < 10 millimetres (e.g. *Stylocheiron affine*) to the largest, *Thysanopoda spinicaudata*, which reaches 150 millimetres (Brinton et al. 1999). In New Zealand, the smallest is probably *S. suhmi* at 6–7 millimetres; the largest so far recorded is *Thysanopoda cornuta*, which can reach 120 millimetres.

Classification

Martin and Davis (2001) placed the order Euphausiacea, with the Decapoda and Amphionidacea, in the superorder Eucarida, well separated from the Mysidacea and other orders of the Peracarida. Brinton et al. (1999) recorded earlier recognition of the similarities between krill and the pelagic decapod shrimps of the Sergestidae (suborder Dendrobranchiata). Krill and sergestid shrimps have free-swimming nauplius larvae, metamorphose to the post-naupliar larval stage, have reduced posterior thoracic limbs, and have a petasma in the male and thelycum in the female. However, Brinton (1966) had suggested these similarities might reflect parallel evolution rather than a close relationship. A recent analysis of ribosomal DNA sequences in krill (Jarman et al. 2000) indicates that they may be more closely related to the Mysida than to the Sergestidae, which accords with Brinton's suggestion.

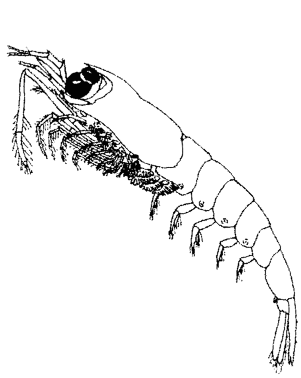
Discovery and diversity of New Zealand krill

Most krill are oceanic in distribution, with consequent low endemicity, and no species is confined to the New Zealand region, so the history of studies of species recorded in the region is mostly international. The first species recorded from the New Zealand region were those collected by the 1873–76 *Challenger* Expedition (Sars 1883, 1885). Sars's reports included 12 of the 21 species now known from New Zealand waters (see end-chapter checklist). H. J. Hansen (1905a,b–1911) described many species in several papers published in the early 20th century, including five species that occur in the New Zealand EEZ.

Tattersall (1924) provided the first list of seven New Zealand krill species gleaned from the reports of Sars (1883), Thomson (1900), and Hansen (1911) and added six more collected by the *Terra Nova* Expedition of 1910. Soon after, Chilton (1926) listed them again but included two species that Tattersall had reported, although rather unclearly, as occurring only in Australian waters (*Pseudeuphausia latifrons* and *Euphausia tenera*). Neither has been recorded from New Zealand since, meaning Chilton's (1926) list more accurately gives 13 New Zealand species. The remaining 12 recorded species have resulted from surveys of pelagic faunas and plankton off New Zealand's coasts (Roberts 1972; Bradford 1972; Bartle 1976; Robertson et al. 1978). The work of Bartle (1976) focused on krill in Cook Strait and is the most extensive study of the New Zealand fauna to date. Four new records are included in the current checklist from collections held at the Museum of New Zealand.

The only identification guide to krill that includes the New Zealand region was produced by Kirkwood (1982), but, apart from the early works listing New Zealand species and referred to above, no taxonomic works on krill in New Zealand waters have appeared. Sheard (1953) reported in detail on the taxonomy, distribution, and development of the Euphausiacea with particular emphasis on the Australasian species *Nyctiphanes australis*. A number of recent papers have reported on aspects of the biology of *N. australis* in southern New Zealand waters and/or included useful distributional and biological observations (e.g. Bary 1956, 1959; Jillett 1971; Bradford 1972; Dalley & McClatchie 1989; McClatchie et al. 1989, 1990, 1991a,b; Murdoch 1989; O'Driscoll 1998a,b; O'Driscoll & McClatchie 1998).

Research on krill biology continues around the world, especially on species of economic importance such as *Euphausia superba*, but the review of Mauchline and Fisher (1969) remains the major source of information. These authors brought



Thysanoessa gregaria.
After Sars 1885

together a large and disparate literature on all aspects of euphausiid biology, and Mauchline (1980) updated this. Baker et al.'s (1990) guide to the world's krill species is indispensable. It includes a good brief description of euphausiid anatomy and well-illustrated keys to the species. A paper on krill fisheries of the world (Nicol & Endo 1997) was recently published by FAO, and an easy-to-use CD by Brinton et al. (1999), giving illustrated identification of species, synonymies, references and distribution maps, was published by UNESCO.

The genus best represented in the New Zealand region is *Stylocheiron*. Half of the 12 species known globally occur in New Zealand waters, whereas only two (20%) of 10 *Thysanoessa* species have been recorded here. *Nyctiphanes australis* is one of four and *Nematobrachion flexipes* one of three species in their genera. Two of seven species of *Nematosceles* (29%) and five of 14 *Thysanopoda* species (36%) are present. *Euphausia*, the largest euphausiid genus with 31 species, is represented in New Zealand waters by just six species and one subspecies (22%). Records from New Zealand include three 'round-eyed' genera (*Euphausia*, *Nyctiphanes*, *Thysanopoda*) and three genera with bilobed eyes and elongated legs (*Nematobrachion*, *Nematosceles*, *Stylocheiron*). Both *Thysanoessa* species found in New Zealand waters also have bilobed eyes.

Species recorded in the literature as present, and species believed to be correctly identified, are listed in the end-chapter checklist, but this probably does not give the full picture. Other species are very likely to occur in New Zealand waters. Brinton (1962a) and Brinton et al. (1999) have given Pacific-wide and worldwide distributions of krill. Because they are typically offshore and pelagic in habit, mostly with wide geographic distributions, these distributional data and maps are, of necessity, generalised. Records from outside New Zealand's EEZ suggest that some species may range within the EEZ boundary, and shading on some maps in both works (Brinton 1962a; Brinton et al. 1999) indicates that they do. It is possible, though unlikely, that one or two species have been recorded from New Zealand in food studies of their many predators (fish, birds and whales), not reviewed here. Unrecorded krill species likely to be present include some medium-to-large sized species that may escape capture; not all krill swarm, and swarming species are easier to catch. Some species also live at depths where fine mesh nets are seldom deployed. The deep-living species *Nematosceles tenella* and oceanic *N. atlantica* fit these criteria and have yet to be found in New Zealand waters.

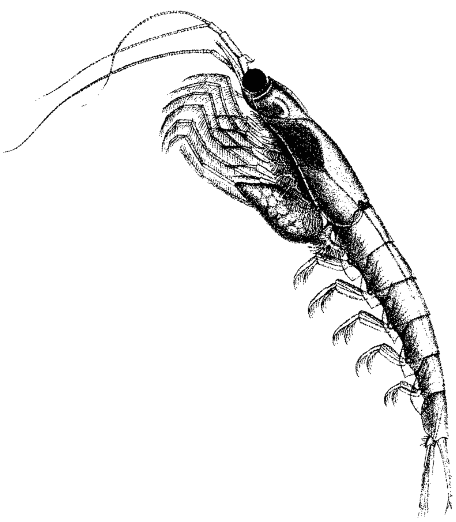
More species of *Thysanopoda* are also likely to be present in New Zealand waters. Mesopelagic *T. astylata*, *T. cristata*, *T. orientalis*, and *T. pectinata* occur widely in the Pacific to about 35° S and a few *Thysanopoda* species are meso- or bathypelagic and seldom sampled, e.g. *T. spinicaudata*, found at 2000–3000 metres. Species such as *T. cristata* are sparsely distributed and not caught regularly. Distributional records in Brinton et al. (1999) suggest at least some of these species may occur in the deep offshore waters of New Zealand but have yet to be collected, which is also the case for *Bentheuphausia amblyops* (Bentheuphausiidae) found throughout the Pacific to 54° S.

The species considered above live either in tropical or subtropical waters or are bathypelagic. Several species present in colder, Antarctic circumpolar water lying south of the Subantarctic Convergence (*Euphausia superba*, *E. frigida*, *E. triacantha*, *Thysanoessa macrura*, and *T. vicina*) must also come close to encroaching on the southern areas of New Zealand's EEZ. However, Morris et al. (2001) have shown that the Subantarctic Front (Convergence) forms a boundary between the colder, fresher Antarctic water to the south and warmer saltier subantarctic water to the north of the front. This abrupt, hydrographic and biological barrier extends deeply into the water column and is apparently a permanent phenomenon. The front also skirts the southern edge of the Campbell Plateau, 200 kilometres south of Campbell Island. This suggests that these circumpolar species are unlikely to be found within the EEZ, except perhaps as stragglers.

Nyctiphanes australis, a small species with adults 10–17 mm long and first recorded in New Zealand more than a century ago (Thomson 1900), is probably the best-known euphausiid of New Zealand waters, being abundant around the main islands and south to The Snares. It has also been studied more than any other species occurring here or in Australian waters, where it is also plentiful from New South Wales to South Australia including Tasmania.

The New Zealand species of *Euphausia* are all small to medium-sized; as adults, *E. recurva* is smallest at 10–14 millimetres long; *E. longirostris*, the largest, can reach 34 millimetres. *Euphausia similis* and *E. similis armata*, both 22–26 millimetres long as adults, are difficult to distinguish but the latter is more often caught and is one of the commonest krill species encountered in New Zealand.

Three of the five species of *Thysanopoda* found in New Zealand waters are new records (*T. cornuta*, *T. egregia*, *T. monacantha*). The largest of these is *T. cornuta* at 50–120 millimetres adult length; purple-red *T. egregia* reaches 50–62 millimetres, and *T. obtusifrons* is the smallest at 18–23 millimetres (Brinton et al. 1999).



Nyctiphanes australis.
From Sars 1885

The identity of *Stylocheiron longicorne* is complicated by the existence of three 'forms' – a North Indian Ocean form, a short form, and a long form. The latter is present in New Zealand waters and throughout all three main oceans, while the short form is almost as widespread and may occur in northern New Zealand. *Stylocheiron longicorne* is also one of three species of the '*S. longicorne* species group' (Brinton *et al.* 1999) in New Zealand waters, the other two being *S. elongatum* and *S. suhmi*.

Ecology and distribution of New Zealand krill species

Most krill live in the upper layers of the oceans or in coastal areas. Because they are pelagic at all stages in their life cycles and strongly influenced by currents and environmental factors (light intensity, oxygen saturation, temperature, salinity, and food availability), they tend to be confined to certain water-masses. The majority of species undertake daily migrations, swimming upwards into shallower strata of the water column by night and back down before daylight. Most species are omnivores and feed day and night. Upward migration at night into shallower waters may enable consumption of phytoplankton, while retreat to deeper layers during daylight probably helps to avoid pelagic predators.

Krill are well known for swarming, which they do at regular seasonal intervals or irregularly (Mauchline 1984). Aggregations form at or below the surface for feeding or reproduction and swarming by *Nyctiphanes australis* during the breeding season is well developed. Swarms of *N. australis* have been found in harbour and coastal waters of Otago in summer and autumn and a very dense swarm of about four cubic metres was photographed off The Snares by Fenwick (1978). Such swarms tend to be patchy and ephemeral (O'Driscoll & McClatchie 1998) but can be huge and occasionally wash ashore. The largest of a series of strandings of *N. australis* on Otago Harbour beaches in January 1990 was estimated to be ca. 100 tonnes (McClatchie et al. 1991b). *Euphausia similis armata* also intermittently strands in large numbers. In March 1985 and February 2002, millions of live individuals were washed ashore at Waikanae Beach north of Wellington. Drifts were hundreds of metres long and 'ankle deep', as reported by locals, who also observed gulls gorging themselves on the windfall. The krill had apparently been brought ashore by unusual wind and current patterns in the Cook Strait area.

Although krill actively swim, they are classified as plankton because they are moved about by currents, but the larger-sized species may behave more as nekton. *Nyctiphanes australis* lives mainly over the continental shelf and further inshore than other species recorded in the New Zealand region (Bary 1956; Blackburn 1980; Brinton et al. 1999). Offshore transport of *N. australis* is limited by coastal currents running parallel to the coast and by behaviour generated by environmental factors, possibly including vertical movements that place the krill in currents that retain them near the coast (Bradford 1979). Murdoch (1989) and O'Driscoll and McClatchie (1998) found that *N. australis* off Otago became entrained in an anticlockwise gyre off Blueskin Bay and are most numerous in low-salinity coastal waters resulting from river runoff. Bary (1956) observed that the species tolerates a wide salinity range and also penetrates semi-enclosed waters such as Otago and Wellington Harbours and the Marlborough Sounds. *Nyctiphanes australis* undertakes diel vertical migrations from below 150 metres into the top 40 metres of the water column (Bartle 1976) and Bradford (1979) observed that *N. australis* off Kaikoura was able to exist in water temperatures from 8–10° to 23°C.

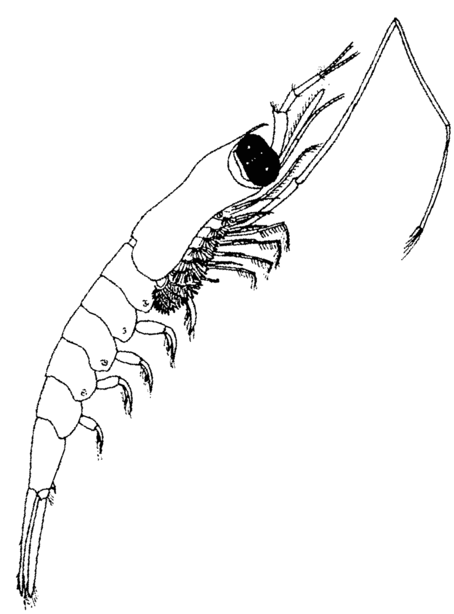
All species of *Euphausia* recorded in New Zealand waters are oceanic with a circumglobal distribution in the Southern Hemisphere. Only one subspecies, *Euphausia similis similis*, occurs in both hemispheres; the remaining New Zealand representatives of the genus are confined to the Southern Hemisphere, with each distributed in a circumglobal band. South of the Equator *E. similis similis* ranges from 25°S to 55°S (Brinton et al. 1999), which coincides with the northern and southern extremities of the EEZ and encompasses the distribution of its co-subspecies *E. similis armata*. Both subspecies inhabit depths of 0–300 metres but it is not clear if either migrates vertically. Baker (1965) observed what seems to be an inverse relationship between the numbers of the two subspecies and Bartle (1976) suggested this may reflect a difference in depth as he found *E. similis similis* mostly in the upper 100 metres of Cook Strait while *E. similis armata* was mainly deeper.

Euphausia longirostris, *E. lucens*, and *E. spinifera* also occur north and south of the Subtropical Convergence in New Zealand waters (Bary 1956; Bartle 1967; Robertson et al. 1978; James 1989). *Euphausia recurva* is a more tropical species found as far south as Cook Strait (Bartle 1976) and is bi-antitropical in the major oceans, meaning it is distributed both north and south of the Equator but not across it, although it can be found at lower latitudes than 20° S and 20° N. On the other hand, *E. vallentini* is a colder-water species, recorded by Brinton et al. (1999) from 50°–60° south of mainland New Zealand, but also found within or just to the north of the Subtropical Convergence Zone off Kaikoura (Bradford 1972).

Recognition of *Nematobrachion boopis* in New Zealand waters was only a matter of time since it is very widespread in the three main oceans from 42°N to 50°S. It is the deepest-living species in its genus, the adults being mesopelagic at 300 metres or more, but it also performs daily migrations. *Nematobrachion flexipes* is a deeper mesopelagic species (100–600 metres). It is very widespread though more patchily distributed than *N. boopis* (Brinton et al. 1999).

Two species of *Nematosceles* are found in New Zealand – *N. megalops* and *N. microps*. The former is a warm-temperate species found in all main ocean basins in the Southern Hemisphere and in the North Atlantic. *Nematosceles microps* is widespread in warm-temperate seas in all three main oceans between 40° N and 35° S (Brinton et al. 1999) but has been recorded only once off northern New Zealand (Tattersall 1924).

Stylocheiron elongatum is widespread in all oceans from 40° N to 35° S (Brinton et al. 1999) although Bartle (1976) collected two juvenile specimens from Cook Strait. He did not consider this unusual since waters of subtropical origin are known to penetrate southwards along the Hikurangi Trench into Cook Strait at 300–500 m, the appropriate depth for *S. elongatum*. *Stylocheiron carinatum*, *S. suhmi*, and *S. abbreviatum* have been recorded only in northern New Zealand waters (Tattersall 1924) but *S. maximum* is very widespread in the three main oceans. Its distribution encompasses New Zealand to 63° S in the Pacific Ocean (Brinton et al. 1999) although Robertson et al. (1978) found it only north of the Subtropical Convergence east of central New Zealand. *Stylocheiron maximum* is mesopelagic, being mostly caught at depths exceeding 400 metres, while *S. carinatum* occupies near-surface waters above 140 metres both day and night (Brinton et al. 1999).



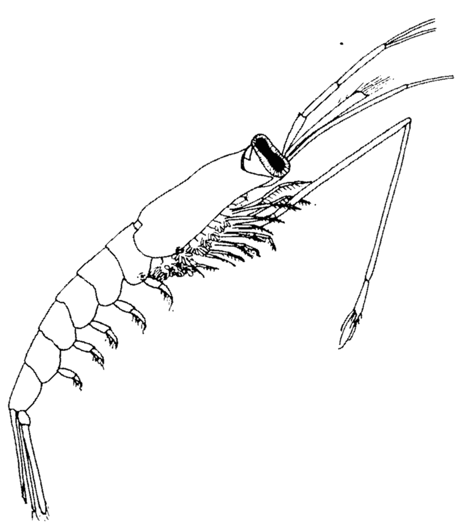
Nematoscelis megalops.
After Sars 1885

Thysanoessa gregaria is biantitropical in all three oceans, is found throughout New Zealand waters, and has been caught regularly in eastern and southern areas (Bartle 1976; Bary 1959; Bradford 1972; Murdoch 1989). While it is usually found above 150 metres depth, Bartle (1976) noted that it is deeper in subtropical than subantarctic waters and suggested it also undergoes extensive vertical migrations. Brinton et al. (1999) indicated that it occupies thermocline waters, rising and falling with them day and night, and that it has been found as deep as 1200 metres. Roberts (1972) identified *Thysanoessa macrura* at the Auckland Islands but Brinton et al. (1999) placed this species in circumpolar Antarctic waters south of 55° S. It seems likely that Roberts was dealing with *T. vicina* rather than *T. macrura* since the two species are difficult to distinguish and, according to Brinton et al. (1999), *T. vicina* overlaps and occurs north of *T. macrura* to 50° S.

Thysanopoda cornuta has been found at scattered locations in the three main oceans at 1200–2500 metres depth, while larvae and juveniles are present at 700 metres or deeper. *Thysanopoda egregia* occurs at 800–2000 metres, while *T. monacantha* is mesopelagic at 300–400 metres, rising into the upper layers at night. Like several other widespread krill found at these depths, *T. monacantha* requires water fully saturated with oxygen and is absent from oxygen-deficient areas of the northern Indian and eastern central Pacific Oceans (Brinton 1962b). *Thysanopoda obtusifrons* inhabits the low-nutrient central water masses of the main oceans and is found up to 140 metres deep at night, migrating below 300 metres during the day.

Breeding and development of krill

Krill sexes are separate. During mating, a sperm package is transferred to the female and sperm are stored in a reservoir until eggs are laid and fertilised externally. In the species of *Nematobrachion*, *Nematosceles*, *Nyctiphanes*, *Pseudeuphausia*, *Stylocheiron,* and *Tessarabrachion,* eggs are attached to the posterior three pairs of thoracic limbs until they hatch at the second nauplius (metanauplius) larval stage. As in other *Nyctiphanes* species, *N. australis* females not only retain their eggs until this stage, but also secrete a paired, membranous 'egg sac' to hold the eggs (Brinton et al. 1999). *Nematosceles megalops* lays 220–250 small eggs per brood and *Stylocheiron* species 2–50 larger eggs (Mauchline & Fisher 1969), both taxa being represented in New Zealand. In the remaining genera (58 species), the first nauplius hatches from eggs that are shed directly into the water. Thus krill have two nauplius stages, but in those with attached eggs the first stage is passed through in the egg.



Stylocheiron longicorne.
After Sars 1885

Nauplius larvae swim using their antennae, and all subsequent developmental stages through to the adult are pelagic. The nauplius metamorphoses to the first of three calyptopus stages in which the abdomen develops its full complement of six segments, a telson and uropods. Throughout the calyptopus phase the eyes remain beneath the carapace, and locomotion continues to be provided by the antennae. The final calyptopus moults to the first of several furcilia stages in which the eyes become stalked and free of the carapace, the antennae are no longer natatory, the thoracic legs and gills appear, and, throughout a series of moults, the pleopods and photophores become fully developed. The furcilia passes through various numbers of moults both between and within species and the rate of addition of functional parts varies, depending on environmental conditions. *Euphausia superba* has the least number of furcilia stages of any euphausiid (six) while species of *Thysanoessa* may have as many as 11 stages (Mauchline & Fisher 1969).

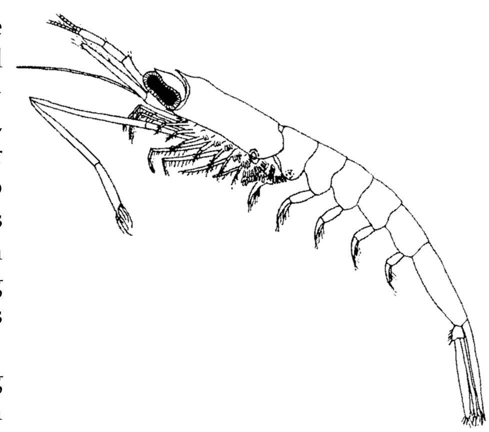
Sheard (1953) described these complex larval phases of the life-cycle in several species that happen to occur in New Zealand waters, including a detailed description of those in *Nyctyphanes australis*. Typical of coastal species, the number of larval instars and the sequence of addition of morphological characters (the developmental pathways taken) in *N. australis* is variable, and more so than in oceanic species. The final furcilia moults to the first adolescent stage with little morphological change.

Food, predation, and parasitism

Krill are omnivorous, feeding on phytoplankton, zooplankton, and organic detritus from bottom sediments. Species with highly fringed feeding limbs use them to filter minute protozoans and algal plankton from the water. The bristles effectively form a fine net to strain food from currents created by the thoracic limbs and pleopods. Species with less setose appendages feed more on zooplankton.

The anterior thoracic limbs can be held in such a way as to form a 'food basket' between them and the mouthparts (Mauchline 1984). Bottom-feeding krill employ two methods of collecting food. In one, the animal approaches the bottom in a near-vertical position and, by beating the thoracic exopods, raises into suspension sediment that is filtered by the mouthparts. In the second method, the animal approaches the bottom at a flatter angle and ploughs up the soft sediments with its antennae to form a lump, which it 'sucks' into the food basket by a sudden lateral movement of the thoracic limbs. This method is also used repeatedly as the animals swim, to trap planktonic prey such as copepods or chaetognaths in the food basket.

Among New Zealand krill, 'round-eye' *Euphausia*, *Nyctiphanes*, and *Thysanopoda* species have more highly fringed feeding limbs than 'bilobed-eye' *Nematobrachion*, *Nematosceles*, *Stylocheiron*, and *Thysanoessa* species. In general, the former group is omnivorous, consuming bottom detritus as well as small plankton and non-living particles from the water column. The two large deep-sea species *Thysanopoda cornuta* and *T. egregia* are also known to eat live prey, having been found with copepods, arrow worms, and juvenile fish in their stomachs (Brinton et al. 1999). Carnivory had been suspected in the latter group of krill because bilobed eyes and elongated legs are thought to be adaptations for the capture of live prey (Mauchline & Fisher 1969). The two large deep-sea species *Thysanopoda cornuta* and *T. egregia* are also known to eat live prey, having been found with copepods, arrow worms, and juvenile fish in their stomachs (Brinton et al. 1999).



Stylocheiron elongatum.
After Sars 1885

Nyctiphanes australis is the only one among the above species whose feeding has been studied in New Zealand waters. Bradford (1972) found maximum numbers of this species in Kaikoura waters underneath concentrations of copepods, eating their faecal pellets. Blackburn (1980) listed diatoms, copepods, and copepod faecal pellets in its diet and McClatchie et al. (1991a) also confirmed omnivory in the species in Otago waters.

Dalley and McClatchie (1989) carried out a detailed study of the feeding morphology of *Nyctiphanes australis* in Otago, and McClatchie et al. (1991a) measured the spaces between setae of the food basket at 2–8 micrometres, the finest of any euphausiid measured to that time. This suggested *N. australis* is equipped to filter nanoplankton-sized particles. However, Dalley and McClatchie (1989) also concluded that the species is an 'opportunistic omnivore' since it has both a mandibular molar process typical of predators and a mandibular palp and stomach armature characteristic of herbivores. Gut contents, measured using a pigment fluorescence technique (McClatchie et al. 1991a), also revealed substantial amounts of chlorophyll pigments from phytoplankton much larger than nannoplankton, consumed directly, or secondarily in the gut contents of prey. The swarming of *N. australis* in Otago Harbour also coincides with the spring diatom bloom (McClatchie et al. 1991a).

Krill are eaten by a wide variety of cetaceans, fish, and birds. Mauchline (1980) listed the euphausiid species, their major predators, and whether they swarm or not, swarming being an important aspect of their consumption in large numbers. Little appears to be known about predators of *Euphausia longirostris* but five of the other six New Zealand *Euphausia* species that swarm are an important constituent in the diets of baleen whales. *Euphausia vallentini* was reported by Nemoto (1962b in Mauchline and Fisher 1969) to be eaten by fin and sei whales in waters south of New Zealand. Among the six species of *Stylocheiron*, only *S. abbreviatum* is reported as swarming, but all are known to be important food for planktivorous and micronektonic fish. Being mesopelagic, *S. maximum* is also found in the stomach contents of some demersal fish. Whales, planktivorous fish, and seabirds all eat *Thysanoessa gregaria* when it swarms at the sea surface but, while *T. macrura* has been found in whale stomachs, much less is known about it as a food item. *Nematosceles megalops* swarms but both it and *N. microps* apparently do not approach the surface and are preyed on by demersal and planktivorous fish. Pelagic and midwater fish feed on *Thysanopoda monacantha,* and whales and demersal fish on *T. acutifrons*.

Studies of feeding in New Zealand fish and seabirds have revealed that *Nyctiphanes australis* plays an important role in their diets. Kahawai (*Arripis trutta*) around Kaikoura depend on *N. australis* for much of their diet (Bradford 1972) and barracouta (*Thyrsites atun*) also eat this species (Bartle 1976). O'Driscoll and McClatchie (1998) used side-scan radar to study schooling behaviour in barracouta off Otago and came to the conclusion that 'schooling of barracouta seems to be a feeding strategy to exploit surface swarms of krill'. They also found that jack mackerel (*Trachurus murphyi*) and slender tuna (*Allothunnus fallai*) prey on *N. australis*. Blackburn (1980) reported that southern bluefin (*Thunnus thynnus maccoyii*) and skipjack tuna (*Katsuwonus pelamis*), common in New Zealand waters, eat *N. australis* off Australia. No doubt other pelagic fish prey on this species, and Fenwick (1978) saw six different species of bottom-dwelling fish attacking a swarm near The Snares.

With the exception of penguins, seabirds can exploit krill only at or near the sea surface. Rockhopper penguin (*Eudyptes chrysocome*) stomachs have been found with *N. australis* remains – mainly eyes, which seem to resist digestion longer than other body parts (Te Papa unpubl. data). Many flying birds also exploit this species, e.g. grey-faced petrels (*Pterodroma macroptera*), fairy prions (*Pachyptila turtur*) (Bartle 1976), and, importantly, black-billed gulls (*Larus bulleri*) (McClatchie et al. 1989). They are eaten at sea by red-billed gulls (*Larus novaehollandiae*) but not by black-backed gulls (*Larus dominicanus*), which prefer stranded krill (McClatchie et al. 1991b).

Krill are hosts to various parasites. Mauchline (1980) listed three types of ectoparasites – ellobiopsid and apostome protozoans and dajid isopods. The effects of ectoparasites on the host are not always obvious but it is thought that they impair swimming, increase the risk of predation, and damage the cuticle, allowing bacterial infections (McClatchie et al. 1990). Among krill species found in New Zealand, *Euphausia lucens*, *E. recurva*, *E. similis*, *E. vallentini*, *Nyctiphanes australis*, and *Thysanoessa gregaria* have been recorded as being infested with the ellobiopsid protozoan *Thalassomyces fagei* (phylum Myzozoa) (Mauchline 1980). Its precise life-history is not known, but *T. fagei* first appears under the upper carapace of the host, sends a root-like structure down among the organs to gain nourishment, then grows a 'neck', up through the carapace, that branches and produces spores. Dajid isopods attach themselves to the cephalothorax of the host. Among the krill recorded in New Zealand, dajids have been observed in *Nematosceles megalops*, *T. gregaria*, and *Stylocheiron longicorne*. McClatchie et al. (1990) discovered that a stalked pennate diatom also grows externally on *N. australis* caught in Otago Harbour, the first record of such an infestation; 50–70% of *N. australis* sampled in the Harbour were infested. The effects of the diatom on the host were unclear but diatom chlorophyll introduced error into their chlorophyll pigment fluorescence experiments on the krills' diet.

Commercial exploitation and resource potential of krill

The publication by Nicol and Endo (1997) on the world's krill fisheries is an accessible and essential reference for anyone interested in the subject. These authors listed six species of krill commercially harvested in various parts of the world – *Euphausia superba* in the Antarctic Ocean, *E. pacifica* off Japan and British Columbia, *E. nana* off southern Japan, *Thysanoessa inermis* off northern Japan and in the Gulf of St Lawrence (eastern Canada), and *T. raschi* and *Meganyctiphanes norvegica* also in the Gulf of St Lawrence. In 1997, the annual catch of krill for human use was estimated at 160,000 tonnes, with *E. superba* the most important species.

Japan is *the* major fishing nation of both Antarctic krill and northern species, but Ukraine and Poland also have an important stake in the Antarctic fishery. Russia, Korea, and Chile have also been involved at various times. Probably of more interest to New Zealand is research carried out in Tasmania on the potential for a fishery there for *Nyctiphanes australis*, since the species is abundant in New Zealand coastal waters as well.

Human uses of krill include food, bait for sport fishing, aquarium food, and aquaculture food, which is the major use. Krill are of high nutritional value and in Japan are also used to add colour to fish flesh for human consumption. Like the exploited species, *N. australis* has also been shown to have high nutritional value. Krill contain a wide variety of biochemicals, some of possible pharmaceutical value, and Nicol and Endo (1997) listed and discussed their properties and potential uses. They also outlined conservation needs for krill. Current catch rates are thought to be far below the potential for sustainable fishing but the importance of krill in marine food-webs is enormous. The probable effects of overfishing on the many bird, cetacean, and fish predators of krill was important in setting the regulatory Convention on the Conservation of Antarctic Marine Resources in 1980.

Scope for future work

New records of krill species found elsewhere can be expected in the New Zealand region and there is a need to clarify the status of species 'forms' and species groups. Compared to the northern Pacific and Atlantic Oceans there is a lack of data on krill in the SW Pacific. Should a fishery for *Nyctiphanes australis* prove commercially viable off Tasmania, investment in further research on this and other species in New Zealand waters will probably follow.

Order Decapoda: Shrimps, lobsters, crabs, and kin

Decapods ('10-footed') are the most familiar crustaceans, numbering more than 10,000 living species worldwide – almost half the named species of Crustacea. They occur in a great diversity of forms and habitats and some are highly specialised. Most decapods are marine, living from above high tide to depths of more than 5000 metres and at all levels of the ocean. Some live in fresh water and on land but all land dwellers, including the forest crabs of tropical latitudes, must have access to water to hatch their eggs and to drink. Decapods range in size from tiny shrimps about a millimetre long to the largest of all arthropods, the giant Japanese spider crab *Macrocheira kaempferi* with claws that can span up to four metres. There are tiny crabs that live out their lives within coral galls and the huge xanthid crab *Pseudocarcinus gigas* of southern Australia that reaches 15 kilograms in weight. While North American clawed lobsters are the heaviest of all crustaceans, the largest rock (spiny) lobster is the packhorse rock lobster *Sagmariasus verreauxi* of New Zealand and eastern Australia that can weigh 16 kilograms.

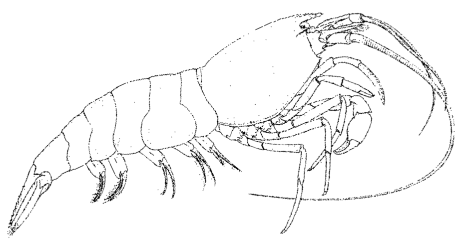
Behaviourally, some shrimps and prawns spend their whole lives swimming, while others associate with various bottom habitats. Lobsters and crabs inhabit all kinds of rocky or soft substrata, some bury themselves temporarily, and others live in permanent burrows in mud and sand. Certain genera of squat lobsters are found only on deep-sea branching corals, while small shrimps are often closely associated with algae, adjusting their colours to blend in. A small number

Carcinologist Rick Webber with a historic specimen of the large packhorse rock lobster *Sagmariasus verreauxi.*

Te Papa Tongarewa

of shrimp species have become specialised fish cleaners and a few decapods are confined to very circumscribed habitats such as coastal anchialine caves, underwater geothermal vents and cold-water or hydrocarbon seeps, or are specialised to live on decaying wood or whale bone.

The relationships of decapods with other orders of Malacostraca continue to be argued as do relationships among decapod groups (e.g. Martin et al. 2009). The classification followed here is that of De Grave et al. (2009). The traditional separation of decapods into natants and reptants has no formal status but is useful when discussing the 'swimming' and 'crawling' members of the order and is used here informally.



Alvinocaris niwa, a hot-vent shrimp.
From Webber 2004

The Decapoda is divided into two suborders, the Dendrobranchiata, which includes the penaeoid and sergestoid prawns with gill lamellae divided into many dendritic branches, and the Pleocyemata, including all remaining Decapoda, whose gill lamellae are not dendritic (gills are lamellar in the caridean shrimps and prawns, Brachyura and most Anomura; filamentous in crayfish, lobsters and some dromiid crabs – see McLaughlin 1980 for description of gill types). The Pleocyemata thus includes the majority of shrimp and prawn species as well as freshwater crayfish, clawed, slipper and rock lobsters, true crabs and king crabs, hermit crabs, and squat lobsters.

Along with all other members of the class Malacostraca, the decapod body consists of five cephalic (head) somites (six if the eyes are taken as representing a separate somite), eight thoracic, and six abdominal somites. Appendages of the anterior three thoracic somites are modified as food-handling maxillipeds, a principal diagnostic character of the Decapoda since other Crustacea have no more than two pairs of maxillipeds, while the legs articulate with the five posterior thoracic segments. In all decapods the cephalic and thoracic segments are fused, and protected by a carapace that extends down each side of the cephalothorax to enclose the gills and form branchial chambers. The carapace varies from more or less cylindrical in shrimps, prawns, and lobsters to rounded and flattened in crabs but it is the abdomen that has undergone the greatest modifications. In the natants, the decapod abdomen is at its largest, most muscular, and least flexible. It is substantial but proportionately smaller in the reptant lobsters and their relatives, and able to be curved under the cephalothorax, but is reduced to a flap normally held firmly beneath the cephalothorax, in crabs and crab-like Anomura. Despite this variation, all but males of a few hermit-crab species retain at least some abdominal pleopods. Pleopods provide propulsion in natant forms and penis-like organs in male decapods, and in female Pleocyemata remain large enough to carry eggs, even in the shell-inhabiting hermit crabs, whose abdomens are soft and pleopod numbers reduced.

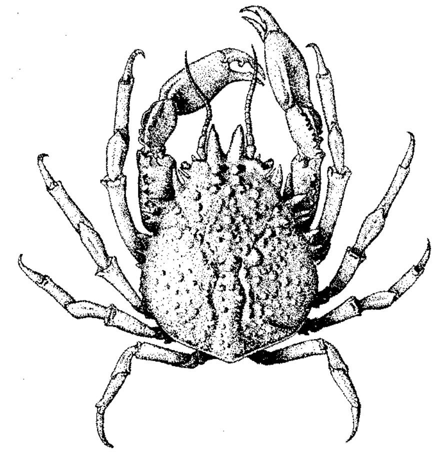
The chitinous integument (exoskeleton) of crustaceans is variously hardened by the addition of calcium salts to increase its strength and rigidity. In crabs and lobsters the skeleton is generally hard and well calcified, except of course at the joints of appendages and abdominal segments, and most extreme in the huge claws of lobsters and mature male crabs. But calcium also adds weight and is therefore minimal in open-water shrimps and prawns. There is also little calcification in burrowing forms, particularly the callianassid 'ghost shrimps', which seldom if ever venture from their protective tunnels, and in hermit crabs the claws and front end of the body are well calcified while the abdomen remains membranous and flexible.

In decapods the sexes are usually separate, although protandry (in which males change to females as they grow) occurs in a number of species and protandric hermaphroditism (where male and female reproductive systems remain functional after the female system develops) has been observed in a shrimp genus. Mating involves the deposition of non-motile sperm, packaged in spermatophores, either externally on the cuticular surface of the female, or internally. Eggs are laid into the surrounding water by dendrobranchs but in the Pleocyemata are retained by the female's pleopods until hatching .

Historical overview of studies on New Zealand Decapoda

Sydney Parkinson, artist on Cook's first voyage to the South Pacific in 1769, illustrated the spider crab now known as *Notomithrax peronii* from material collected in New Zealand. Early settlers and explorers observed and collected intertidal and shallow-water Crustacea (Yaldwyn 1957a) and Cook and his crews traded 'crayfish' with Maori in the Bay of Plenty (Begg & Begg 1969), a hundred years before the species *Jasus edwardsii* (Hutton, 1875) was formally described.

In the last half-century, major reviews of some New Zealand decapod groups have appeared, summarising historical research on these taxa. Forest et al. (2000) monographed the hermit crabs (Diogenidae, Paguridae, Parapaguridae, and Pylochelidae). Their historical account documents an increasingly confused taxonomy of these families in New Zealand, a problem not confined to the hermits. Thirteen years earlier, McLay (1988) published his indispensable book on New Zealand crabs and listed previous contributors to the group. These included Melrose (1975) who reviewed the hitherto poorly known Hymenosomatidae, Griffin (1966) who reviewed the majid spider crabs and their research history, and Bennett (1964) who had himself monographed the Brachyura and provided a critical history of contributions to the group. In two unpublished theses, Yaldwyn (1954, 1959) detailed the history of contributions to New Zealand shrimp and prawn systematics. Wear and Fielder (1985) outlined the very brief history of local larval taxonomy in a monograph on New Zealand brachyuran larvae, a publication that probably advanced knowledge of New Zealand's crab larvae beyond that of any other region.



Spider crab *Notomithrax ursus*.
From Griffin 1966

The first decapod described from New Zealand is probably the shallow-water spider crab *Notomithrax ursus* (Herbst, 1788) collected on one of Cook's voyages. *Halicarcinus planatus* (Fabricius, 1775) may have been the first but McLay (1988) considered this unlikely. No further descriptions of New Zealand material appeared for 46 years (although 14 species now recorded in New Zealand were described from other localities prior to 1834). The mid-1830s saw an increase in taxonomic activity resulting from collections made during exploratory voyages by ships from Europe and North America visiting the New Zealand region.

Several explorations of the region provided early knowledge of decapod diversity. These included d'Urville's first voyage to New Zealand (1826–29) (decapods reported by H. Milne Edwards, e.g. 1834–1840); the U. S. Exploring Expedition (1838–42) (decapods reported by Dana, e.g. 1853–55); HMS *Erebus* and *Terror* (1839–43) (decapods reported by White, e.g. 1847); and the Austrian frigate *Novara* (1857–59) (some decapods reported by Heller, e.g. 1868). Decapoda from early exploratory work were first listed with the 'Annulose Animals' by White and Doubleday (1843) in Dieffenbach's *Travels in New Zealand*. The 1880s were the most significant decade of the 19th century in terms of additions to the fauna. The 1874 French Mission de l'Île Campbell made collections from Cook Strait, Stewart Island, and the subantarctic islands (decapods reported by Filhol, e.g. 1886). HMS *Challenger* visited New Zealand on its round-the-world journey (1873–76) and was the first to sample deep-water stations east and west of the country and off the Kermadec Islands (Yaldwyn 1957). Bate (1881, 1888) reported on the mostly meso- and bathypelagic natants, Henderson (1888) the Anomura, and Miers (1886) the Brachyura. Miers (1876) also compiled a *Catalog of the Stalk- and Sessile-eyed Crustacea of New Zealand* from the literature, museum collections, and a collection borrowed from the New Zealand Government.

New Zealanders began to contribute to local decapod taxonomy with the first publication of G. M. Thomson (1879b) describing two natant species. Thomson went on to make an important contribution to New Zealand crustacean studies, including revisions of the New Zealand hermit crabs (1898) and natants. With Charles Chilton he provided a list of New Zealand decapods for Hutton's (1904) *Index Faunae Novae Zealandiae*. Chilton made a valuable contribution to crustacean systematics in New Zealand in a career lasting more than 40 years. Beginning in 1882 he dealt with a variety of reptants and natants,

King crab *Lithodes aotearoa*.
From Ahyong 2010

from the Subantarctic to the Kermadec Islands and greatly increased knowledge of their distributions. Chilton (1911c) reported on the New Zealand Government *Nora Niven* Trawling Expeditions that covered most of New Zealand's coastlines. His 1910 paper on crustaceans from the Kermadec Islands, collected by Oliver in 1908, remained the major reference to the Decapoda of these islands until the 21st century. The British *Terra Nova* expedition of 1911 sampled a single but very valuable bottom station off Northland from which Borradaile (1916) described brachyurans, hermit crabs, chirostylids, and natants. Decapods collected from the Auckland and Campbell Islands by Mortensen's Pacific Expedition of 1914–16 were described by Stephensen (1927), and Balss (1929) reported on those collected by the 1924 German Expedition to the Subantarctic Islands led by Kohl-Larsen.

Foreign expeditions continue to visit New Zealand but the contribution of local surveys has greatly increased since World War II, such as those organised by university and museum researchers (e.g. Yaldwyn 1957) and the former New Zealand Oceanographic Institute of the DSIR (incorporated into NIWA since 1992). The Ministry of Fisheries' Observer Programme, in which onboard observers monitor commercial fish catches within the EEZ, has yielded a steady flow of interesting decapods from deep water. In addition, NIWA vessels are currently adding new and rare decapods taken in deep water, on and around seamounts and other locations not previously sampled.

In the postwar period, crab systematics was advanced by the work of Richardson (1949a,b) and Dell (e.g. 1960, 1963a,b, 1968a,b, 1971, 1972, 1974), sometimes in collaboration (e.g. Richardson & Dell 1964; Dell et al. 1970). The first recognition of lithodid king crabs in New Zealand waters came from the identification of *Paralomis zealandica* (as *Lithodes* sp.) from Cook Strait by King (1958), and, as deep-water investigations increased, five further species were added (Yaldwyn & Dawson 1970; Dawson & Yaldwyn 1970, 1971, 1985; Dawson 1989; O'Shea et al. 1999), with the total New Zealand fauna now numbering at least 13 species (Ahyong 2010). Schembri and McLay (1983) published an annotated key to hermit crabs of the Otago region that, in the absence of any similar publication, proved a particularly useful guide to identification until the comprehensive review by Forest et al. (2000).

John Yaldwyn of the Dominion (later National) Museum published on several decapod groups but his most extensive contribution concerned the New Zealand shrimp and prawn fauna. In 1957, he described the Sergestidae of Cook Strait, a significant contribution to this difficult group (Yaldwyn 1957b). He and L. R. Richardson published keys to New Zealand's natant decapods (Richardson & Yaldwyn 1958), now outdated but still the only comprehensive guide available. He added numerous new species to the fauna, notably those collected by the Chatham Islands 1954 Expedition (Yaldwyn 1960) and from the National Museum's collection (Yaldwyn 1971), and published or contributed to numerous other works (e.g. Yaldwyn 1954a,b, 1959, 1961, 1974; Yaldwyn & Dawson 1985).

Since 2000, the rate of publication on New Zealand decapod taxonomy has increased Papers on brachyuran crabs have predominated, with the emphasis on collections from the Kermadec Islands (e.g. Takeda & Webber 2006; McLay 2007; Ahyong 2008) and sea mounts and chemosynthetic habitats (Ahyong 2008). Reviews of the chirostylid squat lobsters (Schnabel 2009) and king crabs (Ahyong 2010) added many new species.

It appears the first systematically collected and recorded New Zealand collection of decapods (and other Crustacea) was that of Charles Chilton, who deposited his material in the Canterbury Museum. Another collection of note is that of A. W. B. Powell at the Auckland Institute and Museum, collected in the 1930s and '40s. After World War II, the collection of Decapoda at the then Dominion Museum increased steadily with the efforts of Moreland and Dell and was continued at greater pace by Yaldwyn between 1959 and 1969 and by Webber into the 1990s. This museum collection is particularly strong in offshore natants and decapod larvae but has a wide coverage of New Zealand decapods as well as some valuable material from Pacific Islands. A small collection made by Betty Batham in the 1940s and `50s is housed at the Portobello Marine Laboratory of Otago University. NIWA, Wellington, has a major collection of decapods, which has become the fastest growing in New Zealand.

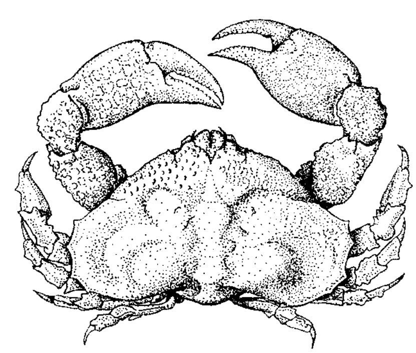
The New Zealand decapod fauna

Some 591 decapod species (492 living, ~99 fossil) are known from New Zealand, not all of them formally named, and there are still more to be discovered. New Zealand's decapod fauna is generally considered depauperate compared to other regions (Dell 1968a), given the extent of the EEZ over 30 degrees of latitude, the exceptionally large area of continental shelf and slope, and the wide variety of seafloor relief and ecological niches available. It is difficult to find comparable areas but the numbers of New Zealand crabs have been compared with South Australia by Dell (1968a) and with the Galápagos, Chile, eastern USA, China, and Japan by Feldmann and McLay (1993). These comparisons certainly indicate the limited nature of New Zealand's crab fauna. This is more simply observed in the lack of variety and number of crabs found on seashores or the small number of locally caught crabs, shrimps, or lobsters in fish shops compared with neighbouring Australia and many places further afield. It is generally felt that this limited diversity of species has resulted from New Zealand's isolation from centres of diversity that might have acted as sources of recruitment. Dell (1968a) suggested that New Zealand's separation from Australia in the Early Tertiary occurred before evolutionary radiation gave Australia its diverse fauna but it is unclear why a similar process has not occurred in New Zealand. It is reasonable to view most of New Zealand's decapod taxa as depauperate but there are exceptions – New Zealand is well represented by southern hemisphere oceanic natants that live independently of shallow water and are less limited by constraints on dispersal, but there is also a high diversity of hermit crabs and some squat lobster genera and the two crab families Majidae and Hymenosomatidae are also well represented.

Taxonomic knowledge of New Zealand's present-day Decapoda is comprehensive for the hermit crabs and squat lobsters, and reasonably good for coastal and shelf natants and the Brachyura, but not so for the thalassinids and penaeoid and sergestoid shrimps and prawns. Present exploration of deep-sea rocky habitats, notably the many seamounts in the New Zealand region, is rapidly increasing our knowledge of decapods in these places. Geographically, the least well-known areas are the Kermadec Islands (although knowledge of the shallow-water crab fauna is rapidly increasing), and much of the west coast of New Zealand.

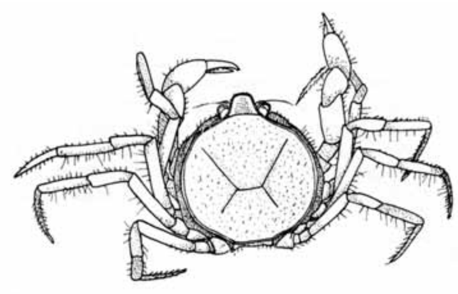
Decapods are an important component of the luxury food market worldwide. Despite New Zealand's limited variety of edible species, some nevertheless support very valuable fisheries, most notably the red rock lobster *Jasus edwardsii*. Interest in developing new crustacean fisheries is growing, and considerable research effort is now expended on ways of improving rock-lobster productivity and quality through habitat enhancement, ongrowing of juveniles, and the possibility of culturing.

The main collections of New Zealand decapods are held at the Museum of New Zealand and NIWA, but considerable historic collections and the majority of types are kept at the Natural History Museum (London) and the Muséum National d'Histoire Naturelle in Paris. Other significant collections are located in the Senckenburg Museum (Frankfurt) and the Australian Museum (Sydney), while further important material resides in a number of other institutions, notably Museum Victoria, the U. S. National Museum of Natural History, and the National Science Museum in Tokyo. The largest type collection in the country is housed at the Museum of New Zealand, where there are 202 lots, including just 42 primary types. A smaller collection of types is held by NIWA and type material is also kept at Auckland, Canterbury, and Otago Museums.



Endemic triangle crab
Eurynolambrus australis.
From Griffin 1966

A total of 492 living decapod species have been recorded within New Zealand's EEZ (see end-chapter checklist). When the first Decapoda checklist was compiled for Species 2000 New Zealand in 2002 the classification used was that of Martin and Davis (2001). The greatest effect their revised classification had on the hierarchy of New Zealand decapods was to increase the number of families recognised locally, mainly by raising subfamilies to family status, especially in the Brachyura. Since then, there has been less change in the classification of shrimps and prawns and other non-brachyuran groups but changes continue to be made in brachyuran families (e.g. Ng et al. 2008). New Zealand has 84 of the 151 families of Martin and Davis (2001) although a large proportion of them (43%) contain only one or two species (20 with only one species, 15 with two). In contrast, the three most species-rich families contain 112 species, or almost a quarter of the decapod fauna. Of these three, the Galatheidae has the greatest number with 46 species, the Paguridae with 34 species and the Chirostylidae with 33. The Chirostylidae also includes the most speciose New Zealand genus, *Uroptychus*, with 27 named species. The largest natant family is the Oplophoridae with 18 species, all named. Among the subfamilies raised to family in Martin and Davis (2001) are those of the superfamily Majoidea (previously family Majidae), which contains 33 species. Despite this division, however, the previous subfamily Majinae (now the Majidae in the strict sense) contains 17 species, almost as many as the largest New Zealand brachyuran family, Xanthidae (18 species).



Freshwater hymenosomatid crab *Amarinus lacustris*.
From Melrose 1975

Endemism

Of the 492 living New Zealand decapods known, 12 are unnamed or not yet fully determined. The level of endemism is only ~30% (144 species). As might be expected, endemism is lowest in pelagic offshore species and highest among benthic and shallow-water forms. Thus all seven dendrobranch families (23 named species, two undetermined) contain no endemics at all and the four pelagic carid families Nematocarcinidae, Oplophoridae, Pandalidae, and Pasiphaeidae (44 species in total) include only one endemic species. New Zealand's dearth of nearshore pelagic natants in any of these groups is reflected in this low endemism and, although an estimated 35 additional penaeoid and sergestoid species may be anticipated for the fauna, few if any are likely to be restricted to New Zealand waters. Subtract offshore natant groups from the named decapods and the proportion of endemics rises. But lower endemism is not characteristic of all natants – of the 471 named living New Zealand Decapoda, 97 are carid shrimps of which 30 (~31%) are endemic, the same proportion as for the reptants alone, of which 106 (~31%) are confined to the New Zealand region. Ten of the 253 New Zealand decapod genera are endemic, viz the brachyurans *Eurynolambrus*, *Halimena*, *Heterozius*, *Jacquinotia*, *Neohymenicus*, *Neommatocarcinus*, *Nepinnotheres*, *Pteropeltarion*, and *Trichoplatus* and the slipper lobster genus *Antipodarctus* – all of which contain a single species. One family, Belliidae, is endemic.

Most New Zealand species of Crangonidae and Palaemonidae are endemic, as are both species of Spongicolidae, probably reflecting their close association with hexactinellid sponges. There is also higher-than-average endemism of Axiidea and Gebiidea (former Thalassinidea), Diogenidae, and Paguridae. This is in contrast to the deeper-water hermit crabs of the Pylochelidae and Parapaguridae, which each have only a single endemic species.

Native paddle crab *Ovalipes catharus*.
Shane Ahyong

While the two freshwater parastacid crayfish *Paranephrops planifrons* and *P. zealandicus* and the only freshwater shrimp *Paratya curvirostris* are endemic, the freshwater hymenosomatid crab *Amarinus lacustris* is not, occurring also at Norfolk and Lord Howe Islands and in southeastern Australia and Tasmania.

A number of rarely caught deep-sea species previously thought to be endemic to New Zealand have been found in greater numbers and further afield, particularly in southeast Australian waters (e.g. *Lipkius holthuisi*, *Teratomaia* *richardsoni*). The apparent endemism and rarity of some deep-sea species are probably the result of insufficient sampling. Endemism in New Zealand's second-largest crab family, Majidae, is rather low at 35% (six of 17 species) but includes intertidal (e.g. *Notomithrax peronii*) and shelf/slope (e.g. *Thacanophrys filholi*) taxa. Hymenosomatid crabs are well represented in New Zealand and 10 of the 14 species (71%) are also endemic. One of the non-endemics, *Halicarcinus innominatus*, is thought to be of New Zealand origin but accidentally introduced to Tasmania.

New Zealand's two species of Pinnotheridae (pea crabs) are both endemic, as might be expected of shallow-water associates of bivalve molluscs, but endemism in the crab families Portunidae (paddle crabs) and Xanthidae is quite low at less than 30%. Just three of 11 native portunids and three of 15 native xanthids (all found only at the Kermadec Islands) are endemic. Portunids and species of Varunidae tend to have long larval lives and some are able to travel great distances as adults so that most species are distributed widely. Even New Zealand's only terrestrial decapod, *Geograpsus grayi* of the Kermadec Islands, is widespread in the Indo-West Pacific.

Of New Zealand's 132 endemic decapods, 14 are recorded from the Kermadec Islands and nine are restricted there. Five are hermit crabs, all from moderately deep water except *Pagurixus kermadecensis*, which is found in rock pools. Like a number of other apparent endemics, the shrimp *Stylodactylus discissipes* is known from only a single station at 1100 m depth and is likely to be more widespread.

Ecological studies

Paddle crabs (*Ovalipes catharus*) are numerous enough to comprise a small fishery, encouraging investigation of marketing (Cameron 1984) and reproductive biology (Haddon 1994, 1995; Haddon & Wear 1993). University research has made a considerable contribution to decapod biology, particularly that carried out over the years by Malcolm Jones and Colin McLay (Canterbury) and Bob Wear (Wellington), with their students. The physiology of musculature, haemolymph, locomotion, and eye function in shore crabs have been addressed (e.g. Jones & Greenwood 1982; Bedford et al. 1991; Forster 1991; Meyer-Rochow & Reid 1994; Palmer & Williams 1993; Meyer-Rochow & Meha 1994; Depledge & Lundebye 1996) as have the effects of low oxygen and varying pH on freshwater shrimp (West et al. 1997; Dean & Richardson 1999). Feeding studies of shore crabs were carried out (e.g. Wear & Haddon 1987; Creswell & McLay 1990; Woods 199l; Woods & McLay 1994). Jones (1976, 1977, 1978, 1980, 1981), Jones and Winterbourn (1978), and Jones and Simons (1981, 1982, 1983) undertook significant work on intertidal crabs of the Avon-Heathcote Estuary and Kaikoura, and other ecological studies were made by McLay and McQueen (1995), Palmer (1995), and Morrisey et al. (1999). Several papers on the behaviour and associations of shore crabs have also appeared (e.g. Field 1990; Taylor 1991; Chatterton & Williams 1994; Woods & McLay 1994; Woods 1995; Woods & Page 1999) and Berkenbush and Rowden (1998, 1999) studied population dynamics and sediment turnover in the burrowing ghost shrimp *Callianassa filholi*.

Alien species

Interest in adventive species is growing rapidly in New Zealand (see Cranfield et al. 1998 for a list of adventive decapods and the Ministry of Fisheries for details of potential invaders (Marine Pest Identification Guide series)). Some decapods have been introduced intentionally but mostly without success; this is probably a good thing as some crab and lobster species are among the most destructive of invaders. The first such introduction appears to have been of the Australian penaeid prawn *Melicertus canaliculatus* (as *Penaeus canaliculatus*), released at Nelson in 1892 and at the entrance to Otago Harbour in 1894 (Thomson 1922). They were never seen again. Between 1906 and 1918, a more serious attempt

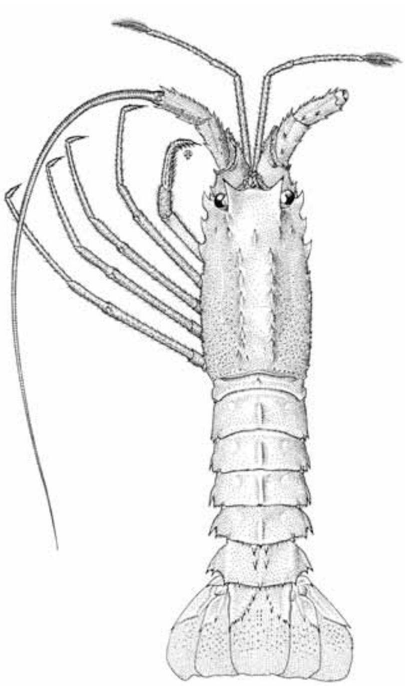
Alien paddle crab *Charybdis japonica*.
Shane Ahyong

was made to introduce the European lobster *Homarus gammarus* into New Zealand. A similar project was undertaken with the European edible crab *Cancer pagurus* between 1907 and 1914 (Thomson & Anderton 1921). Live crabs and lobsters were imported from the United Kingdom and kept at the Portobello Marine Fish-Hatchery in Otago Harbour. Several million crab larvae and more than 750,000 lobster larvae were hatched and liberated in the harbour during those years. Some young lobsters were reared for several years before release, and mature adults of both species were also liberated but no trace of free-living specimens of either species has been found in Otago or New Zealand waters since.

There was a short-term attempt in the early 1990s to farm a 'saltwater king prawn' from Hong Kong, probably the penaeid *Fenneropenaeus chinensis*, at South Kaipara Heads. Like the *H. gammarus* and *C. pagurus* experiments this also failed but in this case the stock was destroyed. So too was the entire stock at a pond farm of the Western Australian crayfish or marron, *Cherax tenuimanus*, at Warkworth, north of Auckland in the late 1980s and early 1990s (Hughes 1988; Lilly 1992). Fear of their escape into waterways led to this action but the same problem does not occur with large palaemonid prawns farmed at Wairakei, near Taupo. Here, *Macrobrachium rosenbergii* from South-east Asia and northern Australia is successfully farmed in artificially heated water. This is drawn from the Waikato River and warmed by a heat exchanger using hot-water runoff from a geothermal power station nearby. *Macrobrachium rosenbergii* cannot breed or survive in ambient New Zealand fresh waters.

Foreign decapods periodically appear accidentally in New Zealand, apparently introduced in ships' ballast water or on hulls. Some species disappear but others threaten to become established and compete with the local biota. The hymenosomatid crab *Halicarcinus ovatus*, normally found around western, southern, and eastern Australia, was recorded just once at Port Chalmers, Otago, by Filhol (1886) but has not been recorded in New Zealand since (Melrose 1975; McLay 1988). In 1978, the small inachoidid spidercrab *Pyromaia tuberculata*, originally from the Central American west coast but subsequently found in other localities in the Pacific and Atlantic Oceans, was discovered in the Firth of Thames (Webber & Wear 1981). It has become established but is not often found and does not seem to be a major threat to endemic species.

In the early 1990s live specimens of three species of crab were found in a ship's sea chest at a Nelson slipway – *Pilumnus minutus*, *Carupa tenuipes*, and *Charybdis hellerii* (Dodgshun & Coutts 1993). The significance of sea chests (recesses in ship hulls housing the intakes of ballast water) as a mode of introduction quickly became apparent. *Pilumnus minutus* is small and uncommon and *C. tenuipes* tropical, and neither is likely to become established, but the Asian and northern Indian Ocean portunid *C. hellerii* is a successful invader of the eastern Mediterranean and western Atlantic from Florida to Brazil. It is unlikely that *C. hellerii* could establish itself in New Zealand, except perhaps in the far north, but a close relative has. First reported from Waitemata Harbour in 2001, hundreds of *Charybdis japonica*, including egg-bearing females, have since been caught, and it is also present in the Firth of Thames (Webber 2001; Smith et al. 2003). Almost as large, and far more aggressive than the paddlecrab *Ovalipes catharus*, *C. japonica* is likely to exclude the local species from harbour and estuary mouths but is unlikely to spread to open sand beaches or much further south, as it is a warm-water species. Its behaviour in nets causes problems for flounder fishers but if it remains in large-enough numbers, it may at least become a new fishery.



Projasus parkeri, a recent palinurid.
W. Richard Webber

Introductions have also occurred in the opposite direction. The small hymenosomatid crab *Halicarcinus innominatus* and the larger pie-crust crab *Metacarcinus novaezelandiae* were probably accidentally introduced to Tasmania when *Ostrea angasi* was imported from New Zealand to enhance the oyster fishery (Lucas 1980).

New Zealand fossil Decapoda

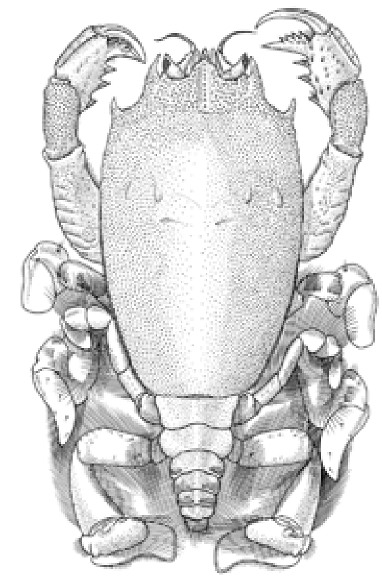
The fossil decapod fauna comprises approximately 99 species, although only 56 of these are named unequivocally owing to the high proportion of small or unique specimens or their often incomplete or fragmentary state. There are 48 named genera in 27 families, and six of the seven Recent reptant infraorders (only Polychelida lacking), and only the Glypheidea (superorder Pleocyemata) among the natants. Nineteen of the 58 Recent reptant families include fossil species, with five families represented in New Zealand only by fossils. Some 22 fossil genera also occur in the present-day New Zealand fauna and four Recent species are represented in the New Zealand fossil record, possibly six, should fossil *Ctenocheles* cf. *maorianus* and *Ommatocarcinus* cf. *Neommatocarcinus huttoni* prove indistinguishable from their living namesakes.

Although the fossil decapod fauna of 99 species is small relative to the present-day fauna, recent research has revealed its significance to the origins of decapods in New Zealand and in the South Pacific (Feldmann 2003). The xanthid crab *Tumidocarcinus tumidus* was the first fossil decapod described from New Zealand, but 94 years were to elapse before additional records were published. Glaessner (1960) published his signal work on the New Zealand fossil Decapoda, recognising 29 species in eight genera, including a new genus and 16 new species. Most of these were brachyurans (22 crabs in seven families) but Glaessner also identified five callianassid ghost shrimps and three astacoidean lobsters of the families Glypheidae and Mecochiridae. In addition, he described the palinurid rock lobster *Sagmariasus flemingi* (as *Jasus flemingi*), the only fossil yet discovered among the nine Recent species of non-stridulating Palinuridae (*Jasus*, *Projasus*, and *Sagmariasus* species, all austral).

Glaessner's (1960) work remains the most important contribution in terms of numbers of taxa added to the fossil fauna, although subsequent work has trebled the known fauna. Only three more new species were added to the fauna during the 1960s and 1970s, but momentum and diversity then increased, with nine new species described in the 1980s and 16 in the 1990s. Crabs predominate among the new records, but several other new taxa have also been identified, leading to fresh interpretations of their origins and relationships to Recent forms. For example, New Zealand's first fossil nephropid lobster, *Metanephrops motunauensis*, was described from north Canterbury.

The first decapod added to the fauna by a New Zealand worker (*Trichopeltarion greggi*) was also the first fossil species of the extant family Atelecyclidae (Dell 1969). The tymoloid family Torynommidae was erected by Glaessner (1980) to contain several extinct Australasian crabs including two new New Zealand species, and in the same paper Glaessner named three new species of raninids for New Zealand. Hyden and Forest (1980) described the first, and so far the only named, fossil hermit crab from New Zealand (*Diacanthurus spinulimanus*), and the late Sir Charles Fleming (1981) described *Miograpsus papaka*, so far the only fossil grapsid recorded from New Zealand.

The description of the squat-lobster-like anomuran *Haumuriaegla glaessneri* was significant, both for the implications it had for the interpretation of New Zealand's fossil record and as the beginning of a major and continuing contribution to New Zealand decapod palaeontology by its author (Feldmann 1984). *Linuparus korura* was the second palinurid added to the New Zealand fossil fauna (Feldmann & Bearlin 1998) and Feldmann and Maxwell (1999) described five more decapods – two raninids, two majids, and a single goneplacid, the first New Zealand fossil of the genus *Carcinoplax*. At this point, a review of the fossil decapods of New Zealand by Feldmann and Keyes (1992) appeared, listing all previously published records, giving a detailed index of locality records and an updated checklist of taxa, and tabulating their stratigraphic ranges in the Mesozoic and Cenozoic. Some 81 decapods were recorded, although just 38 species were named. Forty genera were recorded in 21 or 22 families, a considerable increase from the eight genera in 11 families recognised by Glaessner (1960). Five more



Native frog crab *Notosceles pepeke*.
From Yaldwyn & Dawson 2000

new species were soon added to the fauna by Feldmann (1993), including the first published record for New Zealand of the Calappidae (*Calappilia maxwelli*), the first record of the genus *Glyphea* (*G. stilwelli*), and one further species in each of the Holodromiidae, Torynommidae, and Majidae.

Feldmann and Keyes' (1992) review and McLay's (1988) survey of New Zealand's Recent crab fauna were closely followed by a substantial paper on the paleogeographic history of the New Zealand Brachyura (Feldmann & McLay 1993). In their analysis, these authors compared New Zealand's extant Brachyura with that of other, mostly Pacific, regions and went on to identify significant relationships not recognised previously between New Zealand's Recent and fossil faunas. A number of new taxa have come to light since these works, supporting their observations.

The first recognition of the family Parastacidae in the fossil record (*Paranephrops fordycei*) was published from a single specimen found in Miocene deposits of Central Otago (Feldmann & Pole 1994). Two further majids were added to the fauna by McLay et al. (1995) and a new cancrid by Feldmann and Fordyce (1996). The world's first fossil lithodid (king) crab (*Paralomis debodeorum*) was described only in the 1990s (Feldmann 1998), along with a glypheid lobster, *Glyphea christeyi* (Feldmann & Maxwell 1999), both from Canterbury.

The origins of New Zealand's decapod fauna are far from clear and continue to be debated, particularly because of fossil discoveries over the past 20 years in both New Zealand and Antarctica. Until the early 1980s it was believed that New Zealand's decapod fauna was primarily of Australian and Indo-Pacific origin. Glaessner's (1960) Tertiary material occurred no earlier than the middle Eocene (45–50 million years ago). He considered the presence of *Tumidocarcinus* in the middle Tertiary of Australia and in the Eocene and Miocene of New Zealand as indicative of a 'distinctive zoogeographical province' and that Australasian genera could be considered as originating in the ancient Tethys Sea. Fleming (1962, 1979) also concluded that New Zealand decapods were primarily of Tethyan origin and that typical New Zealand marine decapod faunas had appeared since the Oligocene. In his analysis of the distribution and composition of New Zealand's extant Brachyura, Dell (1968a) found that the strongest external elements in the present-day crab fauna are Australian and Malayo-Pacific in practically equal strength, which also implies a Tethyan origin.

Planktonic zoea larva of the majid crab *Jacquinotia edwardsii*.
W. Richard Webber

The late Mesozoic *H. glaessneri* from North Canterbury was a shallow-water marine species and the earliest known representative of the extant freshwater anomuran family Aeglidae, which is confined to temperate latitudes of southern South America. This discovery, and analysis of fossil and recent species of *Lyreidus* (Raninidae), led Feldmann (1984, 1986, 1990) to believe that these and other decapod genera had evolved in high-latitude southern waters rather than originating in the Tethys. This occurred during the late Mesozoic prior to New Zealand's split from Australia and Australia's split from Antarctica, which also had a cool-temperate climate. Feldmann considered that species evolving along this coast would be dispersed eastwards by the southern Pacific gyre but that this would have discontinued with a cooling climate and the break of Australia from the Antarctic, allowing the circumpolar current to develop.

Newman (1991), however, questioned this view and suggested that taxa like the entirely austral *Jasus* species may have resulted by reliction (reduction in range) following an amphitropical (northern as well as southern hemisphere) distribution. He offered three hypotheses on how such southern hemisphere endemism could have come about – centres of origin, dispersal to the southern hemisphere, or vicariance (see Newman 1991).

This debate continues, with research on fossil decapods worldwide increasing in recent years. Schweitzer (2001) has summarized decapod paleobiogeography and the diverse literature on decapod fossils and their interpretation was reviewed by Feldmann (2003).

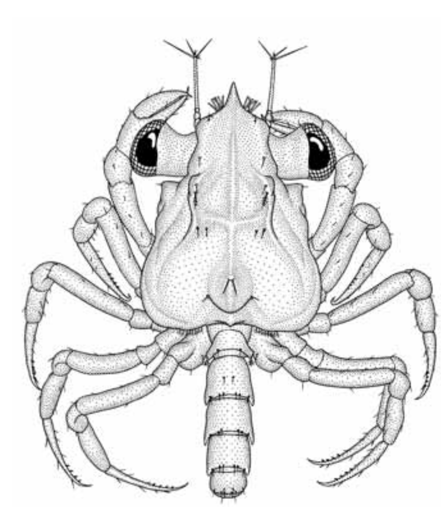
Decapod development

No discussion of decapod diversity would be complete without reference to their larvae. The morphology of decapod developmental stages is an important aspect of decapod systematics, and knowledge of larval biology and recruitment to adult populations is essential to managing decapod fisheries.

Development in the great majority of Decapoda, both natants and reptants, includes free-swimming planktonic larvae. In the penaeoid and sergestoid (dendrobranch) shrimps and prawns, eggs are laid into the surrounding water and tiny, motile nauplius larvae subsequently hatch into the plankton. All other decapod groups (the Pleocyemata) retain their eggs attached to the pleopods until larvae hatch. In the plankton, larvae grow through a series of instars until, at the final moult, they metamorphose into a post-larva, an intermediate form looking more or less like the adult but retaining the ability to swim. The role of the post-larva is to relocate itself to the milieu of the adult phase where it again moults to become a juvenile crab, lobster, shrimp, or prawn. Like their larvae, shrimps and prawns are pelagic. The transition from larva through post-larva to juvenile is less abrupt although the final larval moult is still marked in pelagic species by a fundamental change in locomotion from using appendages of the cephalothorax to propulsion by the abdominal appendages (pleopods).

Most decapod families have different though predictable numbers of larval growth stages and a single post-larva during development, but a few groups and species have either extended or abbreviated development. Some have even eliminated free-swimming larval or post-larval phases altogether, with juveniles hatching directly from the eggs. The number of larval stages relates to the duration of the larval phase, and those species with abbreviated or direct development usually occur in habitats where free-swimming larvae would be lost. Some of these different strategies are exemplified by New Zealand Decapoda.

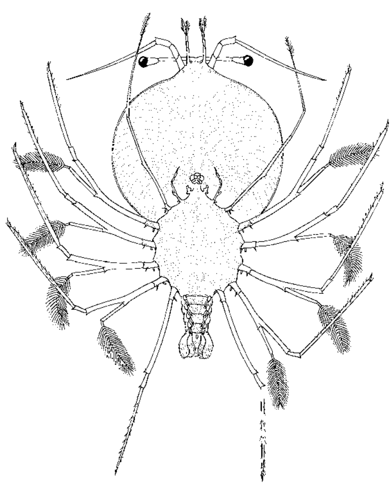
Larval decapods are of taxonomic interest because they differ morphologically from adults. This is particularly so in benthic forms, which make up the majority of decapod species and occupy very different habitats from their offspring. Pelagic larvae have evolved their own adaptations to planktonic life, yet the medium they frequent is in many ways more uniform than the variety of substrata or depths occupied by the adult phase, which serves to emphasise the importance to taxonomy of differences in larval features.



Megalopa larva of spider crab *Notomithrax minor*.
From Webber & Wear 1981

Limits to the use of larval features are more practical than theoretical, however; while larvae caught in plankton can usually be attributed confidently to higher taxa, incorrect identifications of genera and species based on morphology are often made (e.g. McWilliam et al. 1995). The only foolproof method of putting names to larvae caught in plankton is to hatch them from eggs of known parentage or rear planktonic larvae through to identifiable adults. Since Vaughan Thompson (1828) first put the provenance of decapod larvae beyond doubt by observing larvae hatching (see Gurney 1942), rearing techniques have improved, but maintaining ovigerous females and their delicate offspring in captivity, even when robust berried females can be caught, is always difficult and sometimes impossible. However, this impasse has begun to be resolved in the last few years as molecular analysis has enabled more precise matching of adult and larval forms. DNA analysis has even enabled the type species of some old larval genera and species to be matched to the adults they correctly belong with (Palero et al. 2008).

New Zealand's larval decapods, particularly the Brachyura, are comparatively well known, thanks largely to the work of Robert Wear and his students (1965–1985) at Victoria University in Wellington. Their efforts are summarised in two particularly useful publications. One (Wear & Fielder 1985) consists of a comprehensive illustrated atlas of all previously described New Zealand brachyuran larvae, with keys and some new descriptions; the other (Wear 1985), is an annotated list of all non-brachyuran New Zealand species whose larvae had been described to that time. Prior to 1985, numerous authors published descriptions of New Zealand decapod larvae but only the more significant are referred to here. Thomson and Anderson were the first New Zealanders to describe the larvae of brachyurans of the region, hatched at Portobello marine station. Prior to the 1960s, the most substantial contribution to New Zealand larval taxonomy was made by Gurney (1924, 1936, 1942), who described eight decapod species (in seven families) collected by the *Terra Nova* and *Discovery* Expeditions. Webber (1979) described the developmental stages of eight majid spider crabs, published later by Webber and Wear (1981). Larvae of 12 species of carid shrimps, in the families Crangonidae, Hippolytidae, and Palaemonidae, were described in detail by Packer (1983) who published a guide to these and six other shallow-water shrimp species in 1985. Since then, the output of larval taxonomy has slowed. Horn and Harms (1988) completed the larval description of *Halicarcinus varius*; Lemaitre and McLaughlin (1992) described the megalopa of the deep-water parapagurid *Sympagurus dimorphus*; the complete development of the packhorse rock lobster *Sagmariasus verreauxi* was described by Kittaka et al. (1997); and those of the red rock lobster *Jasus edwardsii* by Kittaka et al. (2005) from lobsters cultured in Japan; Cuesta et al. (2001) re-examined the zoeas of *Cyclograpsus lavauxi*, *Hemigrapsus sexdentatus*, and *H. crenulatus*; and detailed descriptions of the phyllosomas and nisto of a slipper lobster *Scyllarus* sp. Z (probably *S. aoteanus*) were published by Webber and Booth (2001).

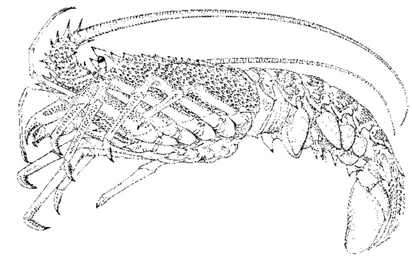


Final phyllosoma larval stage of the rock lobster *Jasus edwardsii*.
From Kittaka et al. 2005

Developmental stages of 94 species (21%) of New Zealand Decapoda have been described, but a much greater proportion of higher taxa is represented by this number. Descriptions of larvae, post-larvae, or both have been published from 45 (54%) of the 84 families recorded from New Zealand. These percentages reflect the high proportion of families containing only one species (larval descriptions of single species account for 27 families) but it also indicates the broad spectrum of decapods whose various larval forms are known to some degree. Best documented are the Brachyura, with 22 of New Zealand's 39 families represented by larval descriptions. The remaining 17 families contain 54 of the 167 brachyuran species, while, in the larger families, 11 of 14 hymenosomatid and five of 12 portunid species include larval descriptions.

Descriptions of all stages in the development of New Zealand's crayfish and lobsters were completed relatively recently, but commercial interest has now generated considerable investment in research into all aspects of their biology. The freshwater crayfish *Paranephrops planifrons* provides an example of direct development in which there are no larval stages and crayfish hatch from the eggs (Hopkins 1967). Young crayfish, with the cephalothorax packed with yolk, attach themselves to the female's pleopods and pass through three stages with the third having exhausted its supply of yolk. Development in scampi (*Metanephrops challengeri*) is not direct but apparently abbreviated. Wear (1976) found that while larvae hatch as prezoeas the prezoeal cuticle is quickly shed and the single-stage large zoea appears to last only two to three days or less before moulting to the post-larva. Scampi zoeas are not found in surface plankton and have a restricted ability to swim, which led Wear (1976) to suggest they are very short-lived and settle as a post-larva soon after hatching.

At the other end of the scale are the palinurid and scyllarid lobsters. New Zealand's rock lobsters *Jasus edwardsii* and *Sagmariasus verreauxi*, and slipper lobsters whose larval development is known (*Ibacus alticrenatus* and *Scyllarus* sp. Z), are typical of the Palinuroidea in having a long-lived larval phase. Longest of all is that of *J. edwardsii*, with 11 phyllosoma stages that can last more than a year, perhaps as long as 24 months, in the plankton (Booth & Phillips 1994). *Sagmariasus verreauxi* has a similar number of stages but of shorter duration (up to a year) (Booth & Phillips 1994), *I. alticranatus* still shorter (4–6 months) with seven stages (Atkinson & Boustead 1982), and *Scyllarus* sp. Z with 10 phyllosoma stages that probably have a duration as short as or shorter than *I. alticrenatus*. Planktonic larval sampling has concentrated on *J. edwardsii* because of its high economic value, but the incidental capture of phyllosomas of other species has enabled useful comparisons to be made. After hatching and shedding the naupliosoma cuticle, early-stage phyllosomas drift out to sea. Most sampled mid- to late-stage larvae of *J. edwardsii* appeared to become entrained in the Wairarapa Eddy southeast of the North Island, while those of *Scyllarus* sp. Z are found much closer to the North Island east and northeast coasts but also in oceanic waters to the north and northwest of New Zealand (Webber & Booth 2001). While mid- and late-stage *J. edwardsii* are rarely found inside the continental-shelf break, all stages of *Scyllarus* sp. Z are found there in good numbers, indicating that they go through larval development closer to shore. This accords with the much shorter larval duration in the scyllarid species and it is assumed that the widely scattered phyllosomas to the north and northwest are lost. The distribution of adult *Scyllarus* sp. Z is confined to the northeast coast of the North Island between Cape Maria van Diemen and Gisborne and is completely overlapped by *J. edwardsii*, yet the larvae they produce become distributed in different geographical areas. Phyllosomas have very limited ability to swim horizontally but they can move vertically through the water column. Coupled with changing phototactic responses during development, vertical mobility enables larvae to exploit currents flowing in different directions at different depths, a strategy that enables them to position themselves in water masses from which they can return to the coast as post-larvae (Webber & Booth 2001).



Rock lobster *Jasus edwardsii*.
W. Richard Webber

Commercial exploitation and resource potential of decapods
Studies of decapod biology and ecology have increased in the last half-century, especially of commercially important species. Early surveys of fishing potential included the southern spider crab *Jacquinotia edwardsii* (Ritchie 1970, 1971; Ryff & Voller 1976), prawns in the Bay of Plenty in the 1970s, and experiments aimed at culturing freshwater crayfish. As one of New Zealand's most valuable fisheries, *Jasus* rock lobsters are the subject of numerous and continuing studies. Their movements and migratory behaviour have been investigated for more than 30 years (e.g. Street 1969, 1971, 1973, 1994; Annala 1981; McCoy 1983; Booth 1984, 1997; MacDiarmid 1991, 1994; MacDiarmid *et al*. 1991; Andrew & MacDiarmid 1991; Annala & Bycroft 1993; Kelly 1995; Babcock et al. 1999; Butler et al. 1999; Kelly et al. 1999). Because rock lobsters have pelagic larvae and post-larvae, research has been carried out on the ecology and recruitment of developmental stages to adult populations (Booth 1979, 1986, 1994, 1995, 1997; Hayakawa et al. 1990; Booth & Grimes 1991; Booth et al. 1991; Booth & Stewart 1992; Booth & Phillips 1994; Booth & Kittaka 1994; Booth et al. 1998, 2000; Nishida et al. 1995; Chiswell & Booth 1999; Chiswell & Roemmich 1999). Rearing of New Zealand lobster larvae has advanced greatly (Kittaka 1994a,b; Kittaka et al. 1997; Tong et al. 1997, 2000a,b; Moss et al. 1999), while additional research on their biology and fisheries has also appeared (e.g. Booth & Breen 1994; James & Tong 1998; MacDiarmid & Butler 1999a,b). Genetic techniques have been employed to improve *Jasus* species stock identities (Ovenden et al. 1992; Ovenden & Brasher 1994; Booth & Ovenden 2000). Allozyme variation has also been identified in scampi populations around New Zealand.

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Checklist of New Zealand living Crustacea

The following classification is based mostly on Martin and Davis (2001). All species are to be regarded as marine unless indicated otherwise by habitat codes.

All species: A, adventive; B, brackish/estuarine; C, commensal; E, endemic; F, freshwater; S, supralittoral; T, terrestrial; *, unpublished (new) record; ? after a genus name or before a species name indicates uncertainty or a possible misidentification. Endemic genera are underlined (first mention).

Notostraca: Hs, hypersaline environments.

Cirripedia: Letters in parentheses following new records indicate where material is held, i.e. AUT (Earth and Oceanic Sciences Research Centre, Auckland University of Technology); GNS (GNS Science, Lower Hutt); NIWA (National Institute of Water & Atmosphere, Wellington); UA (Geology Department, University of Auckland).

Other groups, especially Copepoda: Habitat codes – Be, benthic; L, littoral; Sl, sublittoral (to ca. 10 metres depth); Sh, shelf (ca. 10–200 metres depth); Ba, bathyal (> 200 metres depth); Bp, benthopelagic; Co, coastal; F, freshwater (including wells, as well as species found in terrestrial mosses as they comprise an essentially aquatic habitat); O, oceanic; P, parasitic; Pe, pelagic (planktonic); Ep, epipelagic; Me, mesopelagic; By, bathypelagic; Ph, phytal (if marine, usually in algal and seagrass communities in the littoral or sublittoral, but W indicates decaying or mollusc-bored wood, which may have been dredged from depths up to 2000 metres. If freshwater, usually in algal or flowering-plant communities but M indicates moss or liverwort and includes water courses and damp terrestrial situations. Zoogeography codes: Ant, Antarctic; Ca, Campbell Island; Ch, Chatham Islands; Sa, subantarctic; Sn, Snares Islands; Tr/St, tropical/subtropical; Tz, transition zone; W, widespread.

Amphipoda: Families of the section Gammaridea sensu Barnard and Barnard (1983) (Barnard's 1969 family Gammaridae), follow Barnard and Barnard (1983) and Barnard and Karaman (1991). Known unpublished amphipod taxa are not included in the list.

SUBPHYLUM CRUSTACEA
Class BRANCHIOPODA
Subclass PHYLLOPODA
Order ANOSTRACA
ARTEMIIDAE
Artemia franciscana Kellogg, 1906 Hs A?

Order NOTOSTRACA
TRIOPSIDAE
Lepidurus apus viridis Baird, 1850 F

Order DIPLOSTRACA
Suborder SPINICAUDATA
LIMNADIIDAE
Eulimnadia marplesi Timms & McLay, 2005 F E

Suborder CLADOCERA
Infraorder ANOMOPODA
BOSMINIDAE
Bosmina meridionalis Sars, 1904 F
CHYDORIDAE
Alona abbreviata Sars, 1896 F
Alona affinis s.l. (Leydig, 1860) F
*Alona camboue*i Guerne & Richard, 1893 F
Alona guttata s.l. Sars, 1862 F
Alona quadrangularis (Müller, 1785) F
Alona rectangula s.l. Sars, 1862 F
Armatolona macrocopa Sars, 1895 F
Camptocercus australis Sars, 1896 F
Camptocercus rectirostris Schödler, 1862 F
Chydorus sphaericus s.l. (Müller, 1785) F
Dunhevedia crassa King, 1853 F
Ephemeroporus barroisi s.l. (Richard, 1894) F
Graptoleberis testudinaria (Fischer, 1851) F
Leydigia ?australis Sars, 1885 F
Monospilus dispar Sars, 1861 F A?
Oxyurella tenuicaudis (Sars, 1862) F
Pleuroxus hastirostris Sars, 1904 F E
Pleuroxus helvenacus Frey, 1991 F E
Pleuroxus unispinus Henry, 1922 F

DAPHNIIDAE
Ceriodaphnia dubia Richard, 1895 F
Ceriodaphnia cf. *pulchella* Sars, 1862 F
Ceriodaphnia ?reticulata (Jurine, 1820) F
Daphnia carinata s.l. King, 1852 F
Daphnia dentifera Forbes, 1893 F A
Daphnia lumholtzi Sars, 1903 F
Daphnia obtusa Kurz, 1942 F
Scapholeberis kingi Sars, 1903 F
Simocephalus exspinosus (Koch, 1841) F
Simocephalus obtusatus (Thomson, 1894) F E
Simocephalus ?vetulus (Müller, 1776) F
ILYOCRYPTIDAE
Ilyocryptus sordidus s.l. (Lieven, 1848) F
MACROTHRICIDAE
Lathonura ?rectirostris (Müller, 1785) F
Macrothrix schauinslandi Sars, 1904 F
Pseudomoina lemnae (King, 1853) F
Streblocerus serricaudatus (Fischer, 1849) F
MOINIDAE
Moina australiensis Sars, 1896 F
Moina tenuicornis Sars, 1896 F
NEOTHRICIDAE
Neothrix armata Gurney, 1927
SAYCIIDAE
Saycia cooki novaezealandiae Frey, 1971 F E
SIDIDAE
Penilia avirostris Dana, 1852
Penilia pacifica Kraemer, 1895

Suborder ONYCHOPODA
PODONIDAE
Evadne nordmanni Loven, 1836
Evadne aspinosus Kraemer, 1895
Pleopis polyphaemoides (Leuckart, 1859)
Pleopis trisetosus Kraemer, 1895

Class CEPHALOCARIDA
Order BRACHYPODA
HUTCHINSONIELLIDAE
<u>*Chiltoniella*</u> *elongata* Knox & Fenwick, 1977 E

Class MAXILLOPODA
Subclass THECOSTRACA
Infraclass ASCOTHORACIDA
Order LAURIDA
SYNAGOGIDAE
Gen. et sp. indet. Te Papa Palmer 1997

Order DENDROGASTRIDA
DENDROGASTRIDAE
Dendrogaster argentinensis Grygier & Salvat, 1987
Dendrogaster otagoensis Palmer, 1997 E

Infraclass CIRRIPEDIA
Superorder ACROTHORACICA
Order PYGOPHORA
CRYPTOPHIALIDAE
Australophialus melampygos (Brandt, 1907) E

Superorder RHIZOCEPHALA
Order KENTROGONIDA
LERNAEODISCIDAE
Triangulus munidae Smith, 1906
PELTOGASTRIDAE
Boschmaia munidicola Reinhard, 1958
Briarosaccus callosus Boschma, 1930
Galatheascus babai Lützen, 1985
Peltogaster sp. Lörz et al. 2008 E
Tortugaster discoidalis Lützen, 1985 E
SACCULINIDAE
Sacculina sp. Brockerhoff, McLay & Kluza 2006

Order AKENTROGONIDA
THOMPSONIIDAE
?*Thompsonia affinis* Krüger, 1912
Thylacoplethus novaezealandiae Lützen, Glenner & Lörz, 2009 E
INCERTAE SEDIS
Parthenopea vulcanophila Lützen, Glenner & Lörz,

2009 E
Gen. et sp. indet. Lützen, Glenner & Lörz 2009

Superorder THORACICA
Order IBLIFORMES
IDIOIBLIDAE
Chaetolepas segmentata Studer, 1889 E
Chitinolepas spiritsensis Buckeridge & Newman, 2006 E
Idioibla idiotica (Batham, 1945) E

Order LEPADIFORMES
Suborder LEPADOMORPHA
LEPADIDAE
Alepas pacifica Pilsbry, 1907
Conchoderma auritum (Linné, 1767)
Conchoderma virgatum (Spengler, 1790)
Dosima fascicularis (Ellis & Solander, 1786)
Lepas anatifera Linné, 1758 A
Lepas australis Darwin, 1851
Lepas pectinata Spengler, 1793
Lepas testudinata Aurivillius, 1892
OXYNASPIDAE
Oxynaspis indica (Annandale, 1910)
Oxynaspis terranovae Totton, 1923 E
POECILASMATIDAE
Megalasma carinatum (Hoek, 1883)
Megalasma striatum (Hoek, 1883)
Poecilasma kaempferi (Darwin, 1851)
Trilasmis eburneum Hinds, 1883

Suborder HETERALEPADOMORPHA
ANELASMATIDAE
Anelasma squalicola Lovén, 1845*
HETERALEPADIDAE
Heteralepas japonica (Aurivillius, 1892)
Paralepas minuta (Philippi, 1836)
Paralepas quadrata (Aurivillius, 1894)

Order SCALPELLIFORMES
CALANTICIDAE
Calantica spinosa (Quoy & Gaimard, 1834) E
Calantica spinilatera Foster, 1979 E
Calantica villosa (Leach, 1824) E
Scillaelepas fosteri Newman, 1980 E
Scillaelepas studeri (Weltner, 1922)
Scillaelepas n. sp. 1* NIWA E
Scillaelepas n. sp. 2* NIWA E
Smilium acutum (Hoek, 1883)
Smilium zancleanum (Seguenza, 1876)
EOLEPADIDAE
Ashinkailepas kermadecensis Buckeridge, 2009 E
Vulcanolepas osheai (Buckeridge, 2000) E
SCALPELLIDAE
Alcockianum persona (Annandale, 1916)
Amigdoscalpellum costellatum (Withers, 1935)
Amigdoscalpellum vitreum (Hoek, 1883)
Anguloscalpellum pedunculatum (Hoek, 1883) E
Anguloscalpellum n. sp.* NIWA E
Arcoscalpellum trochelatum Foster, 1979 E
Arcoscalpellum affbricatum Foster, 1979 E
Arcoscalpellum pertosum Foster, 1979 E
Gymnoscalpellum intermedium (Hoek, 1883)
Verum novaezelandiae (Hoek, 1883)
Verum raccidium (Foster, 1979) E
Gen. indet. et n. spp. (2)* NIWA 2E

Order SESSILIA
Suborder VERRUCOMORPHA
VERRUCIDAE
Altiverruca galapagosa Zevina, 1978*
Altiverruca gibbosa (Hoek, 1883)
Altiverruca nitida (Hoek, 1883)*
Metaverruca recta (Aurivillius, 1898)
Metaverruca cf. *defayeae* Buckeridge, 1994*
Gen. nov. et n. sp.* J. Buckeridge E

Suborder BALANOMORPHA
ARCHAEOBALANIDAE
Acasta sp. *AUT
Notobalanus vestitus (Darwin, 1854) E
Solidobalanus auricoma (Hoek, 1913)
AUSTROBALANIDAE
Austrominius modestus (Darwin, 1854) E
Epopella kermadeca Foster, 1979 E
Epopella plicata (Gray, 1843) E
BALANIDAE
Amphibalanus amphitrite (Darwin, 1854) A
Amphibalanus variegatus (Darwin, 1854) A
Austromegabalanus nigrescens (Lamarck 1818)
Austromegabalanus psittacus (Molina, 1782)
Balanus trigonus Darwin, 1854
Notomegabalanus campbelli (Filhol, 1885) E
Notomegabalanus decorus (Darwin, 1854) E
Megabalanus tintinnabulum linzei (Foster, 1979)
BATHYLASMATIDAE
Bathylasma alearum (Foster, 1979)
Hexelasma gracilis Foster, 1981 E
Hexelasma nolearia (Foster, 1979) E
Mesolasma fosteri (Newman & Ross, 1971) E
Tetrachaelasma tasmanicum Buckeridge, 1999
CHIONELASMATIDAE
Chionelasmus crosnieri Buckeridge, 1998
CHTHAMALIDAE
Chamaesipho brunnea Moore, 1944 E
Chamaesipho columna (Spengler, 1790) E
CORONULIDAE
Coronula diadema (Linné, 1767)
Coronula reginae Darwin, 1854
Tubinicella major Lamarck, 1802
PACHYLASMATIDAE
Pachylasma auranticacum Darwin, 1854
Pachylasma scutistriata Darwin, 1854
PLATYLEPADIDAE
Platylepas hexastylos (Fabricus, 1798)
Stomatolepas elegans (Costa, 1838)
PYRGOMATIDAE
Cantellius septimus (Darwin, 1854)
Creusia spinulosa Leach, 1824
TETRACLITIDAE
Tesseropora rosea (Krauss, 1848)
Tetraclita aoranga Foster, 1979 E
Tetraclitella depressa Foster & Anderson, 1986 E

Subclass TANTULOCARIDA
DEOTERTHRIDAE
Deoterthron dentatum Bradford & Hewitt, 1980 P E (ostracod host)
Doryphallophora aselloticola (Boxshall & Lincoln, 1983) P (isopod host)
Doryphallophora megacephala (Lincoln & Boxshall, 1983) P (isopod host) E

Subclass BRANCHIURA
Order ARGULOIDA
ARGULIDAE
Argulus japonicus Thiele, 1900 F P (fish host) A

Subclass PENTASTOMIDA
Order POROCEPHALIDA
LINGUATULIDAE
Linguatula serrata (Leuckart, 1860) T P (mammal) A

Subclass COPEPODA
Order CALANOIDA
ACARTIIDAE
Acartia danae Giesbrecht, 1889 Pe O Ep Tr/St
Acartia negligens Dana, 1849 Pe O Ep Tr
Acartia ensifera Brady, 1899 Pe Co Ep St E
Acartia jilletti Bradford, 1976 Pe Co Ep St E
Acartia simplex Sars, 1905 Pe Co Ep St E
AETIDEIDAE
Aetideus acutus Farran, 1929 Pe Ep Tr
Aetideus australis (Vervoort, 1957) Pe Ep Sa
Aetideus giesbrechti Cleve, 1904 Pe Ep Tr/St
Aetideus pseudarmatus Bradford, 1971 Pe Ep Tr
Aetideopsis tumorosa Bradford, 1969 Pe/BP Me Sa
Bradyidius capax Bradford-Grieve, 2003 Ba Bp
Bradyidius spinifer Bradford, 1969 Ba Bp
Chiridius molestus Tanaka, 1957 Pe Ep/Me Tr/St
Chiridius pacificus Brodsky, 1950 Pe By Tr/St
Chiridius poppei Giesbrecht, 1892 Pe Me Tr
Chirundina streetsii Giesbrecht, 1895 Pe Me Tr/St
Comantenna crassa Bradford, 1969 Ba Bp
Crassantenna comosa Bradford, 1969 Ba Bp
Crassantenna mimorostrata Bradford, 1969 Ba Bp
Euchriella amoena Giesbrecht, 1888 Pe Me Tr
Euchirella bitumida With, 1915 Pe Me Tr
Euchirella curticauda Giesbrecht, 1888 Pe Me Tr/St
Euchirella formosa Vervoort, 1949 Pe Me Tr/St
Euchirella latirostris Farran, 1929 Pe Me Sa
Euchirella messinensis indica Vervoort, 1949 Pe Me Tr/St
Euchirella m. messinensis (Claus, 1863) Pe By Tr/St
Euchirella rostrata (Claus, 1866) Pe Me Tr/St/Sa
Euchirella rostromagna Wolfenden, 1911 Pe Me Sa/Ant
Euchirella similis Wolfenden, 1911 Pe By Tr/St
Euchirella speciosa Grice & Hulsemann, 1968 Pe Me Tr/St
Euchirella truncata Esterly, 1911 Pe Me Tr/St
Euchirella venusta Giesbrecht, 1888 Pe Me Tr/St
Gaetanus brevicornis Esterly, 1906 Pe By Tr/St
Gaetanus brevispinus (Sars, 1900) Pe By Tr/St
Gaetanus kruppii Giesbrecht, 1903 Pe By Tr/St
Gaetanus latifrons Sars, 1905 Pe By Tr/St
Gaetanus minor Farran, 1905 Pe Me Tr/St
Gaetanus minutus (Sars, 1907) Pe Me Tr/St
Gaetanus pileatus Farran, 1903 Pe By Tr/St
Gaetanus secundus Esterly, 1911 Pe Me Tr/St
Gaetanus tenuispinus (Sars, 1900) Pe MR Tr/St/Sa
Lutamator hurleyi Bradford, 1969 Ba Bp
Pseudeuchaeta brevicauda Sars, 1905 Pe By W
Pseudeuchaeta flexuosa Bradford, 1969 Ba Bp
Pseudeuchaeta magna Bradford, 1969 Ba Bp
Pseudochirella dentata (A. Scott, 1909) Pe By Tr/St
Pseudochirella mawsoni Vervoort, 1957 Pe BySt/ Sa/Ant
Pseudochirella notacantha (Sars, 1905) Pe By Tr/St
Pseudochirella obesa Sars, 1920 Pe By Tr/St
Pseudochirella obtusa (Sars, 1905) Pe By Tr/St
Pseudotharybis brevispinus (Bradford, 1969) Ba Bp
Pseudotharybis dentatus (Bradford, 1969) Ba Bp
Pseudotharybis robustus (Bradford, 1969) Ba Bp
Pseudotharybis spinibasis (Bradford, 1969) Ba Bp
Sursamucro spinatus Bradford, 1969 Ba Bp
Undeuchaeta incisa Esterly, 1911 Pe By Tr/St
Undeuchaeta major Giesbrecht, 1888 Pe Me Tr/St
Undeuchaeta plumosa (Lubbock, 1856) Pe Me Tr/St
Valdiviella insignis Farran, 1908 Pe By Tr/St
ARIETELLIDAE
Arietellus aculeatus (T. Scott, 1894b) Pe Me Tr
Arietellus setosus Giesbrecht, 1892 Pe Me/By Tr
Campaneria latipes Ohtsuka, Boxshall & Roe, 1994 Ba Bp St
Paramisophria n. sp.* Bp Sh
Paraugaptiloides magnus (Bradford, 1974) Ba Bp St
Paraugaptilus ?buchani Wolfenden, 1904 Pe Me Tr
Scutogerulus pelophilus Bradford, 1969 Ba Bp St
AUGAPTILIDAE
Augaptilus longicaudatus (Claus, 1863) Pe Me Tr/St
Centraugaptilus horridus (Farran, 1908) Pe By Tr/ St
Euaugaptilus bullifer (Giesbrecht, 1889) Pe By Tr/St/Sa
Euaugaptilus filigerus (Claus, 1963) Pe By T/St
Euaugaptilus hecticus (Giesbrecht, 1889) Pe Ep/

Me Tr
Euaugaptilus humilis Farran, 1926 Pe By Tr
Euaugaptilus laticeps (Sars, 1905) Pe By Tr/St
Euaugaptilus longimanus (Sars, 1905) Pe By Tr
Euaugaptilus nodifrons (Sars, 1905) Pe By Tr/St/Sa
Euaugaptilus oblongus (Sars, 1905) Pe By Tr/St
Euaugaptilus palumbii (Giesbrecht, 1889) Pe Me Tr
Haloptilus acutifrons (Giesbrecht, 1892) Pe Me Tr/St
Haloptilus fons Farran, 1908 Pe Me/By Tr/St/Sa
Haloptilus longicornis (Claus, 1893) Pe Ep/Me Tr/St/Sa
Haloptilus ornatus (Giesbrecht, 1892) Pe Ep/Me Tr/St
Haloptilus oxycephalus (Giesbrecht, 1889) Pe Ep/ Me Tr/St/Sa
Haloptilus spiniceps (Giesbrecht, 1892) Pe Ep/Me Tr
Pachyptilus eurygnathus (Sars, 1905) Pe By Tr/St
BATHYPONTIIDAE
Temorites elongata (Sars, 1905) Pe By W
CALANIDAE
Calanoides acutus (Giesbrecht, 1902) Pe Ep/Me Sa/Ant
Calanoides macrocarinatus Brodsky, 1972 Pe Ep/Me St
Calanus australis Brodsky, 1959 Pe Co Ep St/Sa
Calanus simillimus Giesbrecht, 1902 Pe Ep Sa
Canthocalanus pauper (Giesbrecht, 1888) Pe Ep Tr
Cosmocalanus darwinii (Lubbock, 1860) Pe Ep Tr
Mesocalanus tenuicornis (Dana, 1849) Pe Ep Tr/St/ Sa
Nannocalanus minor (Claus, 1863) Pe Ep Tr/St
Neocalanus gracilis Dana, 1849 Pe Ep Tr/St
Neocalanus tonsus (Brady, 1883) Pe Ep/Me St/Sa
CANDACIIDAE
Candacia bipinnata (Giesbrecht, 1888) Pe Ep/Me Tr/St
Candacia cheirura Cleve, 1904 Pe Ep/Me St/Sa
Candacia ethiopica (Dana, 1849) Pe Ep/Me Tr
Candacia longimana (Claus, 1863) Pe Ep/Me Tr/St
Candacia pachydactyla (Dana, 1849) Pe Ep/Me St
Candacia tenuimana (Giesbrecht, 1888) Pe Me Tr/St
Paracandacia simplex (Giesbrecht, 1889) Pe Ep T/St
Paracandacia worthingtoni Grice, 1981 Pe Ep Tr
CENTROPAGIDAE
Boeckella delicata Percival, 1937 F Pe
Boeckella dilatata Sars, 1904 F Pe E
Boeckella hamata Brehm, 1928 F Pe E
Boeckella minuta Sars, 1896 F Pe A
Boeckella propinqua Sars, 1904 F Pe
Boeckella symmetrica Sars, 1908 F Pe A
Boeckella tanea Chapman, 1973 F Pe E
Boeckella triarticulata (Thomson, 1883) F Pe
Calamoecia lucasi Brady, 1906 F Pe
Centropages aucklandicus Krämer, 1895 Pe Co Ep St E
Centropages bradyi Wheeler, 1900 Pe Me Tr/St
Centropages elegans Giesbrecht, 1895 Pe O Ep Tr
Centropages violaceus (Claus, 1863) Pe O Ep Tr
Gladioferens pectinatus (Brady, 1899) B Pe Ep St
Gladioferens spinosus Henry, 1919 B Pe Ep St
CLAUSOCALANIDAE
Clausocalanus arcuicornis (Dana, 1849) Pe Ep Tr/St
Clausocalanus brevipes Frost & Fleminger, 1968 Pe Ep Sa
Clausocalanus ingens Frost & Fleminger, 1968 Pe Ep Tr/St/Sa
Clausocalanus jobei Frost & Fleminger, 1968 Pe Ep St
Clausocalanus laticeps Farran, 1929 Pe Ep Sa
Clausocalanus lividus Frost & Fleminger, 1968 Pe Ep Tr/St
Clausocalanus parapergens Frost & Fleminger, 1968 Pe Ep Tr/St
Clausocalanus paululus Farran, 1926 Pe Ep Tr/St
Clausocalaus pergens Farran, 1926 Pe Ep St
Ctenocalanus vanus Giesbrecht, 1888 Pe Ep St
Drepanopus pectinatus Brady, 1883 Pe Ep Co Sa
DIAPTOMIDAE A
Sinodiaptomus valkanovi Kiefer, 1938 F Pe A
Skistodiaptomus pallidus (Herrick, 1879) F Pe A
EUCALANIDAE
Eucalanus hyalinus (Claus, 1866) Pe Ep/Me Tr/St
Pareucalanus langae (Fleminger, 1973) Pe Ep Tr
Pareucalanus sewelli (Fleminger, 1973) Pe Ep Tr/St
Rhincalanus gigas Brady, 1883 Pe Ep/Me Sa/Ant
Rhincalanus nasutus Giesbrecht, 1888 Pe Ep/Me St
Rhincalanus rostrifrons (Dana, 1852) Pe Ep Tr
Subeucalanus crassus (Giesbrecht, 1888) Pe Ep Tr/St
Subeucalanus longiceps (Matthews, 1925) Pe Ep Sa
Subeucalanus mucronatus (Giesbrecht, 1888) Pe Ep Tr
EUCHAETIDAE
Euchaeta acuta Giesbrecht, 1892 Pe Ep Tr/St
Euchaeta media Giesbrecht, 1888 Pe Ep Tr/St
Euchaeta longicornis Giesbrecht, 1888 Pe Ep T/St
Euchaeta rimana Bradford, 1974 Pe Ep T/St
Euchaeta pubera Sars, 1907 Pe Ep T/St
Euchaeta spinosa Giesbrecht, 1892 Pe Me Tr
Pareuchaeta biloba Farran, 1929 Pe Me Sa/Ant
Pareuchaeta bisinuata (Sars, 1907) Pe By Tr/St
Pareuchaeta comosa Tanaka, 1958 Pe By Tr/St
Pareuchaeta exigua (Wolfenden, 1911) Pe By Tr/St
Pareuchaeta hansenii (With, 1915) Pe Me Tr/St
Pareuchaeta pseudotonsa (Fontaine, 1967) Pe By Tr/St/Sa
Pareuchaeta sarsi (Farran, 1908) Pe By W
HETERORHABDIDAE
Disseta magna Bradford, 1971 Pe By St
Disseta palumbii Giesbrecht, 1889 Pe By Tr/St
Heterorhabdus abyssalis (Giesbrecht, 1889) Pe Me/By St
Heterorhabdus austrinus Giesbrecht, 1902 Pe Me/By Sa/Ant
Heterorhabdus caribbeanensis Park, 1970 Pe Me Tr
Heterorhabdus lobatus Bradford, 1971 Pe Me Tr
Heterorhabdus pacificus Brodsky, 1950 Pe By Tr/ St
Heterorhabdus papilliger (Claus, 1863) Pe Ep/me Tr
Heterorhabdus proximus Davis, 1949 Pe Me St
Heterorhabdus robustus Farran, 1908 Pe
Heterorhabdus spinifer Park, 1970 Pe Me Tr
Heterorhabdus spinifrons (Claus, 1863) Pe Me Tr/St
Heterohabdus spinosus Bradford 1971 Pe Me St
Heterostylites longicornis (Giesbrecht, 1889) Pe Me Tr/St
LUCICUTIIDAE
Lucicutia bicornuta Wolfenden, 1905 Pe Ep/Me Tr/St
Lucicutia clausi (Giesbrecht, 1889) Pe Me Tr/St
Lucicutia curta Farran, 1905 Pe Me W
Lucicutia flavicornis (Claus, 1863) Pe Ep/Me Tr/St
Lucicutia cf. *flavicornis*, Bradford-Grieve, 1999 Pe Ep/Me Tr/St
Lucicutia gemina Farran, 1926 Pe Ep/Me Tr
Lucicutia grandis (Giesbrecht, 1895) Pe By W
Lucicutia longiserrata (Giesbrecht, 1889) Pe By Tr
Lucicutia magna Wolfenden *in* Fowler, 1903 Pe By W
Lucicutia ovalis (Giesbrecht, 1889) Pe Ep/Me Tr
MECYNOCERIDAE
Mecynocera clausi Thompson, 1888 Pe Ep Tr/St
MEGACALANIDAE
Megacalanus longicornis Sars, 1925 Pe By W
METRIDINIDAE
Gaussia princeps T. Scott, 1894 Pe By Tr/St
Metridia brevicauda Giesbrecht, 1889 Pe Me/By Tr/St
Metridia curticauda Giesbrecht, 1889 Pe Me/By W
Metridia lucens Boeck, 1865 Pe Ep/Me Tr/St/Sa
Metridia princeps Giesbrecht, 1892 Pe By W
Metridia venusta Giesbrecht, 1892 Pe Me/By Tr/ St
Pleuromamma abdominalis (Lubbock, 1856) Pe Me Tr/St/Sa
Pleuromamma borealis (Dahl, 1893) Pe Me Tr/St/Sa
Pleuromamma gracilis (Claus, 1863) Pe Me Tr/St
Pleuromamma piseki Farran, 1929 Pe Me Tr/St
Pleuromamma quadrungulata (Dahl, 1893) Pe Me Tr/St/Sa
Pleuromamma robusta (Dahl, 1893) Pe Me Tr/St/Sa
Pleuromamma xiphias Giesbrecht, 1889 Pe Me Tr/St
NULLOSETIGERIDAE
Nullosetigera bidentatus (Brady, 1883) Pe Me W
Nullosetigera helgae (Farran, 1908) Pe Me/By W
PARACALANIDAE
Calocalanus longispinus Shmeleva, 1978 Pe Ep Tr/St
Calocalanus minutus Andronov, 1973 Pe Ep Tr/St
Calocalanus namibiensis Andronov, 1973 Pe Ep Tr/St
Calocalanus neptunus Schmeleva, 1965 Pe Ep Tr/St
Calocalanus pavo (Dana, 1849) Pe Ep Tr/St
Calocalanus plumulosus (Claus, 1863) Pe Ep T/St
Calocalanus styliremis Giesbrecht, 1888 Pe Ep Tr/St
Calocalanus tenuis Farran, 1926 Pe Ep Tr/St
Paracalanus aculeatus Giesbrecht, 1892 Pe Ep Tr/St
Paracalanus indicus Wolfenden, 1905 Pe Ep Tr/St
PHAENNIDAE
Cornucalanus chelifer (I.C. Thompson, 1903) Pe By Tr/St
Onchocalanus cristatus (Wolfenden, 1904) Pe By T/St
Onchocalanus trigoniceps Sars, 1905 Pe By Tr/St
Neoscolecithrix cf. *magna* (Grice, 1972) Bp
Neoscolecithrix ornata Bradford-Grieve, 2001 Bp
Phaenna spinifera Claus, 1863 Pe Me T/St
Xanthocalanus penicillatus Tanaka, 1960 Pe By Tr/St
PONTELLIDAE
Calanopia aurivilli Cleve, 1901 Pe O Ep Tr
Labidocera cervi Krämer, 1895 Pe Co Ep St
Labidocera detruncata (Dana, 1849) Pe O Ep Tr
Pontella novaezelandiae Farran, 1929 Pe Co Ep St E
Pontella valida Dana, 1852 Pe O Ep Tr
Pontella whiteleggei Krämer, 1896 Pe O Ep Tr
Pontellina plumata (Dana, 1849) Pe O Ep Tr
Pontellopsis grandis (Lubbock, 1853) Pe O Ep Tr
PSEUDOCYCLOPIDAE
Pseudocyclops n. sp.* Bp Sh
SCOLECITRICHIDAE
Amallothrix arcuata (Sars, 1920) Pe By Tr/St
Amallothrix dentipes (Vervoort, 1951) Pe Me Sa/Ant
Amallothirx emarginata (Farran, 1905) Pe By Tr/St
Amallothrix gracilis (Sars, 1905) Pe By Tr/St
Amallothrix parafalcifer (Park, 1980) Pe By St
Amallothrix pseudopropinqua (Park, 1980) Pe By St
Amallothrix valida (Farran, 1908) Pe By W
Lophothrix frontalis Giesbrecht, 1895 Pe By Tr/St
Lophothrix latipes (T. Scott, 1894) Pe Me Tr
Scaphocalanus affinis (Sars, 1905) Pe By W
Scaphocalanus brevicornis (Sars, 1900) Pe Me Tr/St
Scaphocalanus curtus (Farran, 1926) Pe Ep Tr
Scaphocalanus echinatus (Farran, 1905) Pe Ep Tr/St/Sa
Scaphocalanus longifurca (Giesbrecht, 1888) Pe Me Tr/St
Scaphocalanus magnus (T. Scott, 1894) Pe By W
Scaphocalanus major (T. Scott, 1894) Pe Me Tr/St
Scaphoclanaus subbrevicornis (Wolfenden, 1911) Pe Me W
Scolecithricella abyssalis (Giesbrecht, 1888) Pe Me Tr/St
Scolecithricella dentata (Giesbrecht, 1892) Pe Me Tr/St
'Scolecithricella' fowleri (Farran, 1926) Pe Me Tr
Scolecithricella minor (Brady, 1883) Pe Ep W
Scolecithricella ovata (Farran, 1905) Pe Me W
Scolecithricella schizosoma Park, 1980 Pe By Sa/Ant
Scolecithricella vittata (Giesbrecht, 1892) Pe Me Tr/St
Scolecithrix bradyi Giesbrecht, 1888 Pe Ep Tr
Scolecithrix danae (Lubbock, 1856) Pe Ep Tr
Scopalatum sp. Bradford *et al*. 1983 Pe Me St
Scottocalanus helenae (Lubbock, 1856) Pe Me Tr/St

Scottocalanus securifons (T. Scott, 1894) Pe By Tr/ St
Scottocalanus terranovae Farran, 1929 Pe By St
Scottocalanus thorii With, 1915 Pe By Tr/St
SPINOCALANIDAE
Spinocalanus longicornis Sars, 1900 Pe By W
Spinocalanus spinosus Farran, 1908 Pe By Tr
STEPHIDAE
Stephos angulatus Bradford-Grieve, 1999 Bp Sh E
Stephos hastatus Bradford-Grieve, 1999 BP Sh E
SULCANIDAE
Sulcanus conflictus Nicholls, 1945 B Pe Co Ep A?
TEMORIDAE
Temora turbinata (Dana, 1849) Pe Co Ep S/St
Temoropia minor Deevey, 1972 Pe By Tr
Gen. et sp. indet.* Bp Sh
THARYBIDAE
Tharybis inaequalis Bradford-Grieve, 2001 Ba Bp
Tharybis spp. (2)* Bp Sh
Undinella brevipes Farran, 1908 Pe Me Tr/St

Order CYCLOPOIDA
ASCIDICOLIDAE
Botryllophilus cf. *banyulensis* Brément, 1909*
Enteropsis onychophorus Schellenberg, 1922 P (tunicates)
Haplostoma gibberum (Shellenberg, 1922) P (tunicates)
Haplostomides otagoensis Ooishi, 2001 P (tunicates)
BOMOLOCHIDAE
Acanthocolax sp. Beresford 1991 P (fish)
Pseudoeucanthus australiensis Roubal, Armitage & Rohde, 1983* P (fish)
Pseudoeucanthus uniserratus Wilson, 1913 P (fish)
Unicolax chrysophryenus Roubal, Armitage & Rohde, 1983 P (fish)
CHITONOPHILIDAE
Cocculinika myzorama Jones & Marshall, 1986 P (molluscs)
CHONDRACANTHIDAE
Acanthochondria incisa Shiino, 1955 P (fish)
Chondracanthodes radiatus Müller, 1777 P (fish)
Chondracanthus australis Ho, 1991 P (fish)
Chondracanthus distortus Wilson, 1922 P (fish)
Chondracanthus genypteri Thomson, 1890 P (fish)
Chondracanthus lotellae Thomson, 1890 P (fish)
Chondracanthus yanezi Atria, 1980 P (fish)
Mecaderochondria pilgrimi Ho & Dojiri, 1987 P (fish)
Prochondracanthus platycephali Ho, 1975 P (fish)
Pseudochondracanthus chilomycteri (Thomson, 1890) P (fish)
CLAUSIDIIDAE
Hemicyclops? n. sp., n. gen.? * Be C
Teredicola typicus Wilson, 1942 P (boring molluscs)
CORYCAEIDAE
Corycaeus agilis Dana, 1849* Pe Ep Tr/St
Corycaeus aucklandicus Kramer, 1895 Pe Ep Co E
Corycaeus clausi F. Dahl, 1894* Pe Ep Tr/St
Corycaeus crassiusculus Dana, 1849* Pe Ep Tr/St
Corycaeus flaccus Giesbrecht, 1891* Pe Ep Tr/St
Corycaeus furcifer Claus, 1863* Pe Ep Tr/St
Corycaeus latus Dana, 1849* Pe Ep Tr/St
Corycaeus limbatus Brady, 1883* Pe Ep Tr/St
Corycaeus longistylis Dana, 1849* Pe Ep Tr
Corycaeus speciosus Dana, 1849* Pe Ep Tr/St
Corycaeus typicus Krøyer, 1849* Pe Ep Tr
Farranula rostata (Claus, 1863)* Pe Ep S/St
CYCLOPIDAE
<u>*Abdiacyclops*</u> *cirratus* Karanovic, 2005 F E
Acanthocyclops robustus (Sars, 1863) F Be A?
Acanthocyclops vernalis (Fischer, 1853) F Pe
Cyclops? strennus strennus Fischer, 1851 P
Diacyclops bicuspidatus (Claus, 1857) F Be
Diacyclops bisetosus (Rehberg, 1880) F Be A?
Eucyclops serrulatus (Fischer, 1851) F Pe A?
Euryte? *longicauda* Philippi, 1843 Be
Goniocyclops silvestris Harding, 1958 F Ph E
Halicyclops? *magniceps* (Lilljeborg, 1853) B Be
Halicyclops? *neglectus* Kiefer, 1935 F/B Be/Pe
Macrocyclops albidus (Jurine, 1820) F Be
Mesocyclops? *australiensis* (Sars, 1908) F Pe
Mesocyclops? *leuckarti* (Claus, 1857) F Pe
Metacyclops monacanthus (Kiefer, 1928) B Pe E
Microcyclops? *varicans* Sars, 1863 F Be/Pe
Paracyclops chiltoni (Thomson, 1883) F Be
Paracyclops fimbriatus (Fischer, 1853) F/B Be A?
Paracyclops waiariki Lewis, 1974 F Be E
Tropocyclops? *prasinus* (Fischer, 1860) F Be/Pe
Zealandcyclops fenwicki Karanovic, 2005 F E
Zealandcyclops haywardi Karanovic, 2005 F E
ERGASILIDAE
Abergasilus amplexus Hewitt, 1978 B P (fish)
Paeonodes nemaformis Hewitt, 1969 F P (fish, extinct?) E
Thersitina inopinata Percival, 1937 F Pe P (fish, extinct?)
LERNAEIDAE
Lernaea cyprinacea Linnaeus, 1758 F P (fish) A
LICHOMOLGIDAE
Lichomolgidium tupuhiae Jones, 1975 C (molluscs)
Lichomolgus uncus Jones, 1976 C (molluscs)
MYTILICOLIDAE
Pseudomyicola spinosus (Raffaele & Monticelli, 1885) C (molluscs)
NOTODELPHYIDAE
Pygodelphys novaeseelandius (Shellenberg, 1922) C (tunicates)
Doropygus globosus Jones, 1974 C (tunicates)
Doropygus louisae Jones, 1980 C (tunicates)
Doropygus platythorax Jones, 1974 C (tunicates)
Doropygus pulex Shellenberg, 1922 C (tunicates)
Doropygus spinosus Jones, 1980 C (tunicates)
Doropygus trisetosus Shellenberg, 1922 C (tunicates)
Ophioseides schellenbergi Jones, 1980 C (tunicates)
OITHONIDAE
Oithona atlantica Farran, 1908 Pe Ep St
Oithona nana Giesbrecht, 1892 Pe Ep Tr/St
Oithona plumifera Baird, 1843 Pe Ep Tr/St
Oithona similis Claus, 1866 Pe Ep W
ONCAEIDAE
Conaea rapax Giesbrecht, 1891 Pe Me W
Lubbockia aculeata Giesbrecht, 1891 Ep/Me Tr/St
Lubbockia squillimana Claus, 1863 Pe Ep/Me Tr/St
Oncaea antarctica Heron, 1977 Pe Ep/Me Sa/Ant
Oncaea conifera Giesbrecht, 1891 Pe Ep/Bap Tr/St
Oncaea derivata Heron & Bradford-Grieve, 1995 Pe Me Tr/St
Oncaea englishi Heron, 1977 Pe Ep/Bap W
Oncaea furcula Farran, 1936 Pe Me Tr/St
Oncaea inflexa Heron, 1977 Pe Ep/Me Sa
Oncaea media Giesbrecht, 1891 Pe Ep/Me Tr/St
Oncaea mediterranea (Claus, 1863) Pe Ep/Me W
Oncaea quadrata Heron & Bradford-Grieve, 1995 Pe Ep/Me St
Oncaea redacta Heron & Bradford-Grieve, 1995 Pe Ep/Me Tr
Oncaea scottodicarloi Heron & Bradford-Grieve, 1995 Pe Ep Tr/St
Oncaea similis Sars, 1918 Pe Ep/Me St
Oncaea venusta Philippe, 1843 Pe Ep/Me Tr/St
PHILICHTHYIDAE
Philichthys xiphiae Steenstrup, 1862 P (fish)
Sarcotaces sp. Avdeev & Avdeev 1975 P (fish)
SAPPHIRINIDAE
Copilia hendorffi Dahl, 1892* Pe Ep Tr/St
Copilia mirabilis Dana, 1849* Pe Ep/Me Tr/St
Copilia vitrea (Haeckel, 1864)* Pe Ep/Me Tr
Sapphirina angusta Dana, 1849* Pe Ep Tr/St
Sapphirina autonitens-sinuicauda Lehnhofer, 1929* Pe Ep Tr/St
Sapphirina ovatolanceolata-gemma Lehnhofer, 1929* Pe Ep Tr/St
Sapphirina intestinata Giesbrecht, 1891* Pe Ep T/St
Sapphirina iris Dana, 1849* Pe Ep Tr/St
Sapphirina opalina-darwini Lehnhofer, 1929* Pe Ep Tr/St
Sapphirina sali Farran, 1929* Pe Ep St
Sapphirina scarlata Giesbrecht, 1891* Pe Ep T/St
THAMNOMOLGIDAE
Thamnomolgus eurycephalus Humes & Kiss, 2004 P (black coral)

Order MORMONILLOIDA
Mormonilla phasma Giesbrecht, 1891* Pe

Order HARPACTICOIDA
AEGISTHIDAE
Aegisthus mucronatus Giesbrecht, 1891 Pe
AMEIRIDAE
Ameira minuta Boeck, 1864 Ph
Ameira parvula (Claus, 1866) Ph BeL
Ameira sp.* BeL
Ameiropsyllus (?) spp. (5)* BeL
Leptameira sp.* BeL
Nitocra fragilis Sars, 1905 Ch B Be
Nitocra sp. (2)* BeL
Parapseudoleptomesochra (?) sp.* BeL
Parevansula sp.* BeL
Psyllocamptus sp.* BeL
ANCORABOLIDAE
Laophontodes hamatus (Thomson, 1883) Ph E
Laophontodes whitsoni T. Scott, 1912 Ca Be
Paralaophontodes sp.* BeL
ARENOPONTIIDAE
Arenopontia sp.* BeL
CANTHOCAMPTIDAE
Antarctobiotus australis Lewis, 1972 F Ph(M) E
Antarctobiotus diversus Lewis, 1972 F Ph(M) E
Antarctobiotus elongatus Lewis, 1972 F Ph(M) E
Antarctobiotus exiguus Lewis, 1972 F Ph(M) E
Antarctobiotus ignobilis Lewis, 1972 F Ph(M) E
Antarctobiotus triplex Lewis, 1972 F Ph(M) E
Antarctobiotus n. sp.* F Ph(M)
Antipodiella chappuisi Brehm, 1928* F Ph(M)
Antipodiella n. spp. (3)* 3F Ph(M)
Attheyella (*Chappuisiella*) *fluviatilis* Lewis, 1972 F Ph(M) E
Attheyella (*C.*) *maorica* (Brehm, 1928) F Ph(M) E
Attheyella (*C.*) *rotoruensis* Lewis, 1972 F Pe E
Attheyella (*Delachauxiella*) *bennetti* Brehm, 1927 F Ph(M) E
Attheyella (*D.*) *brehmi* Kiefer, 1928 F Ph(M) E
Attheyella (*D.*) *humidarum* Lewis, 1972 F Ph(M) E
Attheyella (*D.*) *stillicidarum* Lewis, 1972 F Ph(M) E
Bryocamptus (*Rheocamptus*) *pygmaeus* (Sars, 1862)* F Ph(M)
Bryocamptus (*Echinocamptus*) *stouti* Harding, 1958 T (forest litter) E
Bryocamptus n. spp. (3)* 3F
Elaphoidella bidens coronata Sars, 1904 F BeL
Elaphoidella silvestris Lewis, 1972 F Ph(M) E
Elaphoidella sp.* F Be
Epactophanes richardi Mrázek, 1893 F Ph, Ph(M)
Loeflerella n. sp.* F Ph(M)
Mesochra flava Lang, 1933 Ph
Mesochra meridionalis Sars, 1905 B
Mesochra parva Thomson, 1946 B BeL BeSL
Mesochra pygmaea (Claus, 1863)* BeL
Mesochra spp. (2)* BeL
Gen. nov. (2) et n. spp. (7)* 7F
CANUELLIDAE
Brianola sp.* B BeL
CLETODIDAE
Enhydrosoma variabile Wells, Hicks & Coull, 1982 BeL BeSL E

Enhydrosoma spp. (2)* BeL
Enhydrosomella spp. (2)* BeL
Stylicletodes longicaudatus (Brady & Robertson, 1880) Ph
Stylicletodes sp.* BeL
DACTYLOPUSIIDAE
Dactylopusia frigida T. Scott, 1912 Ph
Dactylopusia tisboides (Claus, 1863) Ph BeL BeSL
Diarthrodes cystoecus Fahrenbach, 1954 Ph
Diarthrodes novaezealandiae Thomson, 1882 Ph E
Diarthrodes sp.* Ph
Paradactylopodia brevicornis (Claus, 1866) Ph
Paradactylopodia trioculata Hicks, 1988 Ph(W) E
DARCYTHOMPSONIIDAE
Gen. nov. et n. sp. Huys & Gee in press* BeL
ECTINOSOMATIDAE
Arenosetella sp. * BeL
Ectinosoma melaniceps Boeck, 1864 Ca Ch BeL
Ectinosoma sp.* BeL
Glabrotelson spp. (3)* BeL
Halectinosoma hydrofuge Wells, Hicks & Coull, 1982 BeL E
Halectinosoma otakoua Wells, Hicks & Coull, 1982 BeL E
Halectinosoma spp. (3)* BeL
Kliella (?) sp.* BeL
Microsetella norvegica (Boeck, 1864) Pe Ep W
Microsetella rosea (Dana, 1848) Pe Ep W
Noodtiella sp. * BeL
HARPACTICIDAE
Harpacticus furcatus Lang, 1936 Ph
Harpacticus glaber Brady, 1899 Pe SL E
Harpacticus pulvinatus Brady, 1910 Ph
Harpacticus spp. (2)* Ph
Perissocope litoralis Lang, 1934 Ph E
Tigriopus angulatus Lang, 1933 Ca Sn Ph
Tigriopus raki Bradford, 1967 Ph E
Zaus sp.* Ph
Zausopsis contractus (Thomson, 1883) Ph E
Zausopsis mirabilis Lang, 1934 Ph E
LAOPHONTIDAE
Afrolaophonte sp.* BeL
Apolethon sp.* BeL
Folioquinpes chathamensis (Sars, 1905) B E
Harrietella simulans (T. Scott, 1894) Ph(W)
Heterolaophonte campbelliensis (Lang, 1934) Ca Ph
Heterolaophonte tenuispina (Lang, 1934) Ca Ph
Klieonychocamptoides sp.* BeL
Laophonte australasica Thomson, 1883 E
Laophonte cornuta Philippi, 1840 Ca Ph
Laophonte elongata barbata Lang, 1934 Ph
Laophonte inornata A. Scott, 1902 Ph
Laophonte lignosa Hicks, 1988 Ph(W) E
Laophonte sima Gurney, 1927 Ph
Laophonte spp. (2)* BeL
Onychocamptus mohammed (Blanchard & Richard, 1891) B
Paeudonychocamptus sp.* BeL
Paralaophonte aenigmaticum Wells, Hicks & Coull, 1982 BeL E
Paronychocamptus exiguus (Sars, 1905) B E
Paralaophonte meinerti (Brady, 1899) Ca Ph
Paralaophonte spp. (4)* BeL
Pseudolaophonte spp. (2)* BeL
Quinquelaophonte candelabrum Wells, Hicks & Coull, 1982 BeL BeSL Ph E
Quinquelaophonte longifurcata (Lang, 1965) Ph
Quinquelaophonte sp.* BeL
Xanthilaophonte trispinosa (Sewell, 1940) BeL BeSL
LEPTASTACIDAE
Leptastacus sp.* BeL
LOURINIIDAE
Lourinia armata (Claus, 1866) Ph
MIRACIIDAE
Amonardia perturbata Lang, 1965 Ph
Amphiascoides nichollsi Lang, 1965 Ph
Amphiascoides sp.* BeL
Amphiascopsis cinctus (Claus, 1866) Ph
Amphiascopsis southgeorgiensis (Lang, 1936) Ph
Amphiascus waihonu (Hicks, 1986) Be (C?) E
Bulbamphiascus imus (Brady, 1872) Ph
Bulbamphiascus spp. (2)* BeL
Cladorostrata sp.* BeL
Delavalia spp. (3)* BeL
Helmutkunzia sp.* BeL
Macrosetella gracilis (Dana, 1847) Pe Ep Tr/St
Metamphiascopsis monardi (Lang, 1934) Ph E
Miscegenus heretaunga Wells, Hicks & Coull, 1982 BeL BeSL E
Miscegenus spp. (2)* BeL
Oculosetella gracilis (Dana, 1849) Pe Ep Tr/St
Pseudostenhelia sp.* BeL
Robertgurneya sp.* BeL
Robertsonia propinqua (T. Scott, 1893) Ph
Sarsamphiascus hirtus (Gurney, 1927) Ca Ph
Sarsamphiascus lobatus (Hicks, 1971)
Sarsamphiascus pacificus (Sars, 1905) Ch Ph
Sarsamphiascus tainui (Hicks, 1989) W E
Sarsamphiascus spp. (2)* BeL
Schizopera clandestina (Klie, 1924) B
Schizopera longicauda Sars, 1905 Ch B Be
Schizopera sp.* BeL
Stenhelia xylophila Hicks, 1988 Ph(W) E
Stenhelia sp. BeL
Teissierella (?) sp.* BeL
Typhlamphiascus unisetosus Lang, 1965 Ph
Typhlamphiascus sp.*BeL
NANNOPODIDAE
Gen. et sp. indet.* BeL
NORMANELLIDAE
Normanella incerta Lang, 1934 Ph E
ORTHOPSYLLIDAE
Orthopsyllus linearis (Claus, 1866) Ph
PARAMESOCHRIDAE
Apodopsyllus sp.* BeL
Diarthrodella sp.* BeL
Emertonia sp.* BeL
PARASTENHELIIDAE
Parastenhelia hornelli Thompson & A. Scott, 1903 BeL
Parastenhelia megarostrum Wells, Hicks & Coull, 1982 BeL BeSL E
Parastenhelia spinosa (Fischer, 1860) CaPh BeL BeSL
Parastenhelia sp.* BeL
PELTIDIIDAE
Alteutha depressa (Baird, 1837) Ph
Alteutha novaezealandiae (Brady, 1899) Ph E
Alteuthoides kootare Hicks, 1986 C (sponges) E
Clytemnestra rostrata (Brady, 1883) Pe Ep/Me Tr/St
Clytemnestra scutellata Dana, 1848 Pe Ep/Me Tr/St
Eupelte regalis Hicks, 1971 Ph E
Neopeltopsis pectinipes Hicks, 1976 Ph E
PHYLLOGNATHOPODIDAE
Phyllognathopus viguieri (Maupas, 1892) F Ph(M)
Phyllognathopus volcanicus Barclay, 1969 F BeL BeS Ph E
PORCELLIDIIDAE
Dilatatiocauda dilatatum (Hicks, 1971) Ph E
Porcellidium erythrum Hicks, 1971 Ph E
Porcellidium fulvum Thomson, 1883 Ph E
Porcellidium interruptum Thomson, 1883 Ph E
Porcellidium tapui Hicks & Webber, 1983 C E (hermit crabs)
PSAMMOPSYLLIDAE
Psammopsyllus sp.* BeL
PSEUDOTACHIDIIDAE
Dactylopodella flava (Claus, 1866) Ph(W)
Dactylopodella janetae Hicks, 1989 Ph(W) E
Dactylopodella sp.* Ph
Danielssenia sp.* Be L
Donsiella bisetosa Hicks, 1988 Ph(W) E
Paranannopus sp.* BeL
Pseudomesochra sp.* BeL
Pseudonsiella aotearoa Hicks, 1988 Ph(W) E
Xouthous intermedia (Lang, 1934) Ph E
Xouthous novaezealandiae (Thomson, 1882) Ph E
Xylora bathyalis Hicks, 1988 Ph(W) E
Xylora neritica Hicks, 1988 Ph(W)E
RHIZOTHRICIDAE
Rhizothricidae sp.* BeL
RHYNCHOTHALESTRIDAE
Rhynchothalestris campbelliensis Lang, 1934 Ph E
TACHIDIIDAE
Euterpina acutifrons (Dana, 1848) Pe Ep W
Geeopsis incisipes (Klie, 1913) B
Tachidius sp.* BeL
TEGASTIDAE
Syngastes clausii (Thomson, 1883) Ph E
TETRAGONICIPITIDAE
Phyllopodopsyllus minor (Thompson & A. Scott, 1903) Ph
Phyllopodopsyllus sp.* BeL
THALESTRIDAE
Flavia crassicornis Brady, 1899 E
Thalestris australis Brady, 1899 Ph? E
Thalestris ciliata Brady, 1899 Ph? E
TISBIDAE
Scutellidium armatum (Wiborg, 1964) Ph
Scutellidium idyoides (Brady, 1883) Ph?
Scutellidium macrosetum Branch, 1975 Ph
Scutellidium plumosum Brady, 1899 Ca Ph BeL
Scutellidium ringueleti Pallares, 1969 Ph
Tisbe furcata (Baird, 1837) Ch Ph
Tisbe gurneyi (Lang, 1934) Ph E
Tisbe holothuriae Humes, 1957 Ph
Tisbe sp.* Ph

Order SIPHONOSTOMATOIDA
ARTOTROGIDAE
Artotrogus gordoni Kim, 2009 E (bryozoan)
ASTEROCHERIDAE
Cecidomyzon conophorae Stock, 1981 P (coral) E
Cystomyzon dimerum Stock, 1981 P (coral) E
Oedomyzon tripodum Stock, 1981 P (coral) E
CANCERILLIDAE
Cancerilla neozelandica Stephensen, 1927 P (brittlestars) E
CALIGIDAE
Caligus aesopus Wilson, 1921 P (fish)
Caligus bonito Wilson, 1905 P (fish)
Caligus brevis Shiino, 1954 P (fish)
Caligus buechlerae Hewitt, 1964 P (fish) E
Caligus coryphaenae Steenstrup & Lütken, 1861 P (fish)
Caligus elongatus Nordmann, 1832 P (fish)
Caligus epidemicus Hewitt, 1971 P (fish)
Caligus kahawai Jones, 1988 P (fish) E
Caligus lalandei Barnard, 1948 P (fish)
Caligus longicaudatus Brady, 1899 P (fish) E
Caligus pelamydis Krøyer, 1863 P (fish)
Caligus productus Dana, 1852 P (fish) ?
Caligus sp. 1 Sharples & Evans 1995 P (fish)
Caligus sp. 2 Sharples & Evans 1995 P (fish)
Dentigryps sp.* P (fish)
Lepeophtheirus argentus Hewitt, 1963 P (fish) E
Lepeophtheirus crassus Wilson & Bere, 1936 P (fish)
Lepeophtheirus distinctus Hewitt, 1963 P (fish) E
Lepeophtheirus erecsoni Thomson, 1891 P (fish) E
Lepeophtheirus hastus Shiino, 1960 P (fish)
Lepeophtheirus heegaardi Hewitt, 1963 P (fish)
Lepeophtheirus histiopteridi Kazachenko, Korotaeva & Kurochkin, 1972 P (fish) E
Lepeophtheirus nordmanni (Edwards, 1840) P (fish)
Lepeophtheirus polyprioni Hewitt, 1963 P (fish) E

Lepeophtheirus scutiger Shiino, 1952 P (fish)
Lepeophtheirus sekii Yamaguti, 1936 P (fish)
Lepeophtheirus sp.* P (fish)
CECROPIDAE
Cecrops latreillei Leach, 1816 P (fish)
DICHELESTHIIDAE
Anthosoma crassum (Abildgaard, 1794) P (fish)
ENTOMOLEPIDAE
Entomolepis ovalis Brady, 1899 E
EUDACTALINIDAE
Eudactylina acanthii Scott, 1901 P (fish)
Jusheyus shogunus Deets & Benz, 1987 P (fish)
Nemesis lamma lamma Risso, 1826 P (fish)
Nemesis l. vermi Scott, 1929 P (fish)
Nemesis robusta (van Beneden, 1851) P (fish)
EURYPHORIDAE
Euryphorus brachypterus (Gerstaecker, 1853) P (fish)
Euryphorus nordmanni Milne-Edwards, 1840 P (fish)
Gloiopotes huttoni (Thomson, 1890) P (fish)
HATSCHEKIIDAE
Congericola kabatai Hewitt, 1975 P (fish) E
Hatschekia conifera Yamaguti, 1939 P (fish)
Hatschekia crenata Hewitt, 1969 P (fish) E
Hatschekia pagrosomi Yamaguti, 1939 P (fish)
Hatschekia quadrata Hewitt, 1969 P (fish) E
Hatschekia squamata Jones & Cabral, 1990 P E (fish)
HERPYLLOBIIDAE
Herpyllobius rotundus Lutzen & Jones, 1976 P (polychaete) E
KROYERIIDAE
Kroyeria carchariaeglauci Hesse, 1897* P (shark)
Kroyeria cf. *lineata* P (fish)
LERNAEOPODIDAE
Albionella sp.* P (fish)
Alella tarakihi Hewitt & Blackwell, 1987 P (fish) E
Brachiella thynni Cuvier, 1830 P (fish)
Brachiella sp.* P (fish)
Charopinus parkeri (Thomson, 1816) P (fish)
Clavella zini Kabata, 1979 P (fish) E
Clavella sp.* P (fish)
Clavellodes sp. Vooren & Tracey 1976 P (fish)
Clavellopsis sargi (Kurz, 1877) P (fish)
Dendrapta sp. Jones, 1988 P (fish)
Lernaeopoda musteli Thomson, 1890 P (fish) E
Lernaeopoda sp. *B. Jones unpubl. P (fish)
Naobranchia sp. Pilgrim 1985 P (fish)
Parabrachiella amphipacifica Ho, 1982 P (fish)
Parabrachiella insidiosa f. *lageniformes* (Heller, 1865) P (fish)
Parabrachiella sp. Pilgrim 1985 P (fish)
Pseudocharopinus bicaudatus (Kroyer, 1837) P (fish)
Schistobrachia pilgrimi Kabata, 1988 P (fish) E
Vanbenedenia sp. P (fish)
LERNANTHROPIDAE
Aethon garricki Hewitt, 1968 P (fish) E
Aethon morelandi Hewitt, 1968 P (fish)
Aethon percis (Thomson, 1890) P (fish) E
Lernanthropus microlamini Hewitt, 1968 P (fish) E
Lernanthropus sp.* P (fish)
Sagum foliaceus (Goggio, 1905) P (fish)
NICOTHOIDAE
Rhizorhina seriolis Green, 1959 P (isopod) E
Sphaeronella bradfordae Boxshall & Lincoln, 1983 P (isopod) E
Sphaeronella serolis Monod, 1930 P (isopod) E
Sphaeronellopsis littoralis Hansen, 1905 P (ostracod) E
PANDARIDAE
Demoleus latus Shiino, 1954 P (fish)
Dinemoura latifolia Steenstrup & Lütken, 1861 P (fish)
Dinemoura producta (Müller, 1785) P (fish)
Echthrogaleus denticulatus Smith, 1874 P (fish)
Echthrogaleus coleoptratus (Gúerin-Meneville, 1837) P (fish)
Nesippus orientalis Heller, 1865 P (fish)
Nogagus borealis (Steenstrup & Lütken, 1861) P (fish)
Pandarus bicolor Leach, 1816 P (fish)
Pandarus satyrus Dana, 1852 P (fish)
Perissopus dentatus Steenstrup & Lütken, 1861 P (fish)
Phyllothyreus cornutus (Edwards, 1840) P (fish)
PENNELLIDAE
Cardiodectes bellotti (Richiardi, 1882) P (fish)
Pennella histiophori Thomson, 1890 P (fish)
Trifur lotellae Thomson, 1890 P (fish)
PSEUDOCYCNIDAE
Pseudocycnus appendicualatus Heller, 1868 P (fish)
SPHYRIIDAE
Lophoura laticervix Hewitt, 1964 P (fish)
Lophoura spp. *B. Jones unpubl. P (fish)
Periplexis antarcticensis Hewitt, 1965 P (fish)
Sphyrion laevigatum (Quoy & Gaimard, 1824) P (fish)
Sphyrion lumpi (Kroyer, 1845) P (fish)?
Sphyrion quadricornis Gavevskaya & Kovaleva, 1984 P (fish)

Order MONSTRILLOIDA
MONSTRILLIDAE?
Monstrilla sp.* P

Class OSTRACODA
Order PALAEOCOPIDA
Suborder BEYRICHICOPIDA
PUNCIIDAE
Manawa staceyi Swanson, 1989 E
Manawa tryphena Hornibrook, 1949 E
Puncia novozealandica Hornibrook, 1949 E

Order PODOCOPIDA
Suborder PODOCOPINA
BAIRDIIDAE
Bairdoppilata kerryi Milau, 1993
Bairdoppilata villosa (Brady, 1880)
Bairdoppilata sp. Swanson 1979
Neonesidea amygdaloides (Brady, 1880)
Neonesidea crosskeiana (Brady, 1886)
Neonesidea fusca (Brady, 1880)
Neonesidea ovata (Bosquet, 1853)
Neonesidea sp. Ayress 1993
BYTHOCYPRIDIDAE
Orlovibairdia arcaforma (Swanson, 1979) E
Orlovibairdia aff. *angulata* (Brady, 1870)
Orlovibairdia aff. *fumata* (Brady, 1890)
Orlovibairdia sp. Swanson 1979
BYTHOCYTHERIDAE
Baltraella cf. *peterroyi* Yassini & Jones, 1995
Bythocythere arenacea Brady, 1880
Bythocythere bulba Swanson, 1979
Bythoceratina decepta Hornibrook, 1952
Bythoceratina edwardsoni Hornibrook, 1952
Bythoceratina fragilis Hornibrook, 1952
Bythoceratina hornibrooki Jellinek & Swanson, 2003
Bythoceratina maoria Hornibrook, 1952
Bythoceratina mestayerae Hornibrook, 1952
Bythoceratina powelli Hornibrook, 1952
Bythoceratina tuberculata Hornibrook, 1952
Bythoceratina utilazea Hornibrook, 1952
Microceratina quadrata Swanson, 1980
<u>*Miracythere*</u> *novaspecta* Hornibrook, 1952 E
Miracythere speciosa Jellinek & Swanson, 2003 E
CYPRIDIDAE
Candona aotearoa Chapman, 1963 F E
Candona inexpecta Chapman, 1963 F E
Candonocypris assimilis Sars, 1894 F
Candonocypris novaezelandiae (Baird *in* White & Doubleday, 1843) F E
Cypretta turgida (Sars, 1896) F E
Cypretta viridis (Thomson, 1879) F
Cyprinotus flavescens Brady, 1898 F E
Cyprinotus sarsi Brady, 1898 F E
Cypris kaiapoiensis Chapman, 1963 F E
Diacypris thomsoni (Chapman, 1963) F E
Eucypris lateraria (King, 1855) F
Eucypris sanguineus (Chapman, 1963) F E
Eucypris virens (Jurine, 1820) F A
Herpetocypris pascheri Brehm, 1929 F E
Heterocypris incongruens (Rhamdohr, 1808) F E
Ilyodromus stanleyanus (King, 1855) F
Ilyodromus obtusus Sars, 1894 F E
Ilyodromus smaragdinus Sars, 1894 F
Ilyodromus subsriatus Sars, 1894 F E
Ilyodromus varrovillius (King, 1855) F
Mesocypris insularis (Chapman, 1963) F E
Paracypria tenuis (Sars, 1905) F
Potamocypris sp. Hornibrook, 1955 F
Scottia audax (Chapman, 1961) T E
CYPRIDOPSIDAE
Cypridopsis obstinata Barclay, 1968 F E
Cypridopsis vidua (Müller, 1776) F A
Pleisiocypridopsis jolleae (Chapman, 1963) F E
Prionocypris marplesi Chapman, 1963 F E
CYTHERALISONIDAE
Cytheralison fava (Hornibrook, 1952) E
Cytheralison tehutui Jellinek & Swanson, 2003 E
Cytheralison sp. Jellinek & Swanson 2003
Debissonia fenestrata Jellinek & Swanson, 2003 E
Debissonia pravacauda (Hornibrook, 1952) E
Debissonia sp. Jellinek & Swanson 2003
CYTHERIDAE
Loxocythere crassa Hornibrook, 1952
Loxocythere hornibrooki McKenzie, 1967
Loxocythere kingi Hornibrook, 1952
Loxocythere sp. Hornibrook 1952
CYTHERIDEIDAE
Cytheridea aoteana Hornibrook, 1952 E
Hemicytheridea mosaica Hornibrook, 1952
Pseudeucythere sp. Jellinek & Swanson 2003
Pseudocythere (*Pseudocythere*) *caudata* Sars, 1866
Pseudocythere (*Plenocythere*) *fragilis* Swanson, 1979
Rotundracythere gravepuncta Hornibrook, 1952
Rotundracythere cf. *gravepunctata* Hornibrook, 1952
Rotundracythere inaequa Hornibrook, 1952
Rotundracythere mytila Hornibrook, 1952
Rotundracythere nux Jellinek & Swanson, 2003 E
Rotundracythere rotunda Hornibrook, 1952
Rotundracythere subovalis Hornibrook, 1952
Rotundracythere sp. A Jellinek & Swanson 2003
Rotundracythere sp. B Jellinek & Swanson 2003
Rotundracythere sp. C Jellinek & Swanson 2003
Rotundracythere sp. D Jellinek & Swanson 2003
Rotundracythere sp. E Jellinek & Swanson 2003
CYTHERURIDAE
Aversovalva aurea Hornibrook, 1952
Aversovalva sp. Ayress 1995
Cytheropteron anisovalva Ayress, Correge, Passlow & Whatley, 1996
Cytheropteron confusum (Hornibrook, 1952)
Cytheropteron curvicaudum Hornibrook, 1952
Cytheropteron dividentum (Hornibrook, 1952)
Cytheropteron dorsocorrugatum Ayress, Correge, Passlow & Whatley, 1996
Cytheropteron fornix (Hornibrook, 1952)
Cytheropteron hikurangiensis Swanson & Ayress, 1999 E
Cytheropteron latiscalpum Hornibrook, 1952
Cytheropteron obtusalum Hornibrook, 1952
Cytheropteron terecaudum Hornibrook,
Cytheropteron vertex Hornibrook, 1952
Cytheropteron wellingtoniense Brady, 1880
Cytheropteron wellmani Hornibrook, 1952
Cytheropteron willetti Hornibrook, 1952

Cytheropteron sp. Ayress 1993 ?Rec
Cytheropteron sp. Hartmann 1982
Cytherura clausi Brady, 1880
Eucytherura boomeri Ayress, Whatley, Downing & Millson, 1995
Eucytherura calabra (Colalongo & Pasini, 1980)
Eucytherura multituberculata Ayress, Whatley, Downing & Millson, 1995
Eucytherura? *anoda* Ayress, Whatley, Downing, & Millson, 1995
Hemicytherura (*Hemicytherura*) *aucklandica* Hornibrook, 1952
Hemicytherura (*H.*) *delicatula* Hornibrook, 1952
Hemicytherura (*H.*) *fereplana* Hornibrook, 1952
Hemicytherura (*H.*) *gravis* Hornibrook, 1952
Hemicytherura (*H.*) *pandorae* Hornibrook, 1952
Hemicytherura (*H.*) *pentagona* Hornibrook, 1952
Hemicytherura (*H.*) *quadrazea* Hornibrook, 1952
Hemicytherura (*Kangarina*) *radiata* (Hornibrook, 1952)
Microcytherura hornibrooki (McKenzie, 1967)*
Microcytherura (*Elofsonia*) sp. Hayward 1981
Oculocytheropteron acutangulum (Hornibrook, 1952)
Oculocytheropteron confusum (Hornibrook, 1952)
Oculocytheropteron improbum (Hornibrook, 1952)
Pterygocythere mucronalata (Brady, 1880)
Semicytherura arteria Swanson, 1979
Semicytherura cf. *costellata* (Brady, 1880)
Semicytherura hexagona (Hornibrook, 1952
Semicytherura sericava (Hornibrook, 1952
DARWINULIDAE
Penthesilenula aotearoa (Rossetti, Eagar & Martens, 1998) F E
Penthesilenula kohanga (Rossetti, Eagar & Martens, 1998) F E
Penthesilenula? *repoa* (Chapman, 1963) F E
Penthesilenula sphagna (Barclay, 1968) F E
ENTOCYTHERIDAE
Laccocythere aotearoa Hart & Hart, 1970 E
HEMICYTHERIDAE
Ambostracon pumila (Brady, 1880)
Aurila sp. Hartmann 1985
Bradleya arata (Brady, 1880)
Bradleya claudiae Jellinek & Swanson, 2003 E
Bradleya cupa Jellinek & Swanson, 2003
Bradleya deltoides Hornibrook, 1952
Bradleya dictyon (Brady, 1880)
Bradleya fenwicki Jellinek & Swanson, 2003
Bradleya glabra Jellinek & Swanson, 2003 E
Bradleya lordhowensis Whatley, Downing, Kesler & Harlow, 1984
Bradleya opima Swanson, 1979
Bradleya pelasgica Whatley, Downing, Kesler & Harlow, 1984
Bradleya cf. *pelasgica* Whatley, Downing, Kesler & Harlow, 1984
Bradleya perforata Jellinek & Swanson, 2003
Bradleya pygmaea Whatley, Downing, Kesler & Harlow, 1984
Bradleya reticlava Hornibrook, 1952
Bradleya silentium Jellinek & Swanson, 2003 E
Bradleya wyvillethomsoni (Brady, 1880)
Bradleya n. sp.'*dictyon*' Hornibrook 1952
Bradleya (*Quasibradleya*) *cuneazea* Hornibrook, 1952
Harleya ansoni (Whatley, Moguilevsky, Ramos & Coxill, 1998)
Harleya davidsoni Jellinek & Swanson, 2003 E
Harleya sp. Jellinek & Swanson 2003
Hemicythere brunnea (Brady, 1898)
Hemicythere foveolata (Brady, 1880)
Hemicythere fulvotincta (Brady, 1880)
Hemicythere kerguelensis (Brady, 1880)
Hemicythere munida Swanson, 1979
Hermanites andrewsi Swanson, 1979
Hermanites briggsi Swanson, 1979
Jacobella papanuiensis Swanson, 1979
Mutilus cf. *pumilus* (Brady, 1866)
Poseidonamicus major Benson, 1972
Poseidonamicus minor Benson, 1972
Poseidonamicus ocularis Whatley, Downing, Kesler & Harlow, 1986
Poseidonomicus sp. Jellinek & Swanson 2003
Poseidonamicus spp. Ayress, Neil, Passlow & Swanson 1997
Procythereis (*Serratocythere*) *lytteltonensis* Hartmann, 1982
Quadracythere biruga Hornibrook, 1952
Quadracythere mediaruga Hornibrook, 1952
Quadracythere radizea Hornibrook, 1952
Quadracythere truncula Hornibrook, 1952
Waiparacythereis joanae Swanson, 1969
ILYOCYPRIDIDAE
Ilyocypris fallax Brehm, 1929 F E
KRITHIDAE
Krithe antisawanensis Ishizaki, 1966
Krithe comma Ayress, Barrows, Passlow & Whatley, 1999
Krithe compressa (Seguenza, 1980)
Krithe dolichodeira Bold, 1946
Krithe marialusae Abate, Barra, Aiello & Bonaduce, 1993
Krithe minima Coles, Whatley & Moguilevsky, 1994
Krithe morkhoveni morkhoveni Bold, 1960
Krithe nitida Whatley & Downing, 1993 ?Rec
Krithe producta Brady, 1880
Krithe pseudocomma Ayress, Barrows, Passlow & Whatley, 1999
Krithe reversa Bold, 1958
Krithe swansoni Milau, 1993
Krithe trinidadensis Bold, 1958
Krithe sp. Ayress, Neil, Passlow & Swanson 1997
Krithe sp. 2 Ayress, Barrows, Passlow & Whatley 1999
Parakrithe sp. Swanson 1979
LEGUMINOCYTHERIDIDAE
Triginglymus? sp. Hornibrook 1952
LEPTOCYTHERIDAE
Callistocythere dorsotuberculata Hartmann, 1979
Callistocythere innominata (Brady, 1898)
Callistocythere mosleyi (Brady, 1880)
Callistocythere murrayana (Brady, 1880)
Callistocythere neoplana Swanson, 1979 E
Callistocythere obtusa Swanson, 1979 E
Callistocythere puri McKenzie, 1967
Callistocythere n. sp. cf. *crispata* Hornibrook, 1952
Callistocythere sp. Hornibrook 1952
Cluthia australis Ayress & Drapala, 1996
Kangarina unispinosa Swanson, 1980
Leptocythere hartmanni (McKenzie, 1967)
Leptocythere lacustris De Deckker, 1981
Leptocythere swansoni Hartmann, 1982 E
<u>*Swansonella*</u> *novaezealandica* (Hartmann, 1982) E
Swansonella newbrightonensis Guise, 2002 E
LIMNOCYTHERIDAE
Gomphocythere duffi (Hornibrook, 1955) F
Gomphocythere problematica (Brehm, 1932) F
<u>*Kiwicythere*</u> *anneari* Martens, 1992 F E
Kiwicythere vulgaris (McKenzie & Swanson, 1981) F E
Paralimnocythere vulgaris McKenzie & Swanson, 1981 F
LOXOCONCHIDAE
Loxoconcha anomala Brady, 1880
Loxoconcha parvifoveata Hartmann, 1980 A
Loxoconcha punctata Thomson, 1879
Loxoconcha suteri Hartmann, 1982
Loxoconcha tubmani Swanson, 1980
Loxoconcha sp. Swanson 1969
Loxoconcha sp. Hartmann 1982
MACROCYPRIDIDAE
Macrocyprina campbelli Jellinek & Swanson, 2003 E
Macrocyprina sp. Swanson 1979
Macrocyprina sp. A Jellinek & Swanson 2003
Macrocyprina sp. B Jellinek & Swanson 2003
Macrocyprina sp. C Jellinek & Swanson 2003
Macrocypris decora (Brady, 1866)
Macrocypris tumida Brady, 1880 (doubtful)
Macrocypris sp. Hornibrook 1952
Macrocypris sp. Swanson 1979
Macrocypris sp. Ayress 1993
Macromckensiea cf. *porcelica* Whatley & Downing, 1983
Macromckenziea swansoni Maddocks, 1990 E
Macropyxis andreseni Jellinek & Swanson, 2003
Macropyxis sonneae Jellinek & Swanson, 2003 E
'*Macropyxis*' *thiedei* Jellinek & Swanson, 2003 E
Macropyxis sp. Jellinek & Swanson 2003
Macrosarisa sp. Jellinek & Swanson 2003
Macroscapha procera Jellinek & Swanson, 2003 E
Gen et sp. indet. Jellinek & Swanson 2003
NEOCYTHERIDEIDAE
Copytus novaezealandiae (Brady, 1898) E
Neocytherideis muehlenhardtae Hartmann, 1982 E
Pontocythere hedleyi (Chapman, 1906)
NOTODROMADIDAE
Newnhamia fenestrata King, 1855
PARACYPRIDIDAE
Paracypris bradyi McKenzie, 1967
Phylctenophora zealandica Brady 1880
Tasmanocypris sp. Morley & Hayward 2007
PARADOXOSTOMATIDAE
Paradoxostoma spp. Hornibrook 1952
Sclerochillus littoralis (Thomson, 1879)
Sclerochillus sp. a Swanson 1979
Sclerochillus sp. b Swanson 1979
Sclerochillus sp. c Swanson 1979
PARVOCYTHERIDAE
Hemiparvocythere lagunicola Hartmann, 1982
PECTOCYTHERIDAE
Keijia demissa (Brady, 1968)
Kotoracythere formosa Swanson, 1979
Mckenzieartia sp. Morley & Hayward 2007
Munseyella aequa Swanson, 1979
Munseyella brevis Swanson, 1979
Munseyella dedeckeri (Swanson, 1980)
Munseyella modesta, Swanson, 1979
Munseyella punctata Whatley & Downing, 1983
Munseyella tumida Swanson, 1979
Munseyella sp. 10 Hartmann, 1982
Parakeijia aff. *thomi* (Yassini & Mikulandra, 1989)
<u>*Swansonites*</u> *aequa* (Swanson, 1979)
PONTOCYPRIDIDAE
Argilloecia clavata Brady, 1880 E
Argilloecia eburnea Brady, 1880
Argilloecia aff. *pusilla* (Brady, 1880)
Argilloecia sp. Swanson 1979
Propontocypris cf. *attenuata* Brady, 1868)
Propontocypris cf. *herdmani* (Scott, 1905)
Propontocypris (*Ekpontocypris*) *epicyrta* Maddocks, 1969
Propontocypris (*Propontocypris*) sp. Swanson 1979
Propontocypris (*Schedopontocypris*?) sp. 3 Maddocks 1969
TRACHYLEBERIDIDAE
<u>*Abyssophilos*</u> *ktis* Jellinek & Swanson, 2003
Actinocythereis thomsoni (Hornibrook, 1952)
Ambocythere christineae Jellinek & Swanson, 2003
Ambocythere recta Jellinek & Swanson, 2003
Apatihowella (*Apatihowella*) *rustica* Jellinek & Swanson, 2003 E
Apatihowella (*A.*) sp. Jellinek & Swanson 2003
Apatihowella (*Fallacihowella*) *caligo* Jellinek & Swanson, 2003
Apatihowella (*F.*) *sol* Jellinek & Swanson, 2003

Arculacythereis sp. Morley & Hayward 2007
Cletocythereis rastromarginata (Brady, 1880)
Clinocthereis australis Ayress & Swanson, 1991
Cythereis finlayi Hornibrook, 1952
Cythereis incerta Swanson, 1979
Dutoitella suhmi (Brady, 1880)
Henryhowella dasyderma (Brady, 1880)
Glencoeleberis armata Jellinek & Swanson, 2003
Glencoeleberis cf. *armata* Jellinek & Swanson, 2003
Glencoeleberis occultata Jellinek & Swanson, 2003 E
Glencoeleberis thomsoni (Hornibrook, 1952)
Legitimocythere acanthoderma (Brady, 1880)
Legitimocythere aculeata Jellinek & Swanson, 2003
Legitimocythere castanea Jellinek & Swanson, 2003
Legitimocythere sp. A Jellinek & Swanson 2003
Legitimocythere sp. B Jellinek & Swanson 2003
Philoneptunus gigas Jellinek & Swanson, 2003 E
Philoneptunus gravizea Hornibrook, 1952
Philoneptunus neesi Jelinek & Swanson, 2003
Philoneptunus paeminosus Whatley, Millson & Ayress, 1992
Philoneptunus paragravazea Whatley, Millson & Ayress, 1992
Philoneptunus planaltus (Hornibrook, 1952)
Philoneptunus provocator Jellinek & Swanson, 2003
Ponticocythereis decora Swanson, 1979
Ponticocythereis militaris (Brady, 1866)
Rugocythereis reticulata Ayress, 1993
Taracythere ayressi Jellinek & Swanson, 2003
Taracythere rhinoceros Jellinek & Swanson, 2003 E
Taracythere ulcus Jellinek & Swanson, 2003
Taracythere venusta Jellinek & Swanson, 2003 E
Taracythere sp. Jellinek & Swanson 2003
Trachyleberis cf. *clavigera* (Brady, 1880)
Trachyleberis lytteltonsis Harding & Sylvester-Bradley, 1953
Trachyleberis melobesoides (Brady, 1866)
Trachyleberis rugibrevis (Hornibrook, 1952)
Trachyleberis scabrocuneata (Brady, 1898)
Trachyleberis scutigera (Brady, 1880)
Trachyleberis tetrica (Brady, 1880)
Trachyleberis zeacristata Hornibrook, 1952
XESTOLEBERIDIDAE
Foveoleberis sp. Jellinek & Swanson 2003
Microxestoleberis triangulata Swanson, 1980
Semixestoleberis taiaroaensis Swanson, 1979
Xestoleberis africana Brady, 1880
Xestoleberis atra (Thomson, 1879) E
Xestoleberis aff. *chilensis austrocontinentalis* Hartmann, 1978
Xestoleberis compressa Brady, 1898
Xestoleberis cf. *curta* (Brady, 1865)
Xestoleberis foveolata Brady, 1880
Xestoleberis luxata Brady, 1898
Xestoleberis olivacea Brady, 1898
Xestoleberis margaretea Brady, 1865
Xestoleberis setigera Brady, 1880
Xestoleberis cf. *trimaculata* Hartmann, 1962
Xestoleberis sp. Hornibrook 1952
Xestoleberis sp. Swanson 1979
Xestoleberis sp. A Jellinek & Swanson 2003
Xestoleberis sp. B Jellinek & Swanson 2003
Xestoleberis sp. C Jellinek & Swanson 2003
INCERTAE SEDIS
<u>*Bisulcocythere*</u> *novaezealandiae* Ayress & Swanson, 1991 E
Saida torresi (Brady, 1880)*

Suborder PLATYCOPINA
CYTHERELLIDAE
Cytherella corpusculum Swanson, Jellinek, & Malz, 2003
Cytherella eburnea Brady, 1898 E
Cytherella hemipuncta Swanson, 1969
Cytherella hiatus Swanson, Jellinek & Malz, 2003
Cytherella intonsa Swanson, Jellinek & Malz, 2003
Cytherella lata Brady, 1880
Cytherella paranitida Whatley & Downing, 1983
Cytherella permutata Swanson, Jellinek & Malz, 2003
Cytherella plusminusve Swanson, Jellinek & Malz, 2003
Cytherella polita Brady, 1880
Cytherella pulchra Brady, 1880
Cytherella punctata Brady, 1880
Cytheretta sp. Morley & Hayward 2007
Cytherelloidea willetti Swanson, 1969* E
Cytherelloidea n. sp. van den Bold 1963
Grammcythella dyspnoea Swanson, Jellinek & Malz, 2003
Inversacytherella tanantia Swanson, Jellinek & Malz, 2003

Order MYODOCOPIDA
Suborder MYODOCOPINA
CYPRIDINIDAE
Bathyvargula walfordi Poulsen, 1963
Codonocera crueta Brady, 1902
Cypridina inermis (Müller, 1906)
Cypridinodes reticulata Poulsen, 1962 E
Cypridinodes concentrica Kornicker, 1979 E
Gigantocypris australis Poulsen, 1962 Pe
Gigantocypris danae Poulsen, 1962 Pe
Macrocypridina castanea (Brady, 1897) Pe
Metavargula iota Kornicker, 1975 E
Metavargula bradfordi Kornicker, 1979 E
Metavargula mazeri Kornickeri, 1979 E
Paracypridina aberrata Poulsen, 1962 E
Vargula ascensus Kornicker, 1979 E
Vargula stathme Kornicker, 1975 E
PHILOMEDIDAE
Euphilomedes agilis (Thomson, 1879)
Euphilomedes ferox Poulsen, 1962
Harbansus n. sp. Eagar 1995
Scleroconcha arcuata Poulsen, 1962 E
Scleroconcha sculpta (Brady, 1898) E
Scleroconcha flexilis (Brady, 1898) E
Scleroconcha wolffi Kornicker, 1975 E
CYLINDROLEBERIDIDAE
Bathyleberis oculata Kornicker, 1975 E
Cycloleberis bradyi Poulsen, 1965
Diasterope grisea (Brady, 1898) E
Dolasterope johansoni Poulsen, 1965 E
Leuroleberis zealandica (Baird, 1850) E
Parasterope pectinata Poulsen, 1965 E
Parasterope quadrata (Brady, 1898) E
Pasterope crinita Kornicker, 1975 E
Synasterope empoulseni Korniker, 1975 E
SARSIELLIDAE
Ancohenia n sp. Eagar 1995
Chelicopia tasmanensis Kornicker, 1981
<u>*Cymbicopia*</u> *brevicostata* Kornicker, 1975 E
Cymbicopia hanseni (Brady, 1898) E
Cymbicopia hispida (Brady, 1898) E
Cymbicopia zealandica (Poulsen, 1965) E
HALOCYPRIDIDAE
Archiconchoecia cuculata (Brady, 1802)
Archiconchoecia versicula (Deevey, 1978)
Conchoecia acuticostata Müller, 1906
Conchoecia amblypostha Müller, 1906
Conchoecia antipoda Müller, 1906
Conchoecia belgicae Müller, 1906
Conchoecia bispinosa Claus, 1890
Conchoecia brachyaskos Müller (1906)
Conchoecia chuni Müller 1906
Conchoecia ctenophora (Müller, 1906)
Conchoecia discorphora Müller, 1906
Conchoecia eltaninae Deevey, 1982
Conchoecia hyalophyllum Claus, 1890 Pe
Conchoecia loricata (Claus, 1894)
Conchoecia macrocheira Müller, 1906 Pe
Conchoecia magna Claus, 1874 Pe
Conchoecia major Müller, 1906
Conchoecia nasotuberculata Müller, 1906
Conchoecia parvidentata Müller, 1906 Pe
Conchoecia pusilla Müller, 1906
Conchoecia rhynchena Müller, 1906
Conchoecia serrulata laevis Brady, 1907
Conchoecia skogsbergi Iles, 1953
Conchoecia spinifera Clauss, 1890
Conchoecia subarcuata Claus, 1890 Pe
Conchoecia stigmata Müller, 1906
Conchoecia teretivalvata Iles, 1953
Conchoecia (*Alaca*) *hettacra* (Müller, 1906)
Conchoecia (*A.*) *valdiviae* (Müller, 1906)
Conchoecia (*Conchoecilla*) *chuni* (Müller, 1906)
Conchoecia (*C.*) *daphnoides* (Clauss, 1890)
Conchoecia (*Conchoecissa*) *ametra* (Müller, 1906)
Conchoecia (*C.*) *imbricata* (Brady, 1880)
Conchoecia (*C.*) *symmetrica* (Müller, 1906)
Conchoecia (*Discoconchoecia*) *elegans* Sars, 1865
Conchoecia (*Obtusoecia*) *antarctica* (Muller, 1906)
Conchoecia (*Orthoconchoecia*) *haddoni* Brady & Norman, 1896
Conchoecia (*Porroecia*) *spinirostris* Claus, 1874
Conchoecia (*P.*) *porrecta* Claus, 1890
Conchoecia (*Pseudoconchoecia*) *serrulata* Claus 1874
Fellia cornuta (Müller, 1906) Pe
Fellia dispar (Müller, 1906) Pe
Halocypris inflata (Dana, 1849) Pe
Halocypris globosa (Claus, 1874) Pe

Suborder CLADOCOPINA
POLYCOPIDAE
Polycope sp. Swanson 1979
Polycopsis cf. *loscobanosi* Hartmann, 1959

Class MALACOSTRACA
Subclass PHYLLOCARIDA
Order LEPTOSTRACA
NEBALIIDAE
Nebalia longicornis G.M. Thomson, 1879
Nebaliella antarctica Thiele, 1904
Sarsinebalia sp. 1 Dahl 1990
Sarsinebalia sp. 2 Dahl 1990
PARANEBALIIDAE
Levinebalia fortunata (Wakabara, 1976)

Subclass HOPLOCARIDA
Order STOMATOPODA
BATHYSQUILLIDAE
Bathysquilla microps (Manning, 1961)
HEMISQUILLIDAE
Hemisquilla australiensis Stephenson, 1967
ODONTODACTYLIDAE
Odontodactylus brevirostris (Miers, 1884)
SQUILLIDAE
Oratosquilla oratoria (de Haan, 1844) A
Pterygosquilla schizodontia (Richardson, 1953)
TETRASQUILLIDAE
Acaenosquilla brazieri (Miers, 1880)
Heterosquilla tricarinata (Claus, 1871) E
Heterosquilla tridentata (Thomson, 1882) E

Subclass EUMALOCOSTRACA
Superorder SYNCARIDA
Order ANASPIDACEA
STYGOCARIDIDAE
Stygocaris townsendi Morimoto, 1977 F E
Stygocaris sp. 1 Morimoto 1977 F E
Stygocaris sp. 2 Morimoto 1977 F E
Stygocaris sp. Schminke 1980 F
Stygocarella pleotelson Schminke, 1980 F E
Stygocarella sp. Schminke 1973 F E

Order BATHYNELLACEA
BATHYNELLIDAE
Bathynella sp. 1 Schminke 1971 F E
Bathynella sp. 2 Schminke 1971 F E
PARABATHYNELLIDAE
Atopobathynella compagana Schminke, 1973 F E
Hexabathynella aotearoae Schminke, 1973 F E
Notobathynella chiltoni Schminke, 1973 F E
Notobathynella hineoneae Schminke, 1973 F E
Notobathynella longipes Schminke, 1978 F E
Notobathynella sp. Schminke 1973 F E

Superorder PERACARIDA
Order LOPHOGASTRIDA
GNATHOPHAUSIIDAE
Gnathophausia elegans G.O. Sars, 1883
Gnathophausia zoea Willemoes-Suhm, 1875
Neognathophausia ingens (Dohrn, 1870)
Neognathophausia gigas (Willemoes-Suhm, 1875)
LOPHOGASTRIDAE
Lophogaster sp.* MNZ
Paralophogaster glaber Hansen, 1910

Order MYSIDA
MYSIDAE
Boreomysis rostrata Illig, 1906
Euchaetomera oculata Hansen, 1910
Euchaetomera typica G.O. Sars, 1884
Euchaetomera zurstrasseni (Illig, 1906)
Gastrosaccus australis W. Tattersall, 1923 E
Siriella denticulata (Thomson, 1880) E
Siriella thompsonii (H. Milne Edwards, 1837)
Tenagomysis chiltoni W. Tattersall, 1923 E
Tenagomysis longisquama Fukuoka & Bruce, 2005 E
Tenagomysis macropsis W. Tattersall, 1923 E
Tenagomysis novaezealandiae Thomson, 1900 E
Tenagomysis producta W. Tattersall, 1923 E
Tenagomysis robusta W. Tattersall, 1923 E
Tenagomysis scotti W. Tattersall, 1923 E
Tenagomysis similis W. Tattersall, 1923 E
Tenagomysis tenuipes W. Tattersall, 1918 E
Tenagomysis thomsoni W. Tattersall, 1923 E
PETALOPHTHALMIDAE
Petalophthalmus sp.* MNZ

Order AMPHIPODA
Suborder INGOLFIELLIDEA
INGOLFIELLIDAE
"Pseudoingolfiella" sp. a Schminke & Noodt 1968
"Pseudoingolfiella" sp. b Schminke & Noodt 1968

Suborder GAMMARIDEA
AMARYLLIDAE
Amaryllis macrophthalma Haswell, 1880
AMPELISCIDAE
Ampelisca albedo Barnard, 1961 E
Ampelisca chiltoni Stebbing, 1888 E
Byblisoides esferis Barnard, 1961 E
Haploops decansa Barnard, 1961 E
AMPHILOCHIDAE
Amphilochus filidactylus Hurley, 1955 E
Amphilochus marionis? Stebbing, 1888
Amphilochus opunake Barnard, 1972 E
Gitanopsis desmondi Barnard, 1972 E
Gitanopsis kupe Barnard, 1972 E
Gitanopsis squamosa (Thomson, 1880)
AMPITHOIDAE
Ampithoe hinatore Barnard, 1972 E
Ampithoe sp. Barnard 1972 E
Parampithoe aorangi (Barnard, 1972) E
<u>Pseudopleonexes</u> lessoniae (Hurley, 1954) E
AORIDAE
Aora maculata (Thomson, 1879)
Aora typica Kroyer, 1845
Aora sp. Barnard 1972
Camacho bathyplous Stebbing, 1888
Camacho nodderi Coleman & Lörz, 2010 E
Haplocheira barbimana (Thomson, 1879)
Haplocheira lendenfeldi Chilton, 1884 E
Lembos? sp. No. 1 Barnard 1972
Lembos? sp. No. 3 Barnard 1972
Lembos? sp. No. 4 Barnard 1972
<u>Meridiolembos</u> acherontis (Myers, 1981) E
Meridiolembos hippocrenes (Myers, 1981) E
Meridiolembos pertinax (Myers, 1981) E
Microdeutopus apopo Barnard, 1972 E
CAPRELLIDAE
Caprella equilibra Say, 1818
Caprella manneringi McCain, 1979 E
Caprella mutica Schurin, 1935 A
Caprellina longicollis (Nicolet, 1849)
Caprellaporema subantarctica Guerra-García, 2003 E
Caprellinoides mayeri (Pfeffer, 1888)
Pseudaeginella campbellensis Guerra-García, 2003 E
Pseudoprotomima hurleyi McCain, 1969 E
CEINIDAE
Ceina egregia (Chilton, 1883) E
<u>Taihape</u> karori Barnard, 1972 E
<u>Waitomo</u> manene Barnard, 1972 E
CHELURIDAE
Chelura terebrans Philippi, 1839 A
CHEVALIIDAE
Chevalia sp. Ahyong
CHILTONIIDAE
<u>Chiltonia</u> enderbyensis Hurley, 1954 F E
Chiltonia mihiwaka (Chilton, 1898) F E
Chiltonia minuta Bousfield, 1964 ?F E
Chiltonia rivertonensis Hurley, 1954 F E
COLOMASTIGIDAE
Colomastix magnirama Hurley, 1954 E
Colomastix subcastellata Hurley, 1954 E
COROPHIIDAE
Apocorophium acutum Chevreux, 1908 A
Monocorophium acherusicum (Costa, 1857) A
Monocorophium insidiosum (Crawford, 1937) A
Monocorophium sextonae (Crawford, 1937) A
Paracorophium brisbanensis Chapman, 2002 B A
Paracorophium excavatum (Thomson, 1884) F B E
Paracorophium lucasi Hurley, 1954 F B E
CYAMIDAE
Cyamus balaenopterae Barnard, 1931
Cyamus boopis Lutken, 1873
Cyamus erraticus Roussel de Vauzeme, 1834
Cyamus gracilis Roussel de Vauzeme, 1834
Cyamus ovalis Roussel de Vauzeme, 1834
Isocyamus delphini Guerin-Meneville, 1837
Neocyamus physeteris (Pouchet, 1888)
Scutocyamus antipodensis Lincoln & Hurley, 1980 E
CYPHOCARIDIDAE
Cyphocaris anonyx Boeck, 1871
Cyphocaris richardi Chevreux, 1905
CYPROIDEIDAE
<u>Neocyproidea</u> otakensis (Chilton, 1900) E
Neocyproidea pilgrimi Hurley, 1955 E
<u>Peltopes</u> peninsulae (Hurley, 1955) E
Peltopes productus K.H. Barnard, 1930 E
DEXAMINIDAE
Atylus reductus (K.H. Barnard, 1930) E
Atylus taupo Barnard, 1972 E
Guernea timaru Barnard, 1972 E
Lepechinella sucia Barnard, 1961
Lepechinella wolffi Dahl, 1959 E
Paradexamine barnardi Sheard, 1938 E
Paradexamine houtete Barnard, 1972 E
Paradexamine muriwai Barnard, 1972 E
Paradexamine pacifica (Thomson, 1879) E
Paradexamine sp. Barnard 1972 E
Polycheria obtusa Thomson, 1882 E
Syndexamine carinata Chilton, 1914 E
DOGIELINOTIDAE
Allorchestes compressa Dana, 1852
'*Allorchestes compressus*' Bousfield 1964 F? E
Allorchestes novizealandiae Dana, 1852 F E
ENDEVOURIDAE
Ensayara iara Lowry & Stoddart, 1983 E
Ensayara kermadecensis Kilgallen, 2009 E
Ensayara ursus Kilgallen, 2009 E
EOPHLIANTIDAE
Bircenna fulva Chilton, 1884 E
Bircenna macayai Lörz, Kilgallen & Thiel, 2009 E
Cylindryllioides kaikoura Barnard, 1972 E
Wandelia wairarapa Barnard, 1972 E
EPIMERIIDAE
Epimeria bruuni Barnard, 1961 E
Epimeria glaucosa Barnard, 1961 E
Epimeria horsti Lörz, 2008 E
Epimeria norfanzi Lörz, 2010
Epimeriella victoria Hurley, 1957 E
EUSIRIDAE
Atyloella moke Barnard, 1972 E
Bathyschraderia magnifica Dahl, 1959 E
Eusiroides monoculoides (Haswell, 1880)
Eusirus antarcticus Thomson, 1880
Gondogeneia bidentata (Stephensen, 1927)
Gondogeneia danai (Thomson, 1879) E
Gondogeneia rotorua Barnard, 1972 E
Gondogeneia subantarctica (Stephensen, 1938) E
Gondogeneia sp. Chilton 1909 E
Oradarea novaezealandiae (Thomson, 1879) E
Paramoera aucklandica (Walker, 1908) E
Paramoera chevreuxi (Stephensen, 1927) E
Paramoera fasciculata (Thomson, 1880) E
Paramoera fissicauda? (Dana, 1852)
Paramoera rangatira Barnard, 1972 E
Paramoera sp. Barnard 1972 E
Paramoera sp. Barnard 1972 F E
Prostebbingia? *levis* (Thomson, 1879) E
Regalia fascicularis Barnard, 1930 E
Rhachotropis chathamensis Lörz, 2010 E
Rhachotropis delicata Lörz, 2010 E
Rhachotropis levantis Barnard, 1961 E
Schraderia serraticauda (Stebbing, 1888)
<u>Whangarusa</u> translucens (Chilton, 1884) E
EXOEDICEROTIDAE
<u>Patuki</u> breviuropodus Cooper & Fincham, 1974 E
Patuki roperi Fenwick, 1983 E
HADZIIDAE
<u>Zhadia</u> subantarctica Lowry & Fenwick, 1983 E
HYALIDAE
Apohyale hirtipalma (Dana, 1852)
Apohyale media (Dana, 1853)
Apohyale novaezealandiae (Thomson, 1879) E
Protohyale (*Protohyale*) *campbellica* (Filhol, 1885) E
Protohyale (*Boreohyale*) *grenfelli* Chilton, 1916 E
Protohyale (*B.*) *maroubrae* Stebbing, 1899
Protohyale (*B.*) *rubra* (Thomson, 1879)
Hyale sp. Thomson 1899
IPHIMEDIIDAE
Amathillopsis grevei Barnard, 1961
<u>Anisoiphimedia</u> haurakiensis (Hurley, 1954) E
Curidia knoxi Lowry & Myers, 2003 E
Epimeria bruuni Barnard, 1961 E
Epimeria glaucosa Barnard, 1961 E
Epimeriella victoria Hurley, 1957 E
Iphimedia spinosa (Thomson, 1880) E
Labriphimedia hinemoa (Hurley, 1954) E
ISAEIDAE
Gammaropsis chiltoni (Thomson, 1897) E
Gammaropsis crassipes (Haswell, 1881)
Gammaropsis haswelli (Thomson, 1897)
Gammaropsis kermadeci (Stebbing, 1888) E
Gammaropsis longimana (Chilton, 1884) E
Gammaropsis tawahi Barnard, 1972 E
Gammaropsis thomsoni Stebbing, 1888
Gammaropsis typica (Chilton, 1884) E

Gammaropsis sp. Barnard 1972 E
Pagurisaea schembrii Moore, 1983 E
Photis brevicaudatus Norman, 1867
Photis nigrocula Lowry, 1979 E
Photis phaeocula Lowry, 1979 E
Photis sp. Barnard 1972 E
ISCHYROCERIDAE
Ericthonius pugnax (Dana, 1852) A
Ischyrocerus longimanus (Haswell, 1880)
Jassa alonsoae Conlan, 1990
Jassa fenwicki Conlan, 1990
Jassa hartmannae Conlan, 1990 E
Jassa justi Conlan, 1990
Jassa marmorata Conlan, 1990
Jassa slatteryi Conlan, 1990
Notopoma fallohidea (Lowry, 1981) E
Notopoma harfoota (Lowry, 1981) E
Notopoma stoora (Lowry, 1981) E
Parajassa andromedae Moore, 1985 E
Runanga coxalis Barnard, 1961 E
Runanga wairoa McCain, 1969 E
Ventojassa frequens (Chilton, 1883) E
KAMAKIDAE
Aorcho delgadus Barnard, 1961
LEUCOTHOIDAE
Leucothoe trailli Thomson, 1882 E
LILJEBORGIIDAE
Liljeborgia aequabilis Stebbing, 1888
Liljeborgia akaroica Hurley, 1954
Liljeborgia barhami Hurley, 1954 E
Liljeborgia dubia (Haswell, 1880)
Liljeborgia hansoni Hurley, 1954 E
LYSIANASSIDAE
Acheronia pegasus Lowry, 1984 E
Acontiostoma marionis Stebbing, 1888
Acontiostoma tuberculata Lowry & Stoddart, 1983 E
Acontiostoma sp.
Ambasiopsis robustus Barnard, 1961 E
Bruunosa bruuni (Dahl, 1959) E
Cheirimedon cansada (Barnard, 1961)
Eurythenes gryllus (Lichtenstein, 1822)
Hippomedon antitemplado Barnard, 1961 E
Hippomedon concolor Barnard, 1961 E
Hippomedon hake Lowry & Stoddart, 1983 E
Hippomedon hurleyi Kilgallen, 2009 E
Hippomedon incisus K.H. Barnard, 1930 E
Hippomedon iugum Kilgallen, 2009 E
Hippomedon kergueleni (Miers, 1875)
Hippomedon tasmanicus Barnard, 1961 E
Hirondella dubia Dahl, 1959 E
Kakanui punui Lowry & Stoddart, 1983 E
Lepidecreella bidens (Barnard, 1930) E
Lysianopsis tieke Lowry & Stoddart, 1983 E
Ocosingo fenwicki Lowry & Stoddart, 1983 E
Orchomene aahu Lowry & Stoddart, 1983 E
Orchomenella cavimanus (Stebbing, 1888)
Paracentromedon? *manene* (Lowry & Stoddart, 1983) E
Paracentromedon? *matikuku* (Lowry & Stoddart, 1983) E
Paracentromedon? *whero* (Fenwick, 1983) E
Paralicella similis Birnstein & Vinogradov, 1960
Parawaldeckia angusta Lowry & Stoddart, 1983 E
Parawaldeckia dabita Lowry & Stoddart, 1983 E
Parawaldeckia hirsuta Lowry & Stoddart, 1983 E
Parawaldeckia karaka Lowry & Stoddart, 1983 E
Parawaldeckia kidderi Lowry & Stoddart, 1983
Parawaldeckia parata Lowry & Stoddart, 1983 E
Parawaldeckia pulchra Lowry & Stoddart, 1983 E
Parawaldeckia stephenseni Hurley & Cooper, 1974 E
Parawaldeckia suzae Lowry & Stoddart, 1983 E
Parawaldeckia thomsoni (Stebbing, 1906) E
Parawaldeckia vesca Lowry & Stoddart, 1983 E
Pseudambasia rossii Stephensen, 1927 E
Schisturella abyssi tasmanensis (Barnard, 1961) E
Stomacontion hurleyi Lowry & Stoddart, 1983 E
Stomacontion pungapunga Lowry & Stoddart, 1983 E
Stomacontion sp.
Tryphosella moana Kilgallen, 2009 E
Tryphosella serans Lowry & Stoddart, 1983 E
Valettiopsis multidentata Barnard, 1961 E
MELITIDAE
Ceradocopsis macracantha Lowry & Fenwick, 1983 E
Ceradocopsis carnleyi (Stephensen, 1927) E
Ceradocopsis peke Barnard, 1972 E
Ceradocus chiltoni Sheard, 1939 E
Ceradocus rubromaculatus haumuri Barnard, 1972
Elasmopus bollonsi Chilton, 1915
Elasmopus neglectus Chilton, 1915 E
Elasmopus wahine Barnard, 1972 E
Gammarella hybophora Lowry & Fenwick, 1983 E
Hoho hirtipalma (Barnard, 1972) E
Linguimaera tias Krapp-Schickel, 2003
Maera incerta Chilton, 1883 E
Maera spp. Barnard 1972
Mallacoota nanaui Myers, 1985
Melita awa Barnard, 1972 B E
Melita festiva (Chilton, 1884)
Melita inaequistylis Dana, 1852 E
Melita? *solada* Barnard, 1961 E
Melita sp. Barnard 1972 E
Micramaera tepuni (Barnard, 1972) E
Parapherusa crassipes (Haswell, 1880)
Tagua aporema Lowry & Fenwick, 1983 E
MELPHIDIPPIDAE
Horniella whakatane (Barnard, 1972) E
NIHOTUNGIDAE
Nihotunga noa Barnard, 1972 E
OCHLESIDAE
Curidia knoxi Lowry & Myers, 2003 E
OEDICEROTIDAE
Bathymedon neozelanicus Barnard, 1930 E
Carolobatea novaezealandiae Chilton, 1909
Lopiceros forensia Barnard, 1961 E
Monoculodes abacus Barnard, 1961 E
Oediceroides apicalis Barnard, 1931
Oediceroides limpieza Barnard, 1961 E
Oediceroides microcarpa Barnard, 1930 E
Oediceroides wolffi Barnard, 1961
PARACALLIOPIIDAE
Paracalliope fluviatilis (Thomson, 1879) F E
Paracalliope karitane Barnard, 1972 F E
Paracalliope novizealandiae (Dana, 1853) E
PARACRANGONYCTIDAE E
Paracrangonyx compactus (Chilton, 1882) F E
Paracrangonyx winterbourni Fenwick, 2001 F E
Pseudoingolfiella Morimotoi Grosso, Peralta & Ruffo, 2006 F E
PARALEPTAMPHOPIDAE E
Paraleptamphopus caeruleus (Thomson, 1885) F E
Paraleptamphopus subterraneus (Chilton, 1882) F E
Paraleptamphopus spp. (10) 10E G. D. Fenwick
Ringanui koonuiroa Fenwick, 2006 F E
Ringanui toonuiiti Fenwick, 2006 F E
Gen. nov. (~10) et n. spp. (~20) ~ 20E G. D. Fenwick
PARDALISCIDAE
Arculfia trago Barnard, 1961 E
Halice macronyx (Stebbing, 1888)
Halice secunda (Stebbing, 1888)
Halice sublittoralis Lowry, 1979 E
Halicoides tambiella Barnard, 1961 E
Pardaliscoides longicaudatus Dahl, 1959 E
Princaxelia abyssalis Dahl, 1959
PHLIANTIDAE
Iphinotus typicus (Thomson, 1882) E
PHOXOCEPHALIDAE
Booranus? *spinibasus* (Cooper, 1974) E
Cephaloxoides keppeli (Barnard & Drummond, 1978) E
Cephalophoxus regium (Barnard, 1930) E
Harpiniopsis nadania (Barnard, 1961) E
Joubinella traditor Pirlot, 1932
Palabriaphoxus palabria Barnard, 1961 E
Parajoubinella concinna Gurjanova, 1977 E
Paraphoxus? *pyripes* Barnard, 1930 E
Protophoxus australis Barnard, 1930
Ringaringa littoralis (Cooper & Fincham, 1974) E
Synphoxus novaezelandicus Gurjanova, 1980 E
Torridoharpinia hurleyi (Barnard, 1958) E
Trichophoxus capillatus Barnard, 1930 E
Waitangi rakiura (Cooper & Fincham, 1974) E
Waitangi? *brevirostris* Fincham, 1977 E
Waitangi? *chelatus* (Cooper, 1974) E
Wildus waipiro (Barnard, 1972) E
PHREATOGAMMARIDAE E
Phreatogammarus fragilis (Chilton, 1882) F E
Phreatogammarus helmsi Chilton, 1918 F E
Phreatogammarus propinquus Chilton, 1907 F E
Phreatogammarus waipoua Chapman, 2003 F E
PLATYISCHNOPIDAE
Otagia neozelanicus (Chilton, 1987) E
PODOCERIDAE
Podocerus cristatus (Thomson, 1879) E
Podocerus karu Barnard, 1972 E
Podocerus manawatu Barnard, 1972 E
Podocerus sp. Chilton, 1926
Podocerus wanganui Barnard, 1972 E
RAKIROIDAE E
Rakiroa rima Lowry & Fenwick, 1982 E
SCOPELOCHEIRIDAE
Scopelocheirus? *schellenbergi* Bernstein & Vinogradov, 1958
SEBIDAE
Seba typica (Chilton, 1884)
STEGOCEPHALIDAE
Andaniotes corpulentus (Thomson, 1882)
Euandandania gigantea (Stebbing, 1888)
Phippsiella nipoma Barnard, 1961
Stegosoladidus simplex (Barnard, 1930) E
Tetradeion crassum (Chilton, 1883) E
STENOTHOIDAE
Mesoproboloides? *excavata* Fenwick, 1977 E
Parathaumatelson nasicum (Stephensen, 1927) E
Probolisca ovata (Stebbing, 1888)
Raukumara rongo (Barnard, 1972) E
Stenothoe aucklandicus Stephensen, 1927 E
Stenothoe gallensis Walker, 1904 A
Stenothoe moe Barnard, 1972 E
Stenothoe valida? Dana, 1853
STILIPEDIDAE
Alexandrella mixta (Nicholls, 1938)
Stilipes sanguineus (Hurley, 1954) E
SYNOPIIDAE
Syrrhoe affinis? Chevreux, 1908
TALITRIDAE
Arcitalitrus dorrieni (Hunt, 1925) T A
Arcitalitrus sylvaticus (Haswell, 1880) T A
Austroides sp. Fenwick & Webber 2008 T
Bellorchestia quoyana (Milne-Edwards, 1840) S E
Bellorchestia spadix Hurley, 1956 S E
Bellorchestia tumida Thomson, 1885 S E
Kanikania improvisa (Chilton, 1909) T E
Kanikania motuensis Duncan, 1994 T E
Kanikania rubroannulata (Hurley, 1957) T E
Makawe hurleyi (Duncan, 1968) T E
Makawe insularis (Chilton, 1909) T E
Makawe maynei (Chilton, 1909) T E
Makawe otamatuakeke Duncan, 1994 T E
Makawe parva (Chilton, 1909) T E
Makawe waihekensis Duncan, 1994 T E
Makawe sp. A Fenwick & Webber 2008 T E
Makawe sp. B Fenwick & Webber 2008 T E
Makawe sp. C Fenwick & Webber 2008 T E
Notorchestia aucklandiae (Bate, 1862) S E

Orchestia? *recens* (Thomson, 1884) F E
Orchestia? sp. A Hurley, 1975 F E
Orchestia? sp. B Hurley, 1975 F E
Parorchestia ihurawao Duncan, 1994 T E
Parorchestia lesliensis (Hurley, 1957) T E
Parorchestia longicornis (Stephensen, 1938) T E
Parorchestia tenuis (Dana, 1852) T E
Protorchestia campbelliana (Bousfield, 1964) T E
<u>*Puhuruhuru*</u> *aotearoa* Duncan, 1994 T E
Puhuruhuru patersoni (Stephensen, 1938) T E
Puhuruhuru sp. Fenwick & Webber 2008 T E
<u>*Talitroides*</u> *topitotum* (Burt, 1934) T A
<u>*Tara*</u> *hauturu* Duncan, 1994 T E
Tara simularis (Hurley, 1957) T E
Tara sinbadensis (Hurley, 1957) T E
Tara sylvicola (Dana, 1852) T E
Tara taranaki Duncan, 1994 T E
Tara sp. A Fenwick & Webber 2008 T E
Tara sp. B Fenwick & Webber 2008 T E
Transorchestia bollonsi (Chilton, 1909) S E
Transorchestia chathamensis (Hurley, 1956) S E
Transorchestia cookii Filhol, 1885 S E
Transorchestia dentata (Filhol, 1885) S E
Transorchestia kirki (Hurley, 1956) S E
Transorchestia miranda (Chilton, 1916) S E
Transorchestia serrulata (Dana, 1852) S E
Transorchestia telluris (Bate, 1862) S E
<u>*Waematau*</u> *kaitaia* Duncan, 1994 T E
Waematau manawatahi Duncan, 1994 T E
Waematau muriwhenua Duncan, 1994 T E
Waematau reinga Duncan, 1994 T E
Waematau unuwhao Duncan, 1994 T E
URISTIDAE
Abyssorchomene abyssorum (Stebbing, 1888)
<u>*Galathella*</u> *galatheae* (Dahl, 1959) E
Galathella solivagus Kilgallen, 2009 E
UROTHOIDAE
Carangolia puliciformis Barnard, 1961 E
Urothoe elizae Cooper & Fincham, 1974 E
Urothoe wellingtonensis Cooper, 1974 E
Urothoides lachneessa (Stebbing, 1888)

Suborder HYPERIIDEA
ARCHAEOSCINIDAE
Archaeoscina steenstrupi (Bovallius, 1885)
Paralanceola wolffi Zeidler, 2006
BRACHYSCELIDAE
Brachyscelus crusculum Bate, 1861
Brachyscelus rapacoides Stephensen, 1925
Brachyscelus rapax (Claus, 1871)
CHUNEOLIDAE
Chuneola paradoxa Woltereck, 1909
CYLLOPIDAE
Cyllopus magellanicus Dana, 1853
CYSTISOMATIDAE
Cystisoma fabricii Stebbing, 1888
Cystisoma magna (Woltereck, 1903)
Cystisoma pellucida (Willemoes-Suhm, 1873)
DAIRELLIDAE
Dairella californica (Bovallius 1887)
HYPERIIDAE
Hyperia gaudichaudii Milne-Edwards, 1840
Hyperia spinigera Bovallius, 1889
Hyperiella antarctica Bovallius, 1887
Hyperoche mediterranea Senna, 1908
Hyperoche medusarum (Kroyer, 1838)
Lestrigonus schizogeneios (Stebbing, 1888)
Themisto australis (Stebbing, 1888)
Themisto gaudichaudi Guerin, 1825
IULOPIDIDAE
Iulopis loveni Bovallius, 1887
LANCEOLIDAE
Lanceola clausi Bovallius, 1885
Lanceola grunneri Zeidler, 2009
Lanceola intermedia Vinogradov, 1960
Lanceola longidactyla Vinogradov, 1964
Lanceola loveni (Bovallius, 1885)
Lanceola pacifica Stebbing, 1888
Lanceola sayana Bovallius, 1885
Lanceola serrata Bovallius, 1885
Scypholanceola aestiva (Stebbing, 1888)
LESTRIGONIDAE
Hyperietta luzoni (Stebbing, 1888)
Hyperietta vosseleri (Stebbing, 1904)
Hyperioides longipes Chevreux, 1900
Hyperionyx macrodactylus (Stephensen, 1924)
LYCAEIDAE
Lycaea nasuta Claus, 1879
Lycaea pachypoda (Claus, 1879)
Lycaea pulex Marion, 1874
Simorhynchotus antennarius (Claus, 1871)
LYCAEOPSIDAE
Lycaeopsis themistoides Claus, 1879
Lycaeopsis zamboangae (Stebbing, 1888)
MEGALANCEOLIDAE
Megalanceola stephenseni (Chevreux, 1920)
MICROPHASMIDAE
Microphasma agassizi Woltereck, 1909
MIMONECTIDAE
Mimonectes gaussi (Woltereck, 1904)
OXYCEPHALIDAE
Calamorhynchus pellucidus Streets, 1878
Leptocotis tenuirostris (Claus, 1871)
Oxycephalus piscator Milne-Edwards, 1830
Streetsia challengeri Stebbing, 1888
Streetsia porcella (Claus, 1879)
PARAPHRONIMIDAE
Paraphronima crassipes Claus, 1879
Paraphronima gracilis Claus, 1879
PARASCELIDAE
Parascelus edwardsi Claus, 1879
PHRONIMIDAE
Phronima atlantica Guérin-Méneville, 1836
Phronima sedentaria (Forsskål, 1775)
Phronimella elongata (Claus, 1862)
PHROSINIDAE
Anchylomera blossevillei Milne-Edwards, 1830
Phrosina semilunata Risso, 1822
Primno macropa Guérin-Méneville, 1836
PROLANCEOLIDAE
Prolanceola vibiliformis Woltereck, 1907
PLATYSCELIDAE
Amphithyrus bispinosus Claus, 1879
Hemityphis tenuimanus Claus, 1879
Paratyphis parvus Claus, 1887
Paratyphis spinosus Spandl, 1924
Platyscelus armatus (Claus, 1879)
Platyscelus ovoides (Risso, 1816)
Platyscelus serratulus Stebbing, 1888
Tetrathyrus arafurae Stebbing, 1888
Tetrathyrus forcipatus Claus, 1879
PRONOIDAE
Eupronoe maculata Claus, 1879
Eupronoe minuta Claus, 1879
Paralycaea gracilis Claus, 1879
Parapronoe campbelli Stebbing, 1888
Parapronoe crustulum Claus, 1879
Parapronoe parva Claus, 1879
Pronoe capito Guérin-Méneville, 1836
SCINIDAE
Acanthoscina acanthodes (Stebbing, 1895)
Scina borealis (G.O. Sars, 1882)
Scina crassicornis (Fabricius, 1775)
Scina curvidactyla Chevreux, 1914
Scina pusilla Chevreux, 1919
Scina tullbergi (Bovallius, 1885)
Scina wagleri abyssalis Vinogradov, 1957
TRYPHANIDAE
Tryphana malmi Boeck, 1871
VIBILIIDAE
Vibilia antarctica Stebbing, 1888
Vibilia armata Bovallius, 1887
Vibilia borealis Bate & Westwood, 1868
Vibilia caeca Bulycheva, 1955
Vibilia chuni Behning & Woltereck, 1912
Vibilia cultripes Vosseler, 1901
Vibilia gibbosa Bovallius, 1887
Vibilia longicarpus Behning, 1913
Vibilia propinqua Stebbing, 1888
Vibilia pyripes Bovallius, 1887
Vibilia robusta Bovallius, 1887
Vibilia stebbingi Behning & Woltereck, 1912
Vibilia viatrix Bovallius, 1887

Order ISOPODA
Suborder ASELLOTA
ACANTHASPIDIDAE
Mexicope sushara Bruce, 2004 E
Acanthaspidia sp. E
DENDROTIIDAE
Acanthomunna proteus Beddard, 1886 E
Dendromunna mirabile Wolff, 1962 E
DESMOSOMATIDAE
Chelator spp. (3) N. Bruce 2008
Desmosoma sp. N. Bruce 2008
Eugerda sp. N. Bruce 2008
Eugerdella spp. (2) N. Bruce 2008
Mirabilicoxa sp. N. Bruce 2008
Prochelator tupuhi Brix & Bruce, 2008 E
HAPLONISCIDAE
Chauliodoniscus tasmanaeus Lincoln, 1985 E
Haploniscus kermadecensis Wolff, 1962 E
Haploniscus piestus Lincoln, 1985 E
Haploniscus miccus Lincoln, 1985 E
Haploniscus saphos Lincoln, 1985 E
Haploniscus silus Lincoln, 1985 E
Haploniscus tangaroae Lincoln, 1985 E
Hydroniscus lobocephalus Lincoln, 1985 E
Mastigoniscus pistus Lincoln, 1985 E
JANIRIDAE
Heterias n. sp. Scarsbrook et al. 2003 E
Iais californica (Richardson, 1904)
Iais pubescens (Dana, 1852)
Ianiropsis neglecta (Chilton, 1909) E
Iathrippa longicauda (Chilton, 1884) E
Iathrippa sp. NIWA N. Bruce
Mackinia sp. Scarsbrook et al. 2003
ISCHNOMESIDAE
Ischnomesus anacanthus Wolff, 1962 E
Ischnomesus birsteini Wolff, 1962 E
Ischnomesus bruuni Wolff, 1956 E
Ischnomesus spaercki Wolff, 1956 E
Mixomesus pellucidus Wolff, 1962 E
JOEROPSIDIDAE
Joeropsis neozealanica Chilton, 1892 E
Joeropsis palliseri Hurley, 1957 E
Joeropsis spp. (2) 2E
MUNNIDAE
Echinomunna sp. E
Munna neozelanica Chilton, 1892 E
Munna spp. (4) 4E
Uromunna schauinslandi (Sars, 1905) E
MUNNOPSIDIDAE
Bathybadistes andrewsi Merrin, Malyutina & Brandt, 2009
Disconectes madseni (Wolff, 1956) E
Echinozone n. sp. E
Epikopais mystax Merrin, 2009 E
Eurycope galatheae Wolff, 1956 E
Eurycope gibberifrons Wolff, 1962 E
Hapsidohedra aspidophora (Wolff, 1962) E
Ilyarachna kermadecensis Wolff, 1962 E
Ilyarachna n. spp. (7) 7E
Munneurycope harrietae Wolff, 1962 E
Munneurycope menziesi Wolff, 1962 E

Munnopsis gracilis Beddard, 1886 E
Notopais euaxos Merrin & Bruce, 2006 E
Notopais zealandica Merrin, 2004 E
Paropsurus giganteus Wolff, 1962
Pseudarachna nohinohi Merrin, 2006 E
Storthyngura benti Wolff, 1956 E
Vanhoeffenura abyssalis Wolff, 1962 E
Vanhoeffenura furcata Wolff, 1956 E
Vanhoeffenura kermadecensis Wolff, 1962 E
Vanhoeffenura novaezelandiae (Beddard, 1885) E
Sursumura affinis Malyutina, 2004
PARAMUNNIDAE
Allorostrata n. sp. NIWA N. Bruce E
Austronanus aucklandensis Just & Wilson, 2006
Austronanus sp. A Just & Wilson 2006
Omanana serraticoxa Just & Wilson, 2004 E
'*Paramunna serrata*' sensu Stephenson 1927 E
Paramunna snaresi Just & Wilson, 2004 E
Spiculonana petraea Just & Wilson, 2004 E
Spiculonana platysoma Just & Wilson, 2004 E
Sporonana concavirostra Just & Wilson, 2004 E
Sporonana litoralis Just & Wilson, 2004 E
Gen. nov. 1 N. Bruce 2008 E
Gen. nov. 2 N. Bruce 2008 E
PSEUDOJANIRIDAE
Schottea taupoensis Serov & Wilson, 1999 E
Schottea n. sp. E
SANTIIDAE
Halacarsantia uniramea (Menzies & Miller, 1955) E
Kuphomunna n. sp. NIWA N. Bruce E
Santia hispida (Vanhöffen, 1914)
Santia n. spp. (2) 2E
STENETRIIDAE
Protallocoxa abyssale (Wolff, 1962) E
Stenetrium fractum Chilton, 1884 E

Suborder PHREATOICIDEA
PHREATOICIDAE
Neophreatoicus assimilis (Chilton, 1894) F E
Notamphisopus benhami Nicholls, 1944 F E
Notamphisopus dunedinensis (Chilton, 1906) F E
Notamphisopus flavius Nicholls, 1944 F E
Notamphisopus kirkii (Chilton, 1906) F E
Notamphisopus littoralis Nicholls, 1944 F E
Notamphisopus percevali Nicholls, 1944 F E
Phreatoicus orarii Nicholls, 1944 F E
Phreatoicus typicus Chilton, 1883 F E

Suborder CYMOTHOIDA
AEGIDAE
Aega komai Bruce, 1996
Aega monophthalam Johnston, 1834
Aega semicarinata Miers, 1875
Aega stevelowei Bruce, 2009
Aega urotoma Barnard, 1914
Aegapheles alazon (Bruce, 2004)
Aegapheles birubi (Bruce, 2004)
Aegapheles copidis Bruce, 2009
Aegapheles hamiota (Bruce, 2004)
Aegapheles mahana Bruce, 2009 E
Aegapheles rickbruscai (Bruce, 2004)
Aegapheles umpara (Bruce, 2004)
Aegiochus coroo (Bruce, 1983)
Aegiochus gordoni Bruce, 2009 E
Aegiochus insomnis Bruce, 2009 E
Aegiochus kakai Bruce, 2009 E
Aegiochus kanohi Bruce, 2009
Aegiochus laevis (Studer, 1883)
Aegiochus nohinohi Bruce, 2009
Aegiochus piihuka Bruce, 2009
Aegiochus riwha Bruce, 2009
Aegiochus tara Bruce, 2009
Aegiochus vigilans (Haswell, 1881)
Aegiochus sp. Bruce 2009
Epulaega derkoma Bruce, 2009
Epulaega fracta (Hale, 1940)
Rocinela bonita Bruce, 2009 E
Rocinela garricki Hurley, 1957 E
Rocinela leptopus Bruce, 2009 E
Rocinela pakari Bruce, 2009 E
Rocinela resima Bruce, 2009 E
Rocinela runga Bruce, 2009 E
Rocinela satagia Bruce, 2009 E
Rocinela sp. Bruce 2009
Syscenus latus Richardson, 1909 Pe
Syscenus springthorpei Bruce, 1997 Pe
Syscenus sp. Bruce 2009
ANTHURIDAE
Haliophasma novaezelandiae Wägele, 1985 E
Haliophasma platytelson Wägele, 1985 E
Quantanthura pacifica Wägele, 1985 E
Quantanthura raoulia Poore & Lew Ton, 1986 E
Mesanthura affinis (Chilton, 1883) E
ANUROPIDAE
Anuropus novaezealandiae Jansen, 1981 Pe E
Anuropus sp. N. Bruce 2008
BOPYRIDAE
Athelges lacertosi Pike, 1961 E
Eophrixus shojii Shiino, 1941
Gigantione pikei Page, 1985 E
Gyge angularis Page, 1985 E
Hemiarthrus nematocarcini Stebbing, 1914
Pleurocryptella infecta Nierstrasz & Brender à Brandis, 1923
Pseudione affinis (Sars, 1882)
Pseudione hayi Nierstrasz & Brender à Brandis, 1931 E
Pseudione hyndmanni (Bate & Westwood, 1868)
Pseudione murawaiensis Page, 1985 E
Pseudione pontocari Page, 1985 E
Pseudostegias otagoensis Page, 1985 E
Rhopalione atrinicolae Page, 1985 E
CIROLANIDAE
Cirolana canaliculata Tattersall, 1921 E
Cirolana kokoru Bruce, 2004 E
Cirolana quechso Bruce, 2004 E
Cirolana quadripustulata Hurley, 19571 E
Cirolana n. spp. (5) 5E
Eurydice subtruncata Tattersall, 1921 E
Eurylana arcuata (Hale, 1925) E
Eurylana cooki (Filhol, 1885) E
Metacirolana caeca (Hansen, 1916) Pe
Metacirolana japonica (Hansen, 1890)
Natatolana amplocula Bruce, 1986
Natatolana aotearoa Keable, 2006 E
Natatolana honu Keable, 2006 E
Natatolana narica (Bowman, 1971) E
Natatolana paranarica Keable, 2006 E
Natatolana pellucida (Tattersall, 1921)
Natatolana rekohu Bruce, 2003 E
Natatolana rossi (Miers, 1876) E
Natatolana n. spp. (3) 3E
Pseudaega melanica Jansen, 1978 E
Pseudaega punctata Thomson, 1884 E
Pseudaega quarta Jansen, 1978 E
Pseudaega secunda Jansen, 1978 E
Pseudaega tertia Jansen, 1978 E
CRINONISCIDAE
Crinoniscus cephalatus Hosie, 2008 E
Crinoniscus politosummus Hosie, 2008 E
CYMOTHOIDAE
Ceratothoa imbricata (Fabricius, 1775)
Ceratothoa lineatus (Miers, 1876) E
Ceratothoa trillesi (Avdeev, 1979) E
Elthusa neocytta (Avdeev, 1975)
Elthusa propinqua (Richardson, 1904)
Elthusa raynaudii (Milne Edwards, 1840)
Mothocya ihi Bruce, 1986 E
Nerocila orbignyi (Guérin-Menéville, 1832)
EXPANATHURIDAE
Eisothistos adlateralis Knight-Jones & Knight-Jones, 2002 E
Heptanthura novaezealandiae Kensley, 1978 E
Rhiganthura spinosa Kensley, 1978 E
GNATHIIDAE
Bathygnathia tapinoma Cohen & Poore, 1994 E
Bathygnathia vollenhovia Cohen & Poore, 1994
Caecognathia akaroensis (Monod, 1926) E
Caecognathia nieli Svavarsson, 2005 E
Caecognathia pacifica (Monod, 1926) E
Caecognathia polythrix (Monod, 1926) E
Caecognathia regalis (Monod, 1926) E
Caecognathia sifae Svarvarsson, 2005 E
Caecognathia n. sp. E
Eunognathia n. sp. E
Gnathia brachyuropus Monod, 1926
Thaumastognathia diceros Monod, 1926 E
HEMIONISCIDAE
Scalpelloniscus nieli Hosie, 2008 E
Scalpelloniscus cf. *penicillatus* Grygier, 1981
Scalpelloniscus vomicus Hosie, 2008
HYSSURIDAE
Kupellonura proberti Wägele, 1985 E
LEPTANTHURIDAE
Albanthura rotunduropus Wägele, 1985 E
Albanthura stenodactyla Wägele, 1985 E
Bullowanthura crebrui Wägele, 1985 E
Cruregens fontanus Chilton, 1882 F E
Leptanthura chiltoni (Beddard, 1886) E
Leptanthura exilis Wägele, 1985 E
Leptanthura profundicola Wägele, 1985 E
Leptanthura truncatitelson Wägele, 1985 E
Psittanthura egregia Wägele, 1985 E
PARANTHURIDAE
Califanthura rima (Poore, 1981) E
Paranthura flagellata (Chilton, 1882) E
Paranthura longa Wägele, 1985 E
TRIDENTELLIDAE
Tridentella acheronae Bruce, 1988 E
Tridentella rosemariae Bruce, 2002 E
Tridentella tangaroae Bruce, 1988 E
Tridentella n. sp.

Suborder LIMNORIIDEA
LIMNORIIDAE
Limnoria convexa Cookson, 1991 E
Limnoria hicksi Schotte, 1989 E
Limnoria loricata Cookson, 1991 E
Limnoria quadripunctata Holthuis, 1949
Limnoria reniculus Schotte, 1989 E
Limnoria rugosissima Menzies, 1957
Limnoria segnis Chilton, 1883 E
Limnoria stephenseni Menzies, 1957 E
Limnoria tripunctata Menzies, 1951

Suborder SPHAEROMATIDEA
PLAKARTHRIIDAE
Plakarthrium typicum Chilton, 1883 E
SEROLIDAE
Acutiserolis sp. Poore & Storey 2009
Brucerolis brandtae Storey & Poore, 2009 E
Brucerolis howensis Storey & Poore, 2009 E
Brucerolis hurleyi Storey & Poore, 2009 E
Brucerolis osheai Storey & Poore, 2009 E
Myopiarolis bicolor (Bruce, 2008) E
Myopiarolis carinata (Bruce, 2008) E
Myopiarolis n. spp. (7) 7E
Spinoserolis latifrons (Miers, 1875) E
SPHAEROMATIDAE
Amphoroidea falcifer Thomson, 1879 E
Amphoroidea longipes Hurley & Jansen, 1977 E
Amphoroidea media Hurley & Jansen, 1971 E
Benthosphaera guaware Bruce, 1994
Bilistra cavernicola Sket & Bruce, 2004 F E
Bilistra millari Sket & Bruce, 2004 F E
Bilistra mollecopulans Sket & Bruce, 2004 F E

Cassidina typa Milne Edwards, 1840 E
Cassidinopsis admirabilis Hurley & Jansen, 1977 E
Cerceis trispinosa (Haswell, 1882)
Cilicaea angustispinata Hurley & Jansen, 1977 E
Cilicaea caniculata (Thomson, 1879) E
Cilicaea dolorosa Hurley & Jansen, 1977 E
Cilicaea tasmanensis Hurley & Jansen, 1977 E
Cilicaeopsis n. sp. N. Bruce 2008 E
Cymodoce allegra Hurley & Jansen, 1977 E
Cymodoce australis Hodgson, 1902 E
Cymodoce convexa Miers, 1876 E
Cymodoce hamata Stephensen, 1927 E
Cymodoce hodgsoni Tattersall, 1921 E
Cymodoce iocosa Hurley & Jansen, 1977 E
Cymodoce penserosa Hurley & Jansen, 1977 E
Cymodocella capra Hurley & Jansen, 1977 E
Cymodocella egregia (Chilton, 1892) E
Cymodocella tubicauda Pfeffer, 1887
Cymodopsis impudica Hurley & Jansen, 1977 E
Cymodopsis sphyracephalata Hurley & Jansen, 1977 E
Cymodopsis torminosa Hurley & Jansen, 1977 E
Dynamenoides decima Hurley & Jansen, 1977 E
Dynamenoides vulcanata Hurley & Jansen, 1977 E
Dynamenopsis varicolor Hurley & Jansen, 1971 E
Exosphaeroma chilense (Dana, 1853)
Exosphaeroma echinense Hurley & Jansen, 1977 E
Exosphaeroma falcatum Tattersall, 1921 E
Exosphaeroma gigas (Leach, 1818)
Exosphaeroma montis (Hurley & Jansen, 1977) E
Exosphaeroma obtusum (Dana, 1853) E
Exosphaeroma planulum Hurley & Jansen, 1971 E
Exosphaeroma waitemata Bruce, 2005 E
Exosphaeroma n. sp. N. Bruce E
Ischyromene condita (Hurley & Jansen, 1977) E
Ischyromene cordiforaminalis (Chilton, 1883) E
Ischyromene hirsuta (Hurley & Jansen, 1971) E
Ischyromene huttoni (Thomson, 1879) E
Ischyromene insulsa (Hurley & Jansen, 1977) E
Ischyromene kokotahi Bruce, 2006 E
Ischyromene mortenseni (Hurley & Jansen), 1977 E
Isocladus armatus (Milne Edwards, 1840) E
Isocladus calcareus (Dana, 1853) E
Isocladus dulciculus Hurley & Jansen, 1977 E
Isocladus inaccuratus Hurley & Jansen, 1977 E
Isocladus reconditus Hurley & Jansen, 1977 E
Isocladus spiculatus Hurley & Jansen, 1977 E
Makarasphaera amnicosa Bruce, 2005 F E
Pseudosphaeroma callidum Hurley & Jansen, 1977 E
Pseudosphaeroma campbellensis Chilton, 1909
Scutuloidea kutu Stephenson & Riley, 1996 E
Scutuloidea maculata Chilton, 1883 E
Sphaeroma laurensi Hurley & Jansen, 1977 E
Sphaeroma quoianum Milne Edwards, 1840
Syncassidina aestuaria Baker, 1929 A?
INCERTAE SEDIS
Paravireia typica Chilton, 1925 E
Paravireia pistus Jansen, 1973 E

Suborder VALVIFERA
ANTARCTURIDAE
Caecarcturus quadraspinosus Schultz, 1981 E
Chaetarcturus myops (Beddard, 1886) E
ARCTURIDAE
Neastacilla antipodea Poore, 1981 E
Neastacilla fusiformis (Hale, 1946) E
Neastacilla levis (Thomson & Anderton, 1921) E
Neastacilla tattersalli Lew Ton & Poore, 1986 E
Neastacilla tuberculata (Thomson, 1879) E
Neastacilla spp. (4) N. Bruce 2008
AUSTRARCTURELLIDAE
Dolichiscus opiliones (Schultz, 1981) E
Austrarcturella galathea Poore & Bardsley, 1992 E
Pseudarcturella chiltoni Tattersall, 1921 E
Pseudarcturella crenulata Poore & Bardsley, 1992 E
CHAETILIIDAE
Macrochiridothea uncinata Hurley & Murray, 1968 E
Maoridotea naylori Jones & Fenwick, 1978 E
Maoridotea n. sp. N. Bruce E
HOLOGNATHIDAE
Cleantis tubicola (Thomson, 1885) E
Holognathus karamea Poore & Lew Ton, 1990 E
Holognathus stewarti (Filhol, 1885) E
IDOTEIDAE
Austridotea annectens Nicholls, 1937 F E
Austridotea benhami Nicholls, 1937 F E
Austridotea lacustris (Thomson, 1879) F E
Batedotea elongata (Miers, 1876)
Euidotea durvillei Poore & Lew Ton, 1993 E
Idotea? *festiva* Chilton, 1881 E
Idotea metallica Bosc, 1802
Paridotea ungulata Pallas, 1772
PSEUDIDOTHEIDAE
Pseudidothea richardsoni Hurley, 1957 E

Suborder ONISCIDEA
Infraorder LIGIAMORPHA
ACTAECIIDAE
Actaecia euchroa Dana, 1853 T E
Actaecia opihensis Chilton, 1901 T E
ARMADILLIDAE
Acanthodillo spinosus (Dana, 1853) T E
Coronadillo hamiltoni (Chilton, 1901) T E
Coronadillo milleri (Chilton, 1917) T E
Coronadillo suteri (Chilton, 1915) T E
Cubaris ambitiosa (Budde-Lund, 1885) T E
Cubaris minima Vandel, 1977 T E
Cubaris murina Brandt, 1833 T A
Cubaris tarangensis (Budde-Lund, 1904) T E
Merulana chathamensis (Budde-Lund, 1904) T E
Sphaerilloides? *antipodum* Vandel, 1977 T E
Sphaerilloides? *invisibilis* Vandel, 1977 T E
Sphaerilloides? *macmahoni* (Chilton, 1901) T E
Sphaerilloides? *minimus* Vandel, 1977 T E
Sphaerilloides? *rugulosus* (Miers, 1876) T E
Sphaerilloides? *tuberculatus* Vandel, 1977 T E
Spherillo bipunctatus Budde-Lund 1904 T E
Spherillo brevis Budde-Lund, 1904 T E
Spherillo danae Heller, 1865 T E
Spherillo inconspicuus (Miers, 1876) T E
Spherillo marginatus Budde-Lund, 1904 T E
Spherillo monolinus Dana, 1853 T E
Spherillo rufomarginatus Budde-Lund, 1904 T E
Spherillo setaceus Budde-Lund, 1904 T E
Spherillo speciosus (Dana, 1853) T E
Spherillo squamatus Budde-Lund, 1904 T E
Reductoniscus watti Vandel, 1977 T E
ARMADILLIDIIDAE
Armadillidium vulgare (Latreille, 1804) T A
LIGIIDAE
Ligia exotica Roux, 1828 T
Ligia novizealandiae Dana, 1853 T E
ONISCIDAE
Phalloniscus armatus Bowley, 1935 T E
Phalloniscus bifidus Vandel, 1977 T E
Phalloniscus bowleyi Vandel, 1977 T E
Phalloniscus chiltoni Bowley, 1935 T E
Phalloniscus cooki (Filhol, 1885) T E
Phalloniscus forsteri Vandel, 1977 T E
Phalloniscus kenepurensis (Chilton, 1901) T E
Phalloniscus lamellatus Vandel, 1977 T E
Phalloniscus minimus Vandel, 1977 T E
Phalloniscus montanus Vandel, 1977 T E
Phalloniscus occidentalis Vandel, 1977 T E
Phalloniscus propinquus Vandel, 1977 T E
Phalloniscus punctatus (Thomson, 1879) T E
PHILOSCIIDAE
Adeloscia dawsoni Vandel, 1977 T E
Okeaninoscia oliveri (Chilton, 1911) T E
Papuaphiloscia hurleyi Vandel, 1977 T
Paraphiloscia brevicornis (Budde-Lund, 1912) T E
Paraphiloscia fragilis (Budde-Lund, 1904) T E
Philoscia novaezealandiae Filhol, 1885 T E
Philoscia pubescens (Dana, 1853) T E
Stephenoscia bifrons Vandel, 1977 T E
PORCELLIONIDAE
Porcellio scaber Latreille, 1804 T A
Porcellionides pruinosus (Brandt, 1833) T A
SCYPHACIDAE
Deto aucklandiae (Thomson, 1879) T E
Deto bucculenta (Nicolet, 1849) T
Scyphax ornatus Dana, 1853 T E
Scyphoniscus magnus Chilton, 1909 T E
Scyphoniscus waitatensis Chilton, 1901 T E
STYLONISCIDAE
Notoniscus australis (Chilton, 1909) T E
Notoniscus helmsii (Chilton, 1901) T E
Styloniscus commensalis (Chilton, 1910) T E
Styloniscus kermadecensis (Chilton, 1911) T E
Styloniscus magellanicus Dana, 1853 T
Styloniscus otakensis Chilton, 1901 T E
Styloniscus phormianus (Chilton, 1901) T E
Styloniscus thomsoni (Chilton, 1885) T E
Styloniscus phormianus (Chilton, 1901) T E
Styloniscus thomsoni (Chilton, 1885) T E
TRACHELIPODIDAE
Nagurus nanus (Budde-Lund, 1908) T A
TRICHONISCIDAE
Haplophthalmus danicus Budde-Lund, 1885 T A

Infraorder TYLOMORPHA
TYLIDAE
Tylos neozelanicus Chilton, 1901 T E

Order TANAIDACEA
Suborder APSEUDOMORPHA
APSEUDIDAE
Apseudes larseni Knight & Heard, 2006 E
Apseudes meridionalis Richardson, 1912*
Apseudes spectabilis Studer, 1883*
Apseudes spp. (9)
Gollumudes spp. (2?) NIWA G. Bird
Leviapseudes galatheae Wolff, 1956* E
Leviapseudes segonzaci Bacescu, 1981*
Spinosapseudes setosus (Lang, 1968) E
Taraxapseudes diversus (Lang, 1968)*
METAPSEUDIDAE
Apseudomorpha timaruvia (Chilton, 1882) E
Cyclopoapseudes latus (Chilton, 1883) E
Metapseudes aucklandiae Stephensen, 1927 E
Synapseudes n. spp. (2)*
PAGURAPSEUDIDAE
Pagurapseudes? sp.*
SPHYRAPIDAE
Kudinopasternakia dispar (Lang, 1968)*
INCERTAE SEDIS
Gen. et sp. indet. NIWA J. Sieg/G. Bird

Suborder NEOTANAIDOMORPHA
NEOTANAIDAE
Herpotanais kirkegaardi Wolff, 1956
Neotanais barfoedi Wolff, 1956
Neotanais hadalis Wolff, 1956
Neotanais mesostenoceps Gardiner, 1975*
Neotanais robustus Wolff, 1956
Neotanais vemae Gardiner, 1975*
Neotanais sp. NIWA G. Bird

Suborder TANAIDOMORPHA
AGATHOTANAIDAE
Agathotanais spinipoda Larsen, 1999*
Paragathotanais sp. NIWA G. Bird*
Paranarthrura fortispina Sieg, 1986*
Paranarthrura meridionalis Sieg, 1986*
Paranarthrura spp. (2)*

ANARTHRURIDAE
Siphonolabrum sp. NIWA G. Bird
Gen. et spp. indet. (2) NIWA G. Bird
COLLETTEIDAE
Collettea cylindratoides Larsen, 1999*
Leptognathiella spp. (2) NIWA G. Bird
Libanius sp. NIWA G. Bird
Macrinella spp. (2?) NIWA G. Bird
LEPTOCHELIIDAE
Konarus sp. G. Bird
Leptochelia mirabilis Stebbing, 1905
LEPTOGNATHIIDAE
Leptognathia spp. (>3)*
NOTOTANAIDAE
Nototanais sp. G. Bird Ca
PARATANAIDAE
Bathytanais spp. (2) NIWA G. Bird
Paratanais oculatus (Vanhoeffen, 1914) B
Paratanais tenuis (G.M.Thomson, 1880) E
Paratanais sp.* Auckland Is.
Paratanais spp. (3)*
PSEUDOTANAIDAE
Akanthinotanais sp. NIWA G. Bird
Cryptocopoides arcticus (Hansen, 1886)
Cryptocopoides sp. NIWA G. Bird
Mystriocentrus sp. NIWA G. Bird
Pseudotanais nordenskioldi (Sieg, 1977)
Pseudotanais spp. (3)*
TANAELLIDAE
Araphura spp. (2) NIWA G. Bird
Araphuroides sp. NIWA G. Bird
Arthrura monocanthus (Vanhoeffen, 1914) n. comb.*
Tanaella forcifera (Lang, 1968)*
Tanaella spp. (4) NIWA G. Bird
TANAIDAE
Pancoloides litoralis (Vanhöffen, 1914)*
Pancoloides sp.* NIWA G. Bird
Sinelobus stanfordi (Richardson, 1901) F B C (sponge)
Synaptotanais sp. NIWA G. Bird
Tanais sp.*
Zeuxo novaezealandiae (Thomson, 1879) E
Zeuxo phytalensis Sieg, 1980*
Zeuxoides aka Bird, 2008 E
Zeuxoides helleri Sieg, 1980*
Zeuxoides ohlini (Stebbing, 1914)*
Zeuxoides pseudolitoralis Sieg, 1980*
Zeuxoides rimuwhero Bird, 2008 E
Zeuxoides sp.*
TYPHLOTANAIDAE
Hamatipeda spp. (2) NIWA G. Bird
Larsenotanais sp. NIWA G. Bird
Meromonakanatha sp. NIWA G. Bird
Paratyphlotanais sp. NIWA G. Bird
Typhlotanais greenwichensis Shiino, 1970*
Typhlotanais spp. (10)*
INCERTAE SEDIS
Akanthophoreus spp. (2) NIWA G. Bird
Chauliopleona spp. (2) NIWA G. Bird
Exspina typica Lang, 1968 C (holothurian)
Mirandotanais vorax Kussakin & Tzareva, 1974*
Stenotanais sp. NIWA G. Bird
Tanaopsis spp. (2) NIWA G. Bird

Order CUMACEA
BODOTRIIDAE
Apocuma n. sp. 1 B E
Bathycuma longirostre Calman, 1905 B
Cyclaspis argus Zimmer, 1902 E
Cyclaspis coelebs Calman, 1907 E
Cyclaspis elegans Calman, 1907 E
Cyclaspis laevis Thomson, 1892
Cyclaspis similis Calman, 1907
Cyclaspis tasmanica Jones, 1969 B E
Cyclaspis thomsoni Calman, 1907
Cyclaspis triplicata Calman, 1907 E
Cyclaspis n. sp. 1 B E
Cyclaspis n. sp. 2 B E
Cyclaspis n. sp. ?3 E
Gaussicuma scabra Jones, 1969 B E
Gaussicuma n. sp. 1 B E
Pomacuma australiae (Zimmer, 1921)
DIASTYLIDAE
Colurostylis castlepointensis Gerken & Lörz, 2007 E
Colurostylis lemurum Calman, 1917 E
Colurostylis longicauda Jones, 1963 E
Colurostylis pseudocuma Calman, 1911 E
Colurostylis stenocuma Lomakina, 1968 E
Diastylis acuminata Jones, 1960 E
Diastylis delicata Jones, 1969 B E
Diastylis insularum (Calman, 1908) E
Diastylis neozelanica Thomson, 1892 E
Diastylopsis crassior Calman, 1911 E
Diastylopsis elongata Calman, 1911 E
Diastylopsis thileniusi (Zimmer, 1902) E
Leptostylis profunda Jones, 1969 E
Leptostylis recalvastrata Hale, 1945
Makrokylindrus? *mersus* Jones, 1969 B E
Makrokylindrus neptunius Jones, 1969 E (abyssal)
Makrokylindrus sp. 1 B E
Paradiastylis? *bathyalis* Jones, 1969 E
Vemakylindrus sp. 1 E
GYNODIASTYLIDAE
Allodiastylis acanthanasillos Gerken, 2001 E
Axiogynodiastylis fimbriata Gerken, 2001 B E
Axiogynodiastylis kopua Gerken, 2001 E
Gynodiastylis carinata Calman, 1911 E
Gynodiastylis koataata Gerken, 2001 E
Gynodiastylis milleri Jones, 1963 E
Litogynodiastylis laevis (Calman, 1911) E
LAMPROPIDAE
Hemilamprops pellucidus Zimmer, 1908 S B
Hemilamprops ?n. sp. 1 E
Hemilamprops n. sp. 2 B E
Mesolamprops sp. B E
Paralamprops sp. 1 B E
Paralamprops sp. 2 B E
Paralamprops? sp. 3 B E
Paralamprops? sp. 4 B E
Watlingia cassis Gerken, 2010 E
Watlingia chathamensis Gerken, 2010 E
LEUCONIDAE
Eudorella hurleyi Jones, 1963 E
Eudorella truncatula (Bate, 1856) ?A
Eudorellopsis resima Calman, 1907 E
Hemileucon comes Calman, 1907 E
Hemileucon uniplicatus Calman, 1907 E
Heteroleucon akaroensis Calman, 1907 E
Leucon (*Alytoleucon*) sp. B E
Leucon (*Crymoleucon*) *heterostylis* Calman, 1907 E
Leucon (*C.*) sp. B E
Leucon (Epileucon) latispina Jones, 1963 E
Leucon (?n. subgen.) sp. B E
Paraleucon suteri Calman, 1907 E
NANNASTACIDAE
Campylaspis inornata Jones, 1969 B E
Campylaspis rex Gerken & Ryder, 2002 B E
Campylaspis sp. 2 B E
Campylaspis sp. 3 B E
Campylaspis sp. 4 B E
Campylaspis sp. 5 B E
Procampylaspis sp. 1 B E
Procampylaspis sp. 2 B E
Scherocumella pilgrimi (Jones, 1963) E
Styloptocuma sp. 1 B E
Gen. nov. et n. sp. B

Order EUPHAUSIACEA
EUPHAUSIIDAE
Euphausia longirostris Hansen, 1908
Euphausia lucens Hansen, 1905
Euphausia recurva Hansen, 1905
Euphausia similis G.O. Sars, 1883
Euphausia s. armata Hansen, 1911
Euphausia spinifera G.O. Sars, 1883
Euphausia vallentini Stebbing, 1900.
Nematobrachion flexipes (Ortmann, 1893)
Nematosceles megalops G.O. Sars, 1883
Nematosceles microps G.O. Sars, 1883
Nyctiphanes australis G.O. Sars, 1883
Stylocheiron abbreviatum G.O.Sars, 1883
Stylocheiron elongatum G.O. Sars, 1883
Stylocheiron longicorne G.O. Sars, 1883
Stylocheiron maximum Hansen, 1908
Stylocheiron suhmi G.O. Sars, 1883
Thysanoessa gregaria G.O. Sars, 1883
Thysanoessa macrura G.O. Sars, 1883
Thysanopoda acutifrons Holt & Tattersall, 1905
Thysanopoda obtusifrons G.O. Sars, 1883

Order DECAPODA
Suborder DENDROBRANCHIATA
ARISTEIDAE
Aristaeomorpha foliacea (Risso, 1826)
Aristaeopsis edwardsiana (Johnson, 1867)
Aristeus semidentatus Bate, 1881
Austropenaeus cf. *nitidus* (Barnard, 1947)
BENTHESICYMIDAE
Benthesicymus cereus Burkenroad, 1936
Benthesicymus investigatoris Alcock & Anderson, 1899
Gennadas capensis Calman, 1925 Pe
Gennadas gilchristi Calman, 1925 Pe
Gennadas incertus (Balss, 1927)
Gennadas kempi Stebbing, 1914 Pe
Gennadas tinayrei Bouvier, 1906 Pe
LUCIFERIDAE
Lucifer typus H. Milne Edwards, 1837 Pe
PENAEIDAE
Funchalia villosa (Bouvier, 1905) Pe
Funchalia woodwardi Johnson, 1867 Pe
SERGESTIDAE
Sergestes arcticus Kröyer, 1855 Pe
Sergestes disjunctus Burkenroad, 1940 Pe
Sergestes index Burkenroad, 1940 Pe
Sergestes cf. *seminudus* Hansen, 1919 Pe
Sergia japonica (Bate, 1881) Pe
Sergia kroyeri (Bate, 1881) Pe
Sergia potens (Burkenroad, 1940) Pe
SICYONIIDAE
Sicyonia inflexa (Kubo, 1940)*
Sicyonia truncata (Kubo, 1949)
SOLENOCERIDAE
Haliporoides sibogae (de Man, 1907)
Hymenopenaeus obliquirostris (Bate, 1881)
Solenocera comata Stebbing 1915

Infraorder CARIDEA
ALPHEIDAE
Alpheopsis garricki Yaldwyn, 1971 E
Alpheus euphrosyne richardsoni Yaldwyn, 1971 E
Alpheus hailstonei Coutière, 1905
Alpheus novaezealandiae Miers, 1876
Alpheus socialis Heller, 1865
Athanas indicus Coutière, 1903
Betaeopsis aequimanus (Dana, 1852) E
ALVINOCARIDIDAE
Alvinocaris alexander Ahyong, 2009 E
Alvinocaris longirostris Kikuchi & Ohta, 1995
Alvinocaris niwa Webber, 2004 E
Nautilocaris saintlaurentae Komai & Segonzac, 2004
ATYIDAE
Paratya curvirostris (Heller, 1862) F E
CAMPYLONOTIDAE
Campylonotus rathbunae Schmitt, 1926
CRANGONIDAE

Aegaeon lacazei (Gourret, 1888)
Metacrangon knoxi (Yaldwyn, 1960) E
Metacrangon richardsoni (Yaldwyn, 1960) E
Philocheras acutirostratus (Yaldwyn, 1960) E
Philocheras australis (Thomson, 1879) E
Philocheras chiltoni (Kemp, 1911) E
Philocheras hamiltoni (Yaldwyn, 1971) E
Philocheras pilosoides (Stephensen, 1927) E
Philocheras quadrispinosus (Yaldwyn, 1971) E
Philocheras yaldwyni (Zarenkov, 1968) E
Parapontophilus junceus Bate, 1888 E
Prionocrangon curvicaulis Yaldwyn, 1960
DISCIADIDAE
Discias cf. *exul* Kemp, 1920
HIPPOLYTIDAE
Alope spinifrons (H. Milne Edwards, 1837) E
Bathyhippolyte yaldwyni Hayashi & Miyake, 1970 E
Hippolyte bifidrostris (Miers, 1876) E
Hippolyte multicolorata Yaldwyn, 1971 E
Lebbeus cristatus Ahyong, 2009 E
Lebbeus wera Ahyong, 2009 E
Leontocaris alexander Poore, 2009
Leontocaris amplectipes Bruce, 1990
Leontocaris yarramundi Taylor & Poore, 1998
Lysmata morelandi (Yaldwyn, 1971)
Lysmata trisetacea (Heller, 1861)
Lysmata vittata (Stimpson, 1860)
Merhippolyte chacei Kensley, Tranter & Griffin, 1987
Nauticaris marionis Bate, 1888
Tozeuma novaezealandiae Borradaile, 1916 E
GLYPHOCRANGONIDAE
Glyphocrangon caeca Wood-Mason & Alcock, 1891
Glyphocrangon lowryi Kensley, Tranter & Griffin, 1987
Glyphocrangon regalis Bate, 1888
Glyphocrangon sculpta (Smith, 1882)
NEMATOCARCINIDAE
Lipkius holthuisi Yaldwyn, 1960
Nematocarcinus cf. *exilis* (Bate, 1888) ZMUC
Nematocarcinus gracilis Bate, 1888
Nematocarcinus hiatus Bate, 1888
Nematocarcinus longirostris Bate, 1888
Nematocarcinus novaezealandicus Burukovsky, 2006
Nematocarcinus serratus Bate, 1888
Nematocarcinus undulatipes Bate, 1888
Nematocarcinus webberi Burukovsky, 2006
Nematocarcinus yaldwyni Burukovsky, 2006
OGYRIDIDAE
Ogyrides delli Yaldwyn, 1971
OPLOPHORIDAE
Acanthephyra brevirostris Smith, 1885 Pe
Acanthephyra eximia Smith, 1884 Pe
Acanthephyra pelagica (Risso, 1816) Pe
Acanthephyra quadrispinosa Kemp, 1939 Pe
Acanthephyra smithi Kemp, 1939 Pe
Ephyrina figueirai Crosnier & Forest, 1973 Pe
Heterogenys microphthalma (Smith, 1885) Pe
Hymenodora glacialis (Buchholz, 1874) Pe
Janicella spinicauda (A. Milne Edwards, 1883) Pe
Kemphyra corallina (A. Milne Edwards, 1883) Pe
Meningadora mollis Smith, 1882 Pe
Meningadora vesca (Smith, 1886) Pe
Notostomus auriculatus Barnard, 1950 Pe
Notostomus japonicus Bate, 1888 Pe
Oplophorus novaezeelandiae de Man, 1931 Pe
Oplophorus spinosus (Brullé, 1839) Pe
Systellaspis debilis (A. Milne Edwards, 1881) Pe
Systellaspis pellucida (Filhol, 1885) Pe
PALAEMONIDAE
Hamiger novaezealandiae (Borradaile, 1916) E
Palaemon affinis H. Milne Edwards, 1937 E
Periclimenes fenneri Bruce, 2005
Periclimenes tangeroa Bruce, 2005
Periclimenes yaldwyni Holthuis, 1959 E
PANDALIDAE
Chlorotocus novaezealandiae (Borradaile, 1916)
Heterocarpus laevigatus Bate, 1888
Notopandalus magnoculus (Bate, 1888) E
Plesionika costelloi (Yaldwyn, 1971)
Plesionika martia (A.Milne Edwards, 1883)
Plesionika spinipes Bate, 1888
PASIPHAEIDAE
Alainopasiphaea australis (Hanamura, 1989)
Eupasiphae gilesii (Wood-Mason, 1892) Pe
Parapasiphae compta Smith, 1884 Pe
Parapasiphae sulcatifrons Smith, 1884 Pe
Pasiphaea barnardi Yaldwyn, 1971 Pe
Pasiphaea burukovskyi Wasmer, 1992 Pe
Pasiphaea grandicula Burukovsky, 1976 Pe
Pasiphaea notosivado Yaldwyn, 1971 Pe
Pasiphaea tarda Kröyer, 1845 Pe
Psathyrocaris infirma Alcock & Anderson, 1894 Pe
PROCESSIDAE
Processa moana Yaldwyn, 1971 E
RHYNCHOCINETIDAE
Rhynchocinetes balssi Gordon, 1936
Rhynchocinetes ikatere Yaldwyn, 1971 E
STYLODACTYLIDAE
Stylodactyloides crosnieri Cleva, 1990
Stylodactylus discissipes Bate, 1888 E

Suborder PLEOCYEMATA
Infraorder STENOPODIDEA
SPONGICOLIDAE
Spongicoloides novaezelandiae Baba, 1980 E
Spongiocaris yaldwyni Bruce & Baba, 1973 E
STENOPODIDAE
Stenopus hispidus (Olivier, 1811)

Infraorder ASTACIDEA
NEPHROPIDAE
Metanephrops challengeri (Balss, 1914) E
Nephropsis suhmi Bate, 1888
PARASTACIDAE
Paranephrops planifrons White, 1842 F E
Paranephrops zealandicus (White, 1847) F E

Infraorder AXIIDEA
AXIIDAE
Axius cf. *werribee* (Poore & Griffin, 1979) MNZ
Calocarides vigila Sakai, 1992 E
Calocaris isochela Zarenkov, 1898 E
Dorphinaxius kermadecensis (Chilton, 1911)
Eiconaxius kermadeci Bate, 1888 E
Eiconaxius parvus Bate, 1888
Eucalastacus torbeni Sakai, 1992 E
Spongiaxius novaezealandiae (Borradaile, 1916) E
CALLIANASSIDAE
Corallianassa articulata (Rathbun, 1906)
Corallianassa cf. *collaroy* (Poore & Griffin, 1979) MNZ
'*Callianassa*' *filholi* (A. Milne Edwards, 1879) E
Vulcanocalliax sp. E
CTENOCHELIDAE
Ctenocheles maorianus Powell, 1949 E

Infraorder GEBIIDEA
LAOMEDIIDAE
Jaxea novaezealandiae Wear & Yaldwyn, 1966 E
UPOGEBIIDAE
Acutigebia danai (Miers, 1876) E
Upogebia hirtifrons (White, 1847) E

Infraorder ACHELATA
PALINURIDAE
Jasus edwardsii (Hutton, 1875)
Sagmariasus verreauxi (H. Milne Edwards, 1851)
Projasus parkeri (Stebbing, 1902)

Infraorder POLYCHELIDA
POLYCHELIDAE
Pentacheles laevis Bate, 1878
Pentacheles validus A. Milne Edwards, 1880
Polycheles enthrix (Bate, 1878)
Polycheles kermadecensis (Sund, 1920)
Stereomastis nana (Smith, 1884)
Stereomastis sculpta (Smith, 1880)
Stereomastis suhmi Bate, 1878
Stereomastis surda (Galil, 2000)
Willemoesia pacifica Sund, 1920
SCYLLARIDAE
Antarctus mawsoni (Bage, 1938)
Antipodarctus aoteanus (Powell, 1949) E
Arctides antipodarum Holthuis, 1960
Ibacus alticrenatus Bate, 1888
Ibacus brucei Holthuis, 1977
Scyllarides haanii (de Haan, 1841)

Infraorder ANOMURA
ALBUNEIDAE
Albunea microps Miers, 1878
CHIROSTYLIDAE
Chirostylus novaecaledoniae Baba, 1991
Eumunida pacifica Gordon, 1930
Gastroptychus novaezelandiae (Baba, 1974)
Gastroptychus rogeri (Baba, 2000)
Uroptychodes epigaster Baba, 2004
Uroptychodes spinimarginatus (Henderson, 1885)
Uroptychus alcocki Ahyong & Poore, 2004
Uroptychus australis (Henderson, 1885)
Uroptychus bicavus Baba & de Saint Laurent, 1992
Uroptychus cardus Ahyong & Poore, 2004
Uroptychus empheres Ahyong & Poore, 2004
Uroptychus flindersi Ahyong & Poore, 2004
Uroptychus gracilimanus (Henderson, 1885)
Uroptychus kaitara Schnabel, 2009
Uroptychus latus Ahyong & Poore, 2004
Uroptychus longicheles Ahyong & Poore, 2004
Uroptychus longvae Ahyong & Poore, 2004
Uroptychus maori Borradaile, 1916 E
Uroptychus multispinosus Ahyong & Poore, 2004
Uroptychus novaezealandiae Borradaile, 1916 E
Uroptychus paku Schnabel, 2009
Uroptychus paracrassior Ahyong & Poore, 2004
Uroptychus pilosus Baba, 1981
Uroptychus politus (Henderson, 1885) E
Uroptychus raymondi Baba, 2000
Uroptychus rutua Schnabel, 2009
Uroptychus scambus Benedict, 1902
Uroptychus spinirostris (Ahyong & Poore, 2004)
Uroptychus thermalis Baba & de Saint Laurent, 1992
Uroptychus toka Schnabel, 2009
Uroptychus tomentosus Baba, 1975 E
Uroptychus webberi Schnabel, 2009
Uroptychus yaldwyni Schnabel, 2009
DIOGENIDAE
Calcinus imperialis Whitelegge, 1901
Cancellus frontalis Forest & McLaughlin, 2000 E
Cancellus laticoxa Forest & McLaughlin, 2000 E
Cancellus rhynchogonus Forest & McLaughlin, 2000 E
Cancellus sphraerogonus Forest & McLaughlin, 2000 E
Dardanus arroser (Herbst, 1796)
Dardanus hessii (Miers, 1884)
Paguristes barbatus (Heller, 1862) E
Paguristes pilosus (H. Milne Edwards, 1836) E
Paguristes setosus (H. Milne Edwards, 1848) E
Paguristes subpilosus Henderson, 1888 E
GALATHEIDAE
Agononida incerta (Henderson, 1888)
Agononida marini (Macpherson, 1994)
Agononida nielbrucei Vereshchaka, 2005 E
Agononida procera Ahyong & Poore, 2004
Agononida squamosa (Henderson, 1885)

Allogalathea elegans (Adams & White, 1848)
Galathea whiteleggii Grant & McCulloch, 1906
Galacantha quiquei Macpherson, 2007
Galacantha rostrata A. Milne Edwards, 1880
Leiogalathea laevirostris (Balss, 1913)
Munida acacia Ahyong, 2007
Munida chathamensis Baba, 1974 E
Munida collier Ahyong, 2007
Munida eclepsis Macpherson, 1994
Munida erato Macpherson, 1994
Munida endeavourae Ahyong & Poore, 2004
Munida exilis Ahyong, 2007
Munida gracilis Henderson, 1885 E
Munida gregaria (Fabricius, 1793)
Munida icela Ahyong, 2007
Munida isos Ahyong & Poore, 2004
Munida kapala Ahyong & Poore, 2004
Munida notata Macpherson, 1994
Munida psylla Macpherson, 1994
Munida notialis Baba, 2005
Munida rubrimana Ahyong, 2007
Munida spinicruris Ahyong & Poore, 2004
Munida zebra Macpherson, 1994
Munidopsis antonii (Filhol, 1884)
Munidopsis bractea Ahyong, 2007
Munidopsis comarge Taylor, Ahyong & Andreakis, 2010
Munidopsis kaiyoae Baba, 1974 E
Munidopsis marginata (Henderson, 1885)
Munidopsis maunga Schnabel & Bruce, 2006
Munidopsis papanui Schnabel & Bruce, 2006
Munidopsis proales Ahyong & Poore, 2004
Munidopsis cf. *serricornis* (Lovén, 1852)
Munidopsis tasmaniae Ahyong & Poore, 2004
Munidopsis treis Ahyong & Poore, 2004
Munidopsis valdiviae (Balss, 1913)
Munidopsis victoriae Baba & Poore, 2002
Onconida alaini Baba & de Saint Laurent, 1996
Paramunida antipodes Ahyong & Poore, 2004
Phylladiorhynchus integrirostris (Dana, 1852)
Phylladiorhynchus pusillus (Henderson, 1885)
Tasmanida norfolkae Ahyong, 2007
LITHODIDAE
Lithodes aotearoa Ahyong, 2010 E
Lithodes jessica Ahyong, 2010
Lithodes macquariae Ahyong, 2010
Lithodes robertsoni Ahyong, 2010 E
Neolithodes brodiei Dawson & Yaldwyn, 1970
Neolithodes bronwynae Ahyong, 2010
Paralomis dawsoni Macpherson, 2001
Paralomis echidna Ahyong, 2010
Paralomis hirtella Saint Laurent & Macpherson, 1997
Paralomis poorei Ahyong, 2010
Paralomis staplesi Ahyong, 2010
Paralomis webberi Ahyong, 2010 E
Paralomis zealandica Dawson & Yaldwyn, 1971 E
PAGURIDAE
Bathypaguropsis cruentus de Saint Laurent & McLaughlin, 2000 E
Bathypaguropsis yaldwyni McLaughlin, 1994
Catapagurus spinicarpus de Saint Laurent & McLaughlin, 2000 E
Diacanthurus ecphyma McLaughlin & Forest, 1997
Diacanthurus rubricatus (Henderson, 1888) E
Diacanthurus spinulimanus (Miers, 1876) E
Lophopagurus (Australeremus) cookii (Filhol, 1883) E
Lophopagurus (*A.*) *cristatus* (H. Milne Edwards, 1836) E
Lophopagurus (*A.*) *eltaninae* (McLaughlin & Gunn, 1992) E
Lophopagurus (*A.*) *kirkii* (Filhol, 1883 E
Lophopagurus (*A.*) *laurentae* (McLaughlin & Gunn, 1992) E
Lophopagurus (*A.*) *stewarti* (Filhol, 1883) E
Lophopagurus (*A.*) *triserratus* (Ortmann, 1892)
Lophopagurus (Lophopagurus) foresti McLaughlin & Gunn, 1992 E
Lophopagurus (*L.*) *lacertosus* (Henderson, 1888) E
Lophopagurus (*L.*) ?*nanus* (Henderson, 1888)
Lophopagurus (*L.*) *nodulosus* McLaughlin & Gunn, 1992 E
Lophopagurus (*L.*) *pumilis* de Saint Laurent & McLaughlin, 2000 E
Lophopagurus (*L.*) *thompsoni* (Filhol, 1885) E
Michelopagurus? sp. E
Pagurixus hectori (Filhol, 1883) E
Pagurixus kermadecensis de Saint Laurent & McLaughlin, 2000 E
Pagurodes inarmatus Henderson, 1888
Pagurojacquesia polymorpha (de Saint Laurent & McLaughlin, 1999)
Pagurus albidianthus de Saint Laurent & McLaughlin, 2000 E
Pagurus iridocarpus de Saint Laurent & Mclaughlin, 2000 E
Pagurus novizealandiae (Dana, 1852) E
Pagurus sinuatus (Stimpson, 1858)
Pagurus traversi (Filhol, 1885) E
Porcellanopagurus chiltoni de Saint Laurent & McLaughlin, 2000
Porcellanopagurus edwardsi Filhol, 1885 E
Porcellanopagurus filholi de Saint Laurent & McLaughlin, 2000
Porcellanopagurus tridentatus Whitelegge, 1900
Propagurus deprofundis (Stebbing, 1924)
PARAPAGURIDAE
Oncopagurus sp. E
Paragiopagurus diogenes (Whitelegge, 1900)
Paragiopagurus hirsutus (de Saint Laurent, 1972)
Parapagurus abyssorum (Filhol, 1885)
Parapagurus bouvieri Stebbing, 1910
Parapagurus latimanus Henderson, 1888
Parapagurus richeri Lemaitre, 1999
Sympagurus dimorphus (Studer, 1883)
Sympagurus papposus Lemaitre, 1996
PORCELLANIDAE
Pachycheles pisoides (Heller, 1865)
Petrocheles spinosus (Miers, 1876) E
Petrolisthes elongatus (H. Milne Edwards, 1837)
Petrolisthes lamarckii (Leach, 1820)
Petrolisthes novaezelandiae Filhol, 1885 E
PYLOCHELIDAE
Cheiroplatea pumicicola Forest, 1987
Pylocheles mortensenii Boas, 1926
Trizocheles brachyops Forest & de Saint Laurent, 1987
Trizocheles perplexus Forest, 1987 E
Trizocheles spinosus (Henderson, 1888)
Trizocheles pilgrimi Forest & McLaughlin, 2000

Infraorder BRACHYURA
AETHRIDAE
Actaeomorpha erosa Miers, 1877
ATELECYCLIDAE
<u>*Pteropeltarion*</u> *novaezelandiae* Dell, 1972 E
Trichopeltarion fantasticum Richardson & Dell, 1964 E
Trichopeltarion janetae Ahyong, 2008
BELLIIDAE E
<u>*Heterozius*</u> *rotundifrons* A. Milne Edwards, 1867 E
BYTHOGRAEIDAE
Gandalfus puia McLay, 2007
CALAPPIDAE
Mursia australiensis Campbell, 1971
Mursia microspina Davie & Short, 1989
CANCRIDAE
Glebocarcinus amphioetus (Rathbun, 1898) A
Metacarcinus novaezelandiae (Hombron & Jacquinot, 1846)
Romaleon gibbulosus (Rathbun, 1898) A
CRYPTOCHIRIDAE
Cryptochirus coralliodytes Heller, 1861
CYMONOMIDAE
Cymonomus aequilonius Dell, 1971 E
Cymonomus bathamae Dell, 1971 E
Cymonomas clarki Ahyong, 2008 E
DROMIIDAE
Cryptodromiopsis unidentata (Rüppell, 1830)
Metadromia wilsoni (Fulton & Grant, 1902)
Tumidodromia dormia (Linnaeus, 1763)
DYNOMENIDAE
Dynomene pilumnoides Alcock, 1900
Metadynomene tanensis (Yokoya, 1933)
EPIALTIDAE
Huenia heraldica (de Haan, 1839)
Leptomaia tuberculata Griffin & Tranter, 1986
Oxypleurodon wanganella Webber & Richer de Forges, 1995 E
Rochinia ahyongi McLay, 2009 E
Rochinia riversandersoni (Alcock, 1895)
ERIPHIIDAE
Bountiana norfolcensis (Grant & McCulloch, 1907)
ETHUSIDAE
Ethusina castro Ahyong, 2008 E
Ethusina rowdeni Ahyong, 2008 E
GERYONIDAE
Chaceon bicolor Manning & Holthuis, 1989
Chaceon yaldwyni Manning, Dawson & Webber, 1990 E
GONEPLACIDAE
Goneplax marivenae Komatsu & Takeda, 2004
<u>*Neommatocarcinus*</u> *huttoni* (Filhol, 1886) E
Pycnoplax meridionalis (Rathbun, 1923)
Pycnoplax victoriensis (Rathbun, 1923)
Thyroplax truncata Castro, 2007
GRAPSIDAE
Geograpsus grayi (H. Milne Edwards, 1853) T
Leptograpsus variegatus (Fabricius, 1793)
Pachygrapsus minutus A. Milne Edwards, 1873
Planes major (MacLeay, 1838)
Planes marinus Rathbun, 1914
HOMOLIDAE
Dagnaudus petterdi (Grant, 1905)
Homola orientalis Henderson, 1888
Homola ranunculus Guinot & Richer de Forges, 1995
Homolochunia kullar Griffin & Brown, 1976
Yaldwynopsis spinimanus (Griffin, 1965)
HOMOLODROMIIDAE
Dicranodromia delli Ahyong, 2008 E
Dicranodromia spinulata Guinot, 1995
Homolodromia kai Guinot, 1993
HYMENOSOMATIDAE
Amarinus lacustris (Chilton, 1882) F
Elamena longirostris Filhol, 1885 E
Elamena momona Melrose, 1975 E
Elamena producta Kirk, 1879 E
Halicarcinus cookii (Filhol, 1885) E
Halicarcinus innominatus Richardson, 1949
Halicarcinus ovatus Stimpson, 1858
Halicarcinus planatus (Fabricius, 1775)
Halicarcinus tongi Melrose, 1975 E
Halicarcinus varius (Dana, 1851) E
Halicarcinus whitei (Miers, 1876) E
<u>*Halimena*</u> *aotearoa* Melrose, 1975 E
Hymenosoma depressum Hombron & Jacquinot, 1846 E
<u>*Neohymenicus*</u> *pubescens* (Dana, 1851) E
INACHIDAE
Achaeus akanensis Sakai, 1938
Achaeus curvirostris (A. Milne Edwards, 1873)
Achaeus kermadecensis Webber & Takeda, 2005 E
Cyrtomaia cornuta Richer de Forges & Guinot, 1988
Cyrtomaia lamellata Rathbun, 1906

Dorhynchus ramusculus (Baker, 1906)
Platymaia maoria Dell, 1963
Platymaia wyvillethomsoni Miers, 1886
Trichoplatus huttoni A. Milne Edwards, 1876 E
Vitjazmaia latidactyla Zarenkov, 1994
INACHOIDIDAE
Pyromaia tuberculata (Lockington, 1877) A
LATREILLIIDAE
Eplumula australiensis (Henderson, 1888)
Latreillia metanesa Williams, 1982
LEUCOSIIDAE
Bellidilia cheesmani (Filhol, 1886) E
Ebalia humilis Takeda, 1977
Ebalia jordani Rathbun, 1906
Ebalia tuberculosa (A. Milne Edwards, 1873)
Ebalia webberi Komatsu & Takeda, 2007 E
Merocryptus lambriformis A. Milne Edwards, 1873
Tanaoa distinctus (Rathbun, 1893)
Tanaoa pustulosus (Wood-Mason *in* Wood-Mason & Alcock, 1891)
MACROPHTHALMIDAE
Macrophthalmus (Hemiplax) hirtipes (Jacquinot *in* Hombron & Jacquinot, 1846) E
MAJIDAE
Eurynolambrus australis H. Milne Edwards & Lucas, 1841 E
Eurynome bituberculata Griffin, 1964 E
Jacquinotia edwardsii (Jacquinot, 1853) E
Leptomithrax australis (Jacquinot, 1853) E
Leptomithrax garricki Griffin, 1966 E
Leptomithrax longimanus Miers, 1876
Leptomithrax longipes (Thomson, 1902)
Leptomithrax tuberculatus mortenseni Bennett, 1964
Naxia spinosa (Hess, 1865)
Notomithrax minor (Filhol, 1885)
Notomithrax peronii (H. Milne Edwards, 1834) E
Notomithrax spinosus (Miers, 1879)
Notomithrax ursus (Herbst, 1788)
Prismatopus filholi (A. Milne Edwards, 1876) E
Prismatopus goldsboroughi (Rathbun, 1906)
Schizophroida hilensis (Rathbun, 1906)
Teratomaia richardsoni (Dell, 1960)
MATHILDELLIDAE
Intesius richeri Crosnier & Ng, 2004
Mathildella mclayi Ahyong, 2008 E
Neopilumnoplax nieli Ahyong, 2008
OCYPODIDAE
Ocypode pallidula Jacquinot *in* Hombron & Jacquinot, 1846
OZIIDAE
Ozius truncatus H. Milne Edwards, 1834
PALICIDAE
Pseudopalicus declivis Castro, 2000
Pseudopalicus oahuensis (Rathbun, 1906)
Pseudopalicus undulatus Castro, 2000
PARTHENOPIDAE
Actaeomorpha erosa Miers, 1877
Garthambrus allisoni (Garth, 1992)
Garthambrus tani Ahyong, 2008
Platylambrus constrictus (Takeda & Webber, 2007)
PILUMNIDAE
Actumnus griffini Takeda & Webber, 2006 E
Pilumnopeus serratifrons (Kinahan, 1856)
Pilumnus fimbriatus H. Milne Edwards, 1834
Pilumnus lumpinus Bennett, 1964 E
Pilumnus novaezelandiae Filhol, 1886 E
PINNOTHERIDAE
Nepinnotheres atrinicola (Page, 1983) E
Nepinnotheres novaezelandiae (Filhol, 1885) E
PLAGUSIIDAE
Miersiograpsus australiensis Türkay, 1978
Percnon planissimum (Herbst, 1804)
Plagusia chabrus (Linnaeus, 1758)
Plagusia dentipes de Haan, 1835
Plagusia squamosa (Herbst, 1790)
PORTUNIDAE
Caphyra acheronae Takeda & Webber, 2006 E
Charybdis japonica (A. Milne Edwards, 1861) A
Liocarcinus corrugatus (Pennant, 1777)
Nectocarcinus antarcticus (Jacquinot, 1853) E
Nectocarcinus bennetti Takeda & Miyake, 1969 E
Ovalipes catharus (White, 1843)
Ovalipes elongatus Stephenson & Rees, 1968
Ovalipes molleri (Ward, 1933)
Portunus pelagicus (Linnaeus, 1766)
Scylla serrata (Forskål, 1775)
Thalamita danae Stimpson, 1858
Thalamita macrops Montgomery, 1931
RANINIDAE
Lyreidus tridentatus de Haan, 1841
Notosceles pepeke Yaldwyn & Dawson, 2000 E
TRAPEZIIDAE
Calocarcinus africanus Calman, 1909
Trapezia cymodoce (Herbst, 1801)
Trapezia guttata Rüppell, 1830
Trapezia septata Dana, 1852
VARUNIDAE
Austrohelice crassa (Dana, 1851) E
Cyclograpsus insularum Campbell & Griffin, 1966
Cyclograpsus lavauxi H. Milne Edwards, 1853 E
Hemigrapsus crenulatus (H. Milne Edwards, 1837)
Hemigrapsus sexdentatus (H. Milne Edwards, 1837) E
XANTHIDAE
Antrocarcinus petrosus Ng & Chia, 1994
Banareia armata A. Milne Edwards, 1869
Banareia banareias (Rathbun, 1911)
Euryxanthops chiltoni Ng & McLay, 2007 E
Gaillardiellus bathus Davie, 1997
Gaillardiellus rueppelli (Krauss, 1843)
Leptodius nudipes (Dana, 1852)
Liomera yaldwyni Takeda & Webber, 2006 E
Lybia leptochelis (Zehntner, 1894)
Medaeops serenei Ng & McLay, 2007 E
Miersiela haswelli (Miers, 1886)
Nanocassiope sp. Takeda & Webber 2006
Pilodius nigrochrinitus Dana, 1852
Platypodia delli Takeda & Webber, 2006 E
Pseudoliomera helleri (A. Milne Edwards, 1865)
Serenius actaeoides (A. Milne Edwards, 1834)
Xanthias dawsoni Takeda & Webber, 2006 E
Xanthias lamarckii (H. Milne Edwards, 1834)
XENOGRAPSIDAE
Xenograpsus ngatama McLay, 2007 E

Synonyms or possible synonyms in cyclopoid Copepoda
Diacyclops crassicaudoides (Kiefer, 1928) = *D. bisetosus* (Rehberg, 1880)
Eucyclops (*Eucyclops*) *serrulatus* (Fischer, 1851) (= *Cyclops novaezealandiae* Thomson, 1879)
?*Euryte longicauda* Philippi, 1843 (= *Thorellia brunnae* Boeck, 1864)
?*Cyclops strennus strennus* Fischer, 1851 (= *C. ewarti* Brady, 1888)
Diacyclops bicuspidatus (Claus, 1857) (= *Cyclops gigas*, Thomson, 1883)
?*Halicyclops magniceps* (Lilljeborg, 1853) (= ?*C. aequorus*, Thomson, 1883)
?*Macrocyclops distinctus* (Richard, 1887) = *M. albidus* (Jurine, 1820)
?*Mesocyclops australiensis* (Sars, 1908) (= ?*M. leuckarti*)

Checklist of New Zealand fossil Crustacea

Letters in parentheses following new records indicate where material is held, i.e. AUT (Earth and Oceanic Sciences Research Centre, Auckland University of Technology); GNS (Institute of Geological and Nuclear Sciences, Lower Hutt); NIWA (National Institute of Water and Atmospheric Sciences, Wellington); UA (Geology Department, University of Auckland). Stratigraphic ranges, using abbreviations for New Zealand stages (Cooper 2004), follow each fossil species listing.

SUBPHYLUM CRUSTACEA
Class MAXILLOPODA
Infraclass CIRRIPEDIA
Superorder ACROTHORACICA
Order PYGOPHORA
CRYPTOPHIALIDAE
Australophialus? sp. nov.* Po-Pl (AUT) E
Gen. et sp. indet..* Po-Pl (UoA)

INCERTAE SEDIS
Zapfella sp.* Bm (GNS)
Zapfella? sp.* Ko (UoA)

Superorder RHIZOCEPHALA
Order KENTROGONIDA
SACCULINIDAE?
Gen. et sp. indet. Feldmann 1998 Mio

Superorder THORACICA
Order LEPADIFORMES
LEPADIDAE
Lepas ?australis Darwin, 1851 Qu
Lepas clifdenica Buckeridge, 1983 Sl-Tt E
Lepas moturoaensis Maxwell, 1968 Po E
Pristinolepas harringtoni (Laws, 1948) Lw-Pl E
Pristinolepas haurakiensis (Buckeridge, 1983) Lw-Po E
Pristinolepas pakaurangiensis (Buckeridge, 1983) Po-Pl E
Pristinolepas waikatoica (Buckeridge, 1983) Ld-Lw E
Pristinolepas n. sp. Ar E

Order SCALPELLIFORMES
ARCOSCALPELLIDAE
Anguloscalpellum complanatum (Withers, 1924) Lwh-Ld E
Anguloscalpellum cf. *complanatum* (Withers, 1924) Po E
Anguloscalpellum crassiforme Buckeridge, 1983 Lwh

E
Anguloscalpellum euglyphum (Withers, 1924) Lwh-Ld E
Anguloscalpellum grantmackiei Buckeridge, 1983 Po-Sw E
Anguloscalpellum? *striatulum* (Withers, 1924) Lwh-Ld E
Anguloscalpellum ungulatum (Withers, 1913) Lwh-Sw E
CALANTICIDAE
Calantica spinilatera Foster, 1979 Ww-Rec E
Cretiscalpellum cf. *glabrum* (Roemer, 1841) Uk
Cretiscalpellum? sp. nov.* Cn (GNS) E
Cretiscalpellum? sp. Buckeridge 1983 Mp-Dt
Euscalpellum egmontense Buckeridge, 1983 Ww E
Pachyscalpellum cramptoni Buckeridge, 1991 Mp
Pachyscalpellum debodae Buckeridge, 1999 Mh E
Scillaelepas arguta (Withers, 1924) Lwh-Ld E
Scillaelepas? *pittensis* Buckeridge, 1984 Ab-Ar E
Scillaelepas cf. *studeri* (Weltner, 1922) Ab-Ar
Scillaelepas waitemata Buckeridge, 1983 Lw-Po E
Smilium calanticoideum Buckeridge, 1983 Dw-Dm
Smilium chathecum Buckeridge, 1984 Pl E
Smilium subplanum (Withers, 1913) Lw-Po E
Zeascalpellum crassum Buckeridge, 1983 Dm-Ab E
Gen. nov. et n. sp.* Mh-Dt (GNS) E
Gen. et sp. indet. Buckeridge 1983 Mp-Mh
EOLEPADIDAE
Eolepas? *novaezelandiae* Buckeridge 1983 Ce E
ZEUGMATOLEPADAE
Zeugmatolepas? sp. Buckeridge 1983 Kh

Order SESSILIA
Suborder VERRUCOMORPHA
VERRUCIDAE
Metaverruca recta (Aurivillius, 1898) Po-Rec
Verruca nuciformis Buckeridge, 1983 Dm-Po E
Verruca sauria Buckeridge, 2010 Mh E
Verruca tasmanica chatheca Buckeridge, 1983 Dw-Dm E
Verruca t. tasmanica Buckeridge, 1983 Lwh

Suborder BALANOMORPHA
ARCHAEOBALANIDAE
Armatobalanus motuketeketeensis Buckeridge, 1983 Po E
Armatobalanus? sp. Buckeridge 1983 Po E
Striatobalanus zelandicus (Withers, 1924) Sl-Tt E
Notobalanus vestitus (Darwin, 1854) Lw-Rec E
Palaeobalanus lornensis Buckeridge, 1983 Ab-Ak E
Palaeobalanus? *waihaoensis* Buckeridge, 1983 Ab E
Tasmanobalanus acutus acutus (Withers, 1924) Pl-Sw E
Tasmanobalanus a. clifdensensis Buckeridge, 1983 Sc E
Tasmanobalanus a. convexus Buckeridge, 1983 Pa E
Tasmanobalanus grantmackiei Buckeridge, 1983 Sw-Ww E
Zullobalanus everetti (Buckeridge, 1983) Lwh E
Zullobalanus novozelandicus (Buckeridge, 1983) Ld-Lw E
AUSTROBALANIDAE
Austrobalanus imperator aotea Buckeridge, 1983 Ld-Po E
Austrobalanus macdonaldensis Buckeridge, 1983 Lwh E
Epopella eoplicata Buckeridge, 1983 Po E
Epopella cf. *plicata* Gray, 1843* Wp (AUT) E
Protelminius pomahakensis (Buckeridge, 1984) Ld E
BATHYLASMATIDAE
Bathylasma aucklandicum (Hector, 1888) Lw-Ww E
Bathylasma rangatira Buckeridge, 1983 Dt-Dm E
BALANIDAE
Amphibalanus variegatus (Darwin, 1854) Ww-Rec
Fistulobalanus kondakovi (Tarasov & Zevina, 1957) ?Wn
Fosterella chathamensis Buckeridge, 1983 Wo-Wn E
Fosterella tubulatus (Withers, 1924) Wo-Wn E
Notomegabalanus decorus argyllensis (Buckeridge, 1983) Wn-Qu E
Notomegabalanus miodecorus (Buckeridge, 1983) Sw-Ww E
CHIONELASMATIDAE
Chionelasmus darwini (Pilsbry, 1907) Ak-Rec
CHTHAMALIDAE
Chamaesipho brunnea Moore, 1944 Po-Rec E
CORONULIDAE
Coronula aotea Fleming, 1959 Ww-Wm E
Coronula diadema (Linné, 1767) Wn-Rec
Coronula intermedia Buckeridge, 1983 Wn E
PACHYLASMATIDAE
Eolasma maxwelli Buckeridge, 1983 Dw-Dm E
Pachylasma distortum Buckeridge, 1983 Lwh E
Pachylasma? *southlandicum* Buckeridge, 1983 Ld-Po E
Pachylasma veteranum Buckeridge, 1983 Dt-Dm E
Pachylasma sp.* Wp (AUT)
Waikalasma juneae Buckeridge, 1983 Po-Pl E
TETRACLITIDAE
Tesseroplax? *maorica* Buckeridge, 1983 Lw-Po E
Tesseropora cf. *pacifica* (Pilsbry, 1928) Po
Tetraclitella nodicostata Buckeridge, 2008 Lw-Po

Class OSTRACODA
All the marine Tertiary species may be regarded as endemic.
Order ARCHAEOCOPIDA
Gen. et spp. indet. (2) Simes 1977 LPz

Order PALAEOCOPIDA
Suborder BEYRICHICOPIDA
PUNCIIDAE
Puncia goodwoodensis Hornibrook, 1963 Pl E

Order PODOCOPIDA
Suborder PODOCOPINA
BAIRDIIDAE
Bairdia canterburyensis Swanson, 1969 Pl E
Bairdoppilata kerryi Milau, 1993 Po-Rec
Bairdoppilata cf. *austracretacea* (Bate, 1972) Mh
Bairdoppilata sp. 5052 Dingle 2009 Mh
Neonesidea australis (Chapman, 1914) Ak-Lw
Neonesidea chapmani Whatley & Downing, 1983 Ak-Lw
Neonesidea waitematanensis Milau, 1993 Po E
Neonesidea sp. Ayress 1993 Ab-Rec
BYTHOCYPRIDIDAE
Bythocypris sudaustralis McKenzie, Reyment & Reyment, 1991 Ak
Bythocypris cf. *sudaustralis* McKenzie, Reyment & Reyment, 1991 Mh
Bythocypris cf. *chapmani* Neale, 1975 Mh
Bythocypris sp. Ayress, 1993 Lwh-Lw
BYTHOCYTHERIDAE
Abyssobythere inequivalva Ayress, Correge, Passlow & Whatley, 1996 Wc
Bythoceratina decepta Hornibrook, 1952 Wc-Rec
Bythoceratina cf. *dubia* (Müller, 1908) Ak
Bythoceratina edwardsoni Hornibrook, 1952 Wc-Rec
Bythoceratina maoria Hornibrook, 1952 Sc-Rec
Bythoceratina mestayerae Hornibrook, 1952 Pl-Rec
Bythoceratina powelli Hornibrook, 1952 Ar-Rec
Bythoceratina robusta Milau, 1993 Po
Bythoceratina utilazea Hornibrook, 1952 Pl-Rec
Bythoceratina sp. Ayress 1993 Ld-Lw
Miracythere novaspecta Hornibrook, 1952 Lw-Rec E
Neobuntonia oneroaensis Milau, 1993 Po
Pseudeucythere biplana Ayress, 1995 Ak-Wc
Vitjasiella duplicispina Avress, 1993 Lw-Pl
Vitjasiella ferox (Hornibrook, 1952) Ab-Wc
CYPRIDIDAE
Candona sp. Hornibrook 1955 Wc F
Candonocypris assimilis Sars, 1894 Wc-Rec F
Cypretta viridis (Thomson, 1879) Wc-Rec F
Cypris sp. Hornibrook 1955 Wc F
Heterocypris ciliata (Thomson, 1879) Wc-Rec F
Heterocypris incongruens (Rhamdohr, 1808) Wc-Rec F E
Ilyodromus stanleyanus (King, 1855) Wc-Rec F
CYTHERALISONIDAE
Cytheralison amiesi Hornibrook, 1953 Lwh-Ld
Cytheralison fava Hornibrook, 1952 Ab-Rec
Cytheralison parafava Ayress, 1993 Ld-Lw
Cytheralison spinosa Ayress, 1993 Ld-Lw
Cytheralison sp. Ayress 1995 Ak
Debissonia hornibrooki Ayress, 2003 Ld-Lw
Debissonia pravacauda (Hornibrook, 1952) Dm-Rec
CYTHERIDAE
Chejudocythere cf. *higashikawai* Ishizaki, 1981 Ak
Cythere allanthomsoni Chapman, 1926 Sw
Loxocythere crassa Hornibrook, 1952 Po-Rec
Loxocythere kingi Hornibrook, 1952 Pl-Rec
CYTHERIDEIDAE
Cytheridea aoteana Hornibrook, 1952 Wc-Rec E
Cytheridea symmetrica Swanson, 1969 Pl
Cytheridea (*Clithrocytheridea*) *marwicki* Hornibrook, 1953 Pl
Hemicytheridea mosaica Hornibrook, 1952 Dm-Rec
Eucythere sulcocostatula Ayress, 1995 Ak-Wc
Eucythere parapubera Whatley & Downing, 1983 Lwh-Ld
Eucythere cf. *parapubera* Whatley & Downing, 1983 Ak
Eucythere sp. Ayress 1995 Ak-Lw
Eucythere sp. 1 Ayress 1993 Lwh-Lw
Rostrocytheridea pukehouensis Dingle, 2009 E Mh
Rostrocytheridea aff. *allaruensis*? Krömmelbein, 1975 Cn
Rostrocytheridea? sp. 4992 Dingle 2009 Mh
Rotundracythere gravepuncta Hornibrook, 1952 Ar-Rec
Rotundracythre inaequa Hornibrook, 1952 Wc-Rec
Rotundracythere mytila Hornibrook, 1952 Ld-Rec
Rotundracythere rotunda Hornibrook, 1952 Ar-Rec
Rotundracythere subovalis Hornibrook, 1952 Ar-Rec
Pseudocythere (*Pseudocythere*) *caudata* Sars, 1866 Ld-Lw
Pseudocythere (*P.*) *caudata* Sars, 1866 Lw-Rec
CYTHEROMATIDAE
Malibaricythere oceanica Yassini & Jones, 1995 Lw
Paracytheroma stilwelli Ayress, 1990 Ld-Pl
Paracytheroma convexa Milau, 1993 Po
Pellucistoma coombsi Ayress, 1990 Ak-Pl
Pellucistoma fordycei Ayress, 1990 Ak-Pl
CYTHERURIDAE
Aversovalva aurea Hornibrook, 1952 Ab-Rec
Aversovalva pteroalata Ayress, 1993 Lwh-Ld n. nud.
Cytheropteron anisovalva Ayress, Correge, Passlow & Whatley, 1996 Ar-Rec
Cytheropteron cuneatum Ayress, 1996 Ak
Cytheropteron confusum (Hornibrook, 1952) Lwh-Rec
Cytheropteron crassicutum Ayress, 1998 Po-Wn
Cytheropteron curvicaudum Hornibrook, 1952 Lwh-Rec
Cytheropteron dividentum (Hornibrook, 1952) Lwh-Rec
Cytheropteron dorsocorrugatum Ayress, Correge, Passlow & Whatley, 1996 Wc
Cytheropteron fornix (Hornibrook, 1952) Ab-Rec
Cytheropteron obtusalum Hornibrook, 1952 Ar-Rec
Cytheropteron planalatum Guernet, 1985 Ak-Po
Cytheropteron terecaudum Hornibrook, 1952 Pl-Rec
Cytheropteron testudo Sars, 1869 Ak-Ar
Cytheropteron vertex Hornibrook, 1952 Wn-Rec

Cytheropteron wellmani Hornibrook, 1952 Mp-Rec
Cytheropteron willetti Hornibrook, 1952 Wo-Rec
Cytheropteron sp. Ayress 1993 Ab-?Rec
Cytheropteron sp. Ayress 1995 Ak
Cytheropteron sp. 1 Ayress 1993 Lwh-Lw
Cytheropteron sp. 1 Ayress 1996 Ar-Lw
Cytheropteron sp. 2 Ayress 1993 Lwh-Ld
Cytheropteron sp. 2 Ayress, 1996 Ak
Cytheropteron sp. 3 Ayress 1993 Lwh-Ld
Eocytheropteron? sp. Ayress 1993 Ld-Lw
Cytherura clausi Brady, 1880 Pl-Rec
Cytherura nonspinosa Ayress, 1996 Ak
Eucytherura boomeri Ayress, Whatley, Downing, & Millson, 1995 Wq
Eucytherura calabra (Colalongo & Pasini, 1980) Ak-Rec
Eucytherura downingae Ayress, Whatley, Downing, & Millson, 1995 Wc
Eucytherura elegantula Ayress, Whatley, Downing, & Millson, 1995 Ab
Eucytherura pacifica Ayress, Whatley, Downing, & Millson, 1995 Lw-Wc
Eucytherura tumida Ayress, Whatley, Downing, & Millson, 1995 Wo-Wc (homonym of *E. tumida* Bonnema, 1941)
Eucytherura bakeri Hornibrook, 1952 Po-Pl
Eucytherura batalaria Ayress, Whatley, Downing, & Millson, 1995 Lwh-Wc
Eucytherura multituberculata Ayress, Whatley, Downing, & Millson, 1995 Wo-Rec
Eucytherura sp. Ayress 1993 Ld
Eucytherura sp. 1 Ayress 1993 Ld-Lw
Eucytherura sp. 1 Ayress 1995 Ak
Eucytherura sp. 2 Ayress 1993 Ld
Eucytherura sp. 2 Ayress 1995 Ak
Eucytherura sp. 2 Ayress, Whatley, Downing, & Millson 1995 Wo
Eucytherura? *polydictyota* Ayress, Whatley, Downing, & Millson, 1995 Wc
Hemicytherura (*Hemicytherura*) *aucklandica* Hornibrook, 1952 Lw-Rec
Hemicytherura (*H.*) *delicatula* Hornibrook, 1952 Lwh-Rec
Hemicytherura (*H.*) *fereplana* Hornibrook, 1952 Ak-Rec
Hemicytherura (*H.*) *gravis* Hornibrook, 1952 Ak-Rec
Hemicytherura (*H.*) *quadrazea* Hornibrook, 1952 Lwh-Rec
Hemicytherura sp. Ayress 1993 Ld-Lw
Hemicytherura (*Kangarina*) *radiata* (Hornibrook, 1952) Ak-Rec
Hemiparacytheridae leopardina Ayress, Whatley, Downing & Millson, 1995 Wo
Hemiparacytheridea mediopunctata Ayress, Whatley, Downing & Millson, 1995 Wo-Wc
Hemiparacytheridae vanharteni Ayress, Whatley, Downing & Millson, 1995 Wc
Malabaricythere oceanica Yassini & Jones, 1995 Lw
Microcytherura alata Ayress, 1993 Lw n. nud.
Microcytherura sp. Ayress 1993 Lwh-Lw
Microcytherura haywardi Milau, 1993 Po
Microcytherura sp. Ayress 1993 Lwh-Lw
Microcytherura sp. 1 Ayress 1996 Ak-Ar
Microcytherura sp. 2 Ayress 1996 Ak-Ar
Oculocytheropteron aff. *abyssorum* (Brady, 1880) Ak
Oculocytheropteron acutangulum (Hornibrook, 1952) Lwh-Rec
Oculocytheropteron australopunctatarum McKenzie, Reyment & Reyment 1991 Ak
Oculocytheropteron confusum (Hornibrook, 1952) Lwh-Rec
Oculocytheropteron ferrieri Milau, 1993 Po
Oculocytheropteron grantmackei Milau, 1993 Lw-Po
Oculocytheropteron improbum (Hornibrook, 1952) Ak-Rec
Oculocytheropteron microfornix Whatley & Downing, 1983 Ak
Oculocytheropteron paratinctum Ayress, 1996 Ak
Oculocytheropteron waihoensis Ayress, 1996 Ak
Oculocytheropteron sp. Ayress 1993 Lwh-Lw
Paracytheridea sp. Ayres, 1993 Ld-Lw
Pedicythere ?*australis* Neale, 1975 Ak
Pelecocythere? sp. 5042 Dingle 2009 Mh
Semicytherura arteria Swanson, 1979 Ak-Rec
Semicytherura coeca Ciampo, 1980 Ak-Lw
Semicytherura cf. *costellata* (Brady, 1880) Ak-Rec
Semicytherura eocenica Ayress, 1996 Ak-Ar
Semicytherura hexagona (Hornibrook, 1952) Wn-Rec
Semicytherura okinawaensis Nohara, 1987 Ak
Semicytherura sericava (Hornibrook, 1952) Pl-Rec
Semicytherura sp. Ayress 1993 Ld-Lw
Semicytherura sp. 1 Ayress 1996 Ak
Semicytherura sp. 2 Ayress 1996 Ak
HEMICYTHERIDAE
Ambostracon sp. Ayress 1993 Lw
Ambostracon fredbrooki Milau, 1993 Po
Ambostracon (*Patagonacythere*) *elongata* Milau, 1993 Po
Bradleya arata (Brady, 1880) Wn-Rec
Bradleya clifdenensis Hornibrook, 1952 Ld-Pl
Bradleya dictyon (Brady, 1880) Dm-Rec
Bradleya kaiata Hornibrook, 1953 Ab-Ar
Bradleya opima Swanson, 1979 Ak-Rec
Bradleyla pakaurangia Hornibrook, 1952 Pl
Bradleya proarata Hornibrook, 1952 Ar-Lw
Bradleya pygmaea Whatley, Downing, Kesler & Harlow, 1984 Mio-Rec
Bradleya reticlava Hornibrook, 1952 Ld-Rec
Bradleya semiarata Hornibrook, 1952 Pl
Bradleya (*Quasibradleya*) *cuneazea* Hornibrook, 1952 Ar-Rec
Bradleya (*Q.*) *dictyonites* Benson, 1972 Ak-Lw
Bradleya sp. Ayress 1993 Ab-Lwh
Bradleya sp. Ayress, 1993 Ld-Lw
Caudites impostor Hornibrook, 1953 Dh-Ab
Caudites cf. *scopulicolus* Hartmann, 1981
Hemicythere hornibrooki Swanson, 1969 Pl
Hemicythere munida Swanson, 1979 Ak-Rec
Hermanites andrewsi Swanson, 1979 Ld-Rec
Hermanites ?*briggsi* Swanson, 1979 Ak
Hermanites rectidorsa Milau, 1993 Po
Hermanites spinosa Milau, 1993 Po
Jacobella sp. Ayress 1995 Ak
Jugosocythereis reticulospinosa Ayress, 1993 Lwh-Lw n. nud.
Limburgina quadrazea (Hornibrook, 1952) Dm-Ld
Patagonocythere tricostata Hartmann 1962 Ak
Patagonacythere waihaoensis Ayress, 1995 Ak
Patagonacythere parvitenuis (Hornibrook, 1953) Ak-Ar
Poseidonamicus spp. Ayress, Neil, Passlow & Swanson, 1997 Wc-Rec
Quadracythere alatazea Hornibrook, 1952 Pl-Sw
Quadracythere biruga Hornibrook, 1952 Ld-Rec
Quadracythere chattonensis Hornibrook, 1953 Ld-Lw
Quadracythere claremontensis Swanson, 1969 Pl
Quadracythere clavala Hornibrook, 1952 Lw-Sc
Quadracythere clifdenensis Hornibrook, 1952 Ak-Sl
Quadracythere longazea Hornibrook, 1952 Lwh-Sw
Quadracythere mediaplana Hornibrook, 1952 Po-Pl
Quadracythere mediaruga Hornibrook, 1952 Ak-Rec
Quadracythere planazea Hornibrook, 1952 Ld-Sl
Quadracythere radizea Hornibrook, 1952 Dm-Pl
Urocythereis opima Swanson, 1969 Lwh-Pl
Waiparacythereis caudata Swanson, 1969 Pl
Waiparacythereis decora Swanson, 1969 Pl
Waiparacythereis joanae Swanson, 1969 Pl-Rec
Waiparacythereis sp. Ayress 1993 Lwh
KRITHIDAE
Krithe antisawanensis Ishizaki, 1966 Sl-Rec
Krithe comma Ayress, Barrows, Passlow & Whatley, 1999 Sl-Rec
Krithe compressa (Seguenza, 1980) Sw-Rec
Krithe dolichodeira Bold, 1946 Sw-Rec
Krithe marialusae Abate, Barra, Aiello & Bonaduce, 1993 Tt-Rec
Krithe minima Coles, Whatley & Moguilevsky, 1994 Lw-Rec
Krithe morkhoveni morkhoveni Bold, 1960 Wo-Rec
Krithe nitida Whatley & Downing, 1993 Ak-?Rec
Krithe pseudocomma Ayress, Barrows, Passlow & Whatley, 1999 Lw-Rec
Krithe reversa Bold, 1958 Tk-Rec
Krithe swansoni Milau, 1993 Po-Rec
Krithe triangularis Ayress, Barrows, Passlow & Whatley, 1999 Wc
Krithe trinidadensis Bold, 1958 Ww-Rec
Krithe sp. Ayress 1993 Lwh-Lw
Krithe sp. Ayress 1995 Ak
Krithe sp. 1 Ayress, Barrows, Passlow & Whatley 1999 Wn
Krithe sp. 2 Ayress, Barrows, Passlow & Whatley 1999 Lw-Rec
Krithe sp. 5055 Dingle 2009 Mh
Krithe sp. 5056 Dingle 2009 Mh
Krithe sp. 5079 Dingle 2009 Mh
Parakrithe sp. Ayress 1993 Lwh-Lw
Parakrithella lethiersi Milau, 1993 Po
LEGUMINOCYTHERIDIDAE
Triginglymus? *hobsonensis* Milau, 1993 Po
LEPTOCYTHERIDAE
Bisulcocythere campbelli Ayress & Swanson, 1991 Sw
Bisulcocythere compressa Ayress & Swanson, 1991 Po-Sw
Bisulcocythere eocenica Ayress & Swanson, 1991 Ak
Bisulcocythere micropunctata Ayress & Swanson, 1991 Lwh-Pl
Bisulcocythere novaezealandiae Ayress & Swanson, 1991 Pl-Rec
Callistocythere hanai Swanson, 1969 Pl
Callistocythere kaiata (Hornibrook, 1953) Ar-Ar
Callistocythere mansari Milau, 1993 Po
Cluthia antiqua Ayress & Drapala, 1996 Ak-Ar
Cluthia australis Ayress & Drapala, 1996 Wn-Rec
Cluthia micra Ayress & Drapala, 1996 Pl
Cluthia novaezealandiae Ayress & Drapala, 1996 Wn
Cluthia sp. Ayress 1993 Ld-Lw
Leptocythere sp. Ayress 1993 Ld-Lw
Leptocythere sp. Ayress 2006 Lw-Po
Leptocythere sp. Milau 1993 Po
Vandiemencythere phleboides Ayress & Warne, 1993 Ak-Lw
LIMNOCYTHERIDAE
Gomphocythere duffi (Hornibrook, 1955) Wc-Rec F
Limnocythere mowbrayensis Chapman, 1914 Wc F
Paralimnocythere vulgaris McKenzie & Swanson, 1981 Qu-Rec F
LOXOCONCHIDAE
Kuiperiana juglandica Ayress, 1993 Pl
Kuiperiana cf. *lindsayi* McKenzie, Reyment & Reyment, 1991) Ak
Loxoconcha abrupta Hornibrook, 1952 Ld-Sw
Loxoconcha propunctata Hornibrook, 1952 Pl
Loxoconcha punctata Thomson, 1879 Ak-Rec
Loxoconcha sp. Milau 1969 Po
Microloxoconcha sp. Ayress 1995 Ak
Microloxoconcha sp. Ayress 1995 Ak
Palmoconcha juglandis Ayress, 1993 Lwh-Lw
Sagmatocythere carboneli Milau, 1993 Ak-Po
MACROCYPRIDIDAE
Macrocypris sp. Ayress 1993 Lwh-Lw
Macropyxis? sp. Ayress 2006 Lwh-Po

Macroscapha? sp. Ayress 1995 Ak
NEOCYTHERIDEIDIDAE
Copytus pseudoelongatus Ayress, 1995 Ak
Copytus sp. Ayress 1993 Ld-Lw
Neocytherideis mediata Swanson, 1969 Ld-Pl
Neocytherideis reticulata Ayress, 1995 Ak-Lw
Pontocythere hedleyi (Chapman, 1906) Ak-Rec
NOTODROMADIDAE
Newnhamia fenestrata King, 1855 Wc-Rec
PARACYPRIDIDAE
Aglaia? *praecox* Chapman, 1926 Ld.
Paracypris eocuneata (Hornibrook, 1953) Ab-Lwh
Paracypris sp. 5040 Dingle 2009 Mh
Paracypris? sp. 5080 Dingle 2009 Mh
Phylctenophora zealandica Brady 1880 Ld-Rec
PARADOXOSTOMATIDAE
Cytherois parallella Milau, 1993 Po
Paracytherois cf. *gracilis* (Chapman, 1915) Ak
Paracytherois sp. Ayress 1993 Ld
PECTOCYTHERIDAE
Ameghinocythere eagari Dingle, 2009 Mh
Ameghinocythere? sp. 5078 Dingle 2009 Mh
Keijia? *hornibrooki* Milau, 1993 Po
Keijia sp. Ayress 2006 Po
Munseyella brevis Swanson, 1979 Ld-Rec
Munseyella dunoona McKenzie, Reyment & Reyment, 1993 Ak
Munseyella modesta, Swanson, 1979 Ak-Rec
Munseyella pseudobrevis Ayress, 1995 Ak
Munseyella rectangulata Swanson, 1969 Pl
Munseyella cf. *splendida* Whatley & Downing, 1983 Ld-Lw
<u>*Swansonites*</u> *aequa* (Swanson, 1979) Ld-Rec E
Swansonites intermedia Milau, 1993 Po E
PONTOCYPRIDIDAE
Argilloecia acuticadata Whatley & Downing, 1983 Ak
Argilloecia australomiocenica Whatley & Downing, 1983 Ak
Argillaocia krithiformae Whatley & Downing, 1983 Ak
Argilloecia pusilla (Brady, 1880) Lwh-Lw
Australoecia sp. Ayress 1995 Ak-Lwh
Maddocksella argilloeciaformis (Whatley & Downing, 1883) Ak
Maddocksella tumefacta (Chapman, 1914) Lwh-Lw
Maddocksella sp. 5047 Dingle 2009 Mh
Pontocypria sp. Ayress 1993 Lw
Propontocypris cf. *herdmani* (Scott, 1905) Ab-Rec
PROGONOCYTHERIDAE
Majungaella waiparaensis Dingle, 2009 E Mh
Majungaella wilsoni Dingle, 2009 E Mh
Majungaella sp. 4978 Dingle 2009 Mh
<u>*Parahystricocythere*</u> *ericea* Dingle, 2009 E Mh
Parahystricocythere sp. 5070 Dingle 2009 Mp
ROCKALLIIDAE
Arcacythere chapmani Hornibrook, 1952 Mp-Sw
Arcacythere aff. *chapmani* Hornibrook, 1952 Lwh-Lw
Arcacythere eocenica (Whatley et al, 1980) Ak
SCHIZOCYTHERIDAE
Apateloschizocythere? *colleni* Dingle, 2009 Cn
TRACHYLEBERIDIDAE
Abyssocythere sp. Ayress 1993 Ld-Lw
<u>*Abyssophilos*</u> *leptodictyotus* (Ayress, 1995) Ar E
Actinocythereis microagrenon Ayress, 1995 Ak-Lw
Actinocythereis thomsoni (Hornibrook, 1952) Dw-Rec
Acanthocythereis? *reticulospinosa* Ayress, 1993 Ab
Actinocythereis sp. Ayress 1993 Ab
Alataleberis paranuda Milau, 1993 Po
Anebocythereis hostizea (Hornibrook, 1952) Dh-Ld
Cletocythereis cf. *bradyi* Holden, 1967 Pl
Cletocythereis rastromarginata (Brady, 1880) Ak-Rec
Clinocthereis australis Ayress & Swanson, 1991 Ak-Rec
Cythereis contigua Hornibrook, 1952 Dm-Pl
Cythereis inlayi Hornibrook, 1952 Pl-Rec
Cythereis planalta Hornibrook, 1952 Dh-Po
Cythereis cf. *brevicostata* Bate, 1972 Mh
Glencoeleberis? cf. *armata* Jellinek & Swanson, 2003 Lwh-Po
Glencoeleberis? cf. *brevicosta* (Hornibrook, 1952) Lwh-Po
Glencoeleberis? cf. *incerta* (McKenzie, Reyment & Reyment, 1991) Lwh-Po
Glencoeleberis? cf. *occultata* Jellinek & Swanson, 2003 Lwh-Po
Glencoeleberis thomsoni (Hornibrook, 1952) Pal-Rec
Limburgina postaurora Dingle, 2009 E Mh
<u>*Marwickcythereis*</u> *marwicki* (Hornibrook, 1952) Ab-Ar E
Marwickcythereis ordotormenta Whatley & Millson, 1992 Dw E
Oertliella semivera (Hornibrook, 1952) Dm-Ld
Oertliella echinata (McKenzie, Reyment & Reyment, 1993) Ak-Lw
Philoneptunus alagracilus Whatley, Millson & Ayress, 1992 Mh-Ab
Philoneptunus crassimurus Whatley, Millson & Ayress, 1992 Ld-Lw
Philoneptunus eagari Whatley, Millson & Ayress, 1992 Dh
Philoneptunus eocenicus Whatley, Millson & Ayress, 1992 Dw-Dh
Philoneptunus gravizea Hornibrook, 1952 Dm-Rec
Philoneptunus hornibrooki Whatley, Millson & Ayress, 1992 Ak-Ar
Philoneptunus paragravazea Whatley, Millson & Ayress, 1992 Lwh-Rec
Philoneptunus paeminosus Whatley, Millson & Ayress, 1992 Dh-Rec
Philoneptunus planaltus (Hornibrook, 1952) Lwh-Rec
Philoneptunus praeplanaltus Whatley, Millson & Ayress, 1992 Lwh
Philoneptunus reticulatus Whatley, Millson & Ayress, 1992 Ab-Ar
Philoneptunus swansoni Whatley, Ayress & Millson, 1992 Ab-Lwh
Philoneptunus tricostatus Whatley, Millson & Ayress, 1992 Dm-Dh
Philoneptunus sp. 1 Whatley, Millson & Ayress 1992 Lw
Philoneptunus sp. 2 Whatley, Millson & Ayress 1992 Pli-Ple
Philoneptunus sp. 3 Whatley, Millson & Ayress 1992 Ple
Philoneptunus sp. 5 Whatley, Millson & Ayress 1992 Lwh
Philoneptunus sp. 6 Whatley, Millson & Ayress 1992 Ak
Ponticocythereis praemilitaris Milau, 1993 Po
Protobuntonia hayi (Hornibrook, 1953) Ab-Ar
Rayneria? *punctata* Dingle, 2009 E Mh
Rugocythereis reticulata Ayress, 1993 Ab-Rec
Rugocythereis semicontigua (Hornibrook, 1953) Ab-Lwh
Scepticocythereis cf. *ornata* Bate, 1972 Mh
Scepticocythereis? sp. 5044 Dingle 2009 Mh
Taracythere conjunctispina Ayress, 1995 Ak-Po
Taracythere hampdenensis (Ayress, 1993) Ab-Ak
Taracythere proterva (Hornibrook, 1953) ?Dt-Lw
Taracythere sp. Ayress 1993 Ab
Trachleberis ayressi Milau, 1993 Po
Trachyleberis brevicostata Hornibrook, 1952 Ld-Sl
Trachleberis denticulata Milau, 1993 Po
Trachyleberis hornibrooki Dingle, 2009 E Mh
Trachyleberis jilletti Ayress, 1993 Lw
Trachyleberis lytteltonsis Harding & Sylvester-Bradley, 1953 Tt-Rec
Trachyleberis paucispinosa McKenzie, Reyment & Reyment, 1993 Ak
Trachyleberis probesiodes Hornibrook, 1952 Sc-Wp
Trachyleberis retizea Hornibrook, 1952 Po-Pl
Trachyleberis rugibrevis (Hornibrook, 1952) Ld-Rec
Trachyleberis tridens Hornibrook, 1952 Ar-Pl
Trachyleberis zeacristata Hornibrook, 1952 Lw-Rec
XESTOLEBERIDIDAE
Microxestoleberis sp. Ayress 1993 Ld-Lw
Uroleberis minutissima (Chapman, 1926) Ak-Lw
Xestoleberis basiplana McKenzie, Reyment & Reyment, 1993 Ak
Xestoleberis chilensis austrocontinentalis Hartmann, 1978 Ak
Xestoleberis cf. *curta* (Brady, 1865) Lwh-Rec
Xestoleberis paratruncata Whatley & Downing, 1983 Ak
Xestoleberis waihekeensis Milau, 1993 Po
Xestoleberis sp. 1 Ayress 1993 Lwh-Lw
Xestoleberis sp. 2 Ayress 1993 Lwh-Lw
Xestoleberis sp. Ayress 1995 Ak
INCERTAE SEDIS
Crescentocythere phoebe Ayress, 1993 Pl
Saidia limbata Colalongo & Passini, 1980 Ak
Saida torresi (Brady, 1880)*An-Rec
Saida sp. Ayress 1993 Lwh-Lw

Suborder PLATYCOPINA
CYTHERELLIDAE
Cytherella ballancei Milau, 1993 Po
Cytherella bisson Milau, 1993 Po-Pl
Cytherella chapmani Milau, 1993 Po
Cytherella elongata Swanson, 1969 Pl
Cytherella hemipunctata Swanson, 1969 Lw-Rec
Cytherella ?hemipunctata Swanson, 1969 Ak
Cytherella magna Ayress, 2006 Lw-Sc
Cytherella paranitida Whatley & Downing, 1983 Ab-Rec
Cytherella sp. Ayress, 1993 Ab-Lw
Cytherella sp. 5051 Dingle 2009 Mh
Cytherella sp. 5063 Dingle 2009 Cn
Cytherella sp. 5086 Dingle 2009 Mh
Cytherella sp. 1a Dingle 2009 Mh
Cytherelloidea paranitida Whatley & Downing, 1993 Lw
Cytherelloidea praeauricula (Chapman, 1926) Ak-Lw
Cytherelloidea willetti Swanson, 1969* Ak-Rec E
Cytherelloidea cf. *westaustraliensis* Bate, 1972 Mh
Cytherelloidea n. sp. van den Bold, 1963 Rec
Cytherelloidea sp. Ayress, 1993 Lwh-Lw
Cytherelloidea sp. 1 Ayress 2006 Ld-Lw
Healdia? sp. Milau, 1993 Po
Platella sp. 5048 Dingle 2009 Mh
Platella sp. 5071 Dingle 2009 Mh
Order MYODOCOPIDA
Suborder MYODOCOPINA
SARSIELLIDAE
Sarsiella sp. Milau, 1993 Po

Class MALACOSTRACA
Subclass PHYLLOCARIDA
Order HYMENOSTRACA
HYMENOCARIDIDAE
Hymenocaris bensoni Chapman, 1934 Ord
Hymenocaris lepadoides Chapman, 1934 Ord

Order ARCHAEOSTRACA
CERATIOCARIDIDAE
Caryocaris cf. *acuta* Bulman, 1931 Ord
Caryocaris bulmani (Chapman, 1934) Ord
Caryocaris maccoyi (Etheridge, 1892) Ord
Caryocaris m. tumida (Chapman, 1934) Ord
Caryocaris marrii Chapman, 1934 Ord

Caryocaris minima Chapman, 1934 Ord
Caryocaris wrightii Chapman, 1934 Ord

Subclass EUMALACOSTRACA
Superorder PERACARIDA
Order ISOPODA
Suborder VALVIFERA
HOLOGNATHIDAE
Debodea mellita Hiller, 1999 (not Cirolanidae) UCret E

Suborder CYMOTHOOIDA
CIROLANIDAE
Cirolana makikihi Feldmann, Schweitzer, Maxwell & Kelley, 2008 Wo E
Palaega kakatahi Feldmann & Rust, 2006 Wo-Wp E

INCERTAE SEDIS
URDIDAE
Urda zelandica Buckeridge & Johns, 1996 UJur E

Superorder EUCARIDA
Order DECAPODA
Suborder PLEOCYEMATA
Infraorder GLYPHEIDEA
ERYMIDAE
Gen. et sp. indet. Mp-Mh
GLYPHEIDAE
Glyphea christeyi Feldmann & Maxwell, 1999 Ab E
Glyphea stilwelli Feldmann, 1993 Dt E
Glypheopsis antipodum Glaessner 1960 Hu E
MECOCHIRIDAE
Mecochirus marwicki Glaessner, 1960 Kh
Mecochirus? sp. Bw, Kh-Op

Infraorder ASTACIDEA
NEPHROPIDAE
Hoploparia sp. Mp
Metanephrops motunauensis Jenkins, 1972 Sw-Tt E
PARASTACIDAE
Paranephrops fordycei Feldmann & Pole, 1994 Po-Sl E

Infraorder AXIIDEA
CALLIANASSIDAE
Callianassa awakina Glaessner, 1960 Po E
Callianassa waikurana Glaessner, 1960 Mh E
Callianassa sp. a Mh
Callianassa sp. b Tt
Callianassa sp. Cn, Mp-Mh
Callianassa sp. Ab, Lwh-Pl, Sw-Tt
Protocallianassa sp. Mp-Mh
CTENOCHELIDAE
Ctenocheles cf. *maorianus* Powell, 1949 Wc
Ctenocheles sp. Wc
INCERTAE SEDIS
Gen. et sp. indet. Feldmann, Schweitzer, Maxwell & Kelley, 2008 Wo E

Infraorder GEBIIDEA
UPOGEBIIDAE
Upogebia kowai Feldmann, Schweitzer, Maxwell & Kelley, 2008 Wo E
Upogebia sp. Ar-Lwh

Infraorder ACHELATA
PALINURIDAE
Jasus flemingi Glaessner, 1960 Pl
Linuparus korura Feldmann & Bearlin, 1988 Ab
Linuparus sp. Mp-Mh
Linuparus? sp. Mp-Mh

Infraorder ANOMURA
AEGLIDAE
Haumuriaegla glaessneri Feldmann, 1984 Mp-Mh E
GALATHEIDAE
Galathea sp. Wp-Wn
LITHODIDAE
Paralomis debodeorum Feldmann, 1998 MMio-LMio E
PAGURIDAE
Diacanthurus clifdenensis (Hyden & Forest, 1980) Pl E
Pagurus sp. Tt, Wp, Wn

Infraorder BRACHYURA
ATELECYCLIDAE
Trichopeltarion greggi Dell, 1969 Sw-Tt E
Trichopeltarion merrinae Schweitzer & Salva, 2000 L Mio E
CALAPPIDAE
Calappilia maxwelli Feldmann, 1993 Po E
CANCRIDAE
Lobocarcinus pustulosus Feldmann & Fordyce, 1996 Pl E
Metacarcinus novaezelandiae (Hombron & Jacquinot, 1846) Wo-Rec
Metacarcinus cf. *novaezelandiae* (Hombron & Jacquinot, 1846) Tk, Wp
Metacarcinus sp. Ak, Ld, Wp-Wn
GONEPLACIDAE
Carcinoplax temikoensis Feldmann & Maxwell, 1990 Ak-Ar E
Carcinoplax sp. Wp-Wn
Kowaicarcinus maxwellae Feldmann, Schweitzer, Maxwell & Kelley, 2008 Wo E
Ommatocarcinus arenicola Glaessner, 1960 Pl E
Ommatocarcinus cf. *arenicola* Glaessner, 1960 Pl
Ommatocarcinus cf. *Neommatocarcinus huttoni* (Filhol, 1886) Wp-Wn
Ommatocarcinus sp. Pl
HOMOLODROMIIDAE
Homolodromia novaezelandica Feldmann, 1993 Mp-Mh E
Homolodromia sp. Mp-Mh
MACROPHTHALMIDAE
Macrophthalmus (*Hemiplax*) *hirtipes* (Heller, 1862) Wq–Rec E
Hemiplax?major Glaessner, 1960 Wn E
Hemiplax cf. *major* Glaessner, 1960 Po, Wc
Hemiplax sp. Wn-Wc
MAJIDAE
Actinotocarcinus chidgeyorum Jenkins, 1974 Sc-Tt E
Actinotocarcinus maclauchlani Feldmann, 1993 Sw-Tt E
Jacquinotia edwardsii (Jacquinot, 1853) Wp-Rec E
Leptomithrax atavus Glaessner, 1960 Tk E
Leptomithrax elongatus McLay, Feldmann & MacKinnon, 1995 Sw E
Leptomithrax garthi McLay, Feldmann & MacKinnon, 1995 Sw-Tt E
Leptomithrax griffini Feldmann & Maxwell, 1990 Ab-Ar E
Leptomithrax irirangi Glaessner, 1960 Wo E
Leptomithrax aff. *irirangi* Glaessner, 1960 Sw
Leptomithrax uruti Glaessner, 1960 E Tt
Leptomithrax cf. *uruti* Glaessner, 1960 Tt
Leptomithrax sp. Tt
Micromithrax? *minisculus* Feldmann & Wilson, 1988 Dm-Dh
Notomithrax allani Feldmann & Maxwell, 1990 Ak-Ar E
Notomithrax minor (Filhol, 1885) Wc – Rec
Notomithrax sp. Wc
MENNIPIDAE
Galene proavita Glaessner, 1960 Pl-Sc E
Galene sp. Wp-Wn
Menippe sp. Pl
Pseudocarcinus sp. Tk
PORTUNIDAE
Ovalipes cf. *catharus* (White, 1843) Wn-Wc
Ovalipes sp. A Wp
Ovalipes sp. Wn-Wc
Pororaria eocenica Glaessner, 1980 Ak-Ar E
Portunus sp. Lwh, Lw
Rhachiosoma granuliferum (Glaessner, 1960) Dp-Ar E
Gen. et sp. indet. Dm-Dh, Ab-Ak
PSEUDOZIIDAE
Tongapapaka motunauensis Feldmann, Schweitzer, Maxwell & Kelley, 2008 Wo E
RANINIDAE
Hemioon novozelandicum Glaessner, 1980 Cn E
Laeviranina keyesi Feldmann & Maxwell, 1990 Ak-Ar E
Laeviranina perarmata Glaessner, 1960 Ab E
Laeviranina pororariensis (Glaessner, 1980) Ak-Ar E
Lyreidus bennetti Feldmann & Maxwell, 1990 Ak-Ar E
Lyreidus elegans Glaessner, 1960 Po-Pl E
Lyreidus waitakiensis Glaessner, 1980 Ab E
Lyreidus sp. Sw
Gen. et sp. indet. Ab
TORYNOMMIDAE
Eodorripe spedeni Glaessner, 1980 Mp-Mh E
Torynomma flemingi Glaessner, 1980 Mp-Mh E
Torynomma planata Feldmann, 1993 Mp-Mh E
TUMIDOCARCINIDAE
Tumidocarcinus dentatus Glaessner, 1960 Lwh-Ld E
Tumidocarcinus cf. *dentatus* (Glaessner, 1960) Lwh
Tumidocarcinus giganteus Glaessner, 1960 Pl-Tt E
Tumidocarcinus cf. *giganteus* Glaessner, 1960 Lw-Po, Sw-Tk
Tumidocarcinus tumidus (Woodward, 1876) Ab-Ld E
Tumidocarcinus cf. *tumidus* (Woodward, 1876) Lwh-Ld
Tumidocarcinus? sp. Ak-Ld, Po-Sc
VARUNIDAE
Austrohelice manneringi Feldmann, Schweitzer, Maxwell & Kelley, 2008 Wo E
Miograpsus papaka Fleming, 1981 Tt E

Developmental stages of New Zealand Decapoda

Compiled by W. R. Webber

Following are the larvae and/or pre- or post-larvae described to date, of species listed in the decapod species list above. Species named below are those with one or more developmental stages described in the literature. Names and dates in brackets indicate publications in which larvae are described, **not** species authorities. However, *Jaxea novaezealandiae* (Gebiidea) was described in the same paper as the adult and two polychelid species were described from the larvae, thus authors in brackets after these names are also the original authorities. Literature sources for the species list below are cited in the References section, above.

PHYLUM CRUSTACEA
Class MALACOSTRACA
Order DECAPODA
Suborder DENDROBRANCHIATA
SERGESTIDAE
Sergestes arcticus [Gurney & Lebour 1940; Wear 1985]
SOLENOCERIDAE
Solenocera comata [Gurney 1924; Wear 1985]

Suborder PLEOCYEMATA
Infraorder STENOPODIDEA
STENOPODIDAE
Stenopus hispidus [Gurney 1936, 1942]

Infraorder CARIDEA
ALPHEIDAE
Alpheus euphrosyne richardsoni [Packer 1983, 1985]
Alpheus socialis [Packer 1983, 1985]
Alpheopsis garricki [Packer 1983, 1985]
Betaeopsis aequimanus [Packer 1983, 1985]
ATYIDAE
Paratya curvirostris [Ch'ng 1973; Wear 1985]
CAMPYLONOTIDAE
Campylonotus rathbunae [Pike & Williamson 1966; Wear 1985]
CRANGONIDAE
Aegaeon lacazei [De Simón 1979; Packer 1983, 1985]
Philocheras australis [Thomson & Anderton 1921; Packer 1983, 1985]
Philocheras chiltoni [Packer 1983, 1985]
Philocheras hamiltoni [Packer 1983, 1985]
Philocheras pilosoides [Packer 1983, 1985]
HIPPOLYTIDAE
Alope spinifrons [Lebour 1955; Packer 1983, 1985]
Hippolyte bifidrostris [Packer 1983, 1985]
Hippolyte multicolorata [Packer 1983, 1985]
Nauticaris marionis [Packer 1983, 1985]
Tozeuma novaezealandiae [Packer 1983, 1985]
OGYRIDIDAE
Ogyrides delli [Packer 1983, 1985]
PALAEMONIDAE
Palaemon affinis [Lebour 1955; Packer 1983, 1985]
Periclimenes yaldwyni [Packer 1983, 1985]
Periclimenes (*Periclimenes*) sp. [Packer 1983, 1985]

Infraorder ASTACIDEA
NEPHROPIDAE
Metanephrops challengeri [Wear 1976]
PARASTACIDAE
Paranephrops planifrons [Hopkins 1967]

Infraorder AXIIDEA
CALLIANASSIDAE
Callianassa filholi [Gurney 1924; Lebour 1955; Wear 1965a]

Infraorder GEBIIDEA
LAOMEDIIDAE
Jaxea novaezealandiae [Wear & Yaldwyn 1966]
UPOGEBIIDAE
Acutigebia danai [Gurney 1924]

Infraorder PALINURA
PALINURIDAE
Jasus edwardsii [Batham 1967; Lesser 1974]
Sagmariasus verreauxi [Lesser 1974; Kittaka *et al.* 1997]
POLYCHELIDAE
Gen. et sp. indet. (as *Eryonicus fagei*) [Bernard 1953]
Gen. et sp. indet. (as *Eryonicus scharffi*) [Selbie 1914]
SCYLLARIDAE
Ibacus alticrenatus [Atkinson & Boustead 1982]
Scyllarus sp. Z [Webber & Booth 2001]

Infraorder ANOMURA
CHIROSTYLIDAE
Gastropyychus novaezelandiae [Pike & Wear 1969]
Uroptychus n. sp. [Pike & Wear 1969]
GALATHEIDAE
Munida gregaria [Roberts 1973]
PAGURIDAE
Pagurixus hectori [Roberts 1971; Wear 1985]
Pagurus novizealandiae [Greenwood 1966; Wear 1985]
Pagurus traversi [Thomson & Anderton 1921; Wear 1985]
Porcellanopagurus edwardsi [Roberts 1972; Wear 1985]
PARAPAGURIDAE
Sympagurus dimorphus [Lemaitre & McLaughlin 1992]
PORCELLANIDAE
Petrocheles spinosus [Wear 1965b, 1966]
Petrolisthes elongatus [Greenwood 1956; Wear 1964b, 1965c]
Petrolisthes novaezelandiae [Greenwood 1956; Wear 1964a, 1965d]

Infraorder BRACHYURA
ATELECYCLIDAE
Trichopeltarion fantasticum [Wear & Fielder 1985]
BELLIIDAE
Heterozius *rotundifrons* [Wear & Fielder 1985]
CANCRIDAE
Metacarcinus novaezelandiae [Wear & Fielder 1985]
CYMONOMIDAE
Cymonomus bathamae [Wear & Fielder 1985
DROMIIDAE
Metadromia wilsoni [Wear & Fielder 1985]
GONEPLACIDAE
Neommatocarcinus *huttoni* Wear & Fielder 1985
GRAPSIDAE
Leptograpsus variegatus [Wear & Fielder 1985]
Planes major [Wear & Fielder 1985]
Planes marinus [Wear & Fielder 1985]
HOMOLIDAE
Dagnaudus petterdi [Williamson 1965; Wear & Fielder 1985]
Homola orientalis [Wear & Fielder 1985]
HYMENOSOMATIDAE
Amarinus lacustris [Wear & Fielder 1985]
Elamena longirostris [Wear & Fielder 1985]
Elamena momona [Wear & Fielder 1985]
Elamena producta [Wear & Fielder 1985]
Halicarcinus cookii [Wear & Fielder 1985]
Halicarcinus innominatus [Wear & Fielder 1985]
Halicarcinus planatus [Wear & Fielder 1985]
Halicarcinus varius [Horn &Harms 1988]
Halicarcinus whitei [Wear & Fielder 1985]
Hymenosoma depressum [Wear & Fielder 1985]
Neohymenicus *pubescens* [Wear & Fielder 1985]
INACHIDAE
Achaeus curvirostris [Wear & Fielder 1985]
Cyrtomaia lamellata [Wear & Fielder 1985]
INACHOIDIDAE
Pyromaia tuberculata [Webber & Wear 1981; Wear & Fielder 1985]
LATREILLIIDAE
Eplumula australiensis (Wear &Fielder 1985)
LEUCOSIIDAE
Bellidilia cheesmani [Wear & Fielder 1985]
MACROPHTHALMIDAE
Macrophthalmus (Hemiplax) hirtipes [Wear & Fielder 1985]
MAJIDAE
Eurynolambrus australis [Webber & Wear 1981; Wear & Fielder 1985]
Jacquinotia *edwardsi* [Webber & Wear 1981; Wear & Fielder 1985]
Leptomithrax longimanus [Webber & Wear 1981; Wear & Fielder 1985]
Leptomithrax longipes [Webber & Wear 1981; Wear & Fielder 1985]
Leptomithrax tuberculatus mortenseni [Wear & Fielder 1985]
Notomithrax minor [Webber & Wear 1981; Wear & Fielder 1985]
Notomithrax peronii [Webber & Wear 1981; Wear & Fielder 1985]
Notomithrax ursus [Webber & Wear 1981; Wear & Fielder 1985]
OZIIDAE
Ozius truncatus (Wear & Fielder 1985)
PILUMNIDAE
Pilumnopeus serratifrons [Wear & Fielder 1985]
Pilumnus lumpinus [Wear & Fielder 1985]
Pilumnus novaezelandiae [Wear & Fielder 1985]
PINNOTHERIDAE
Nepinnotheres *novaezelandiae* [Wear & Fielder 1985]
PLAGUSIIDAE
Plagusia chabrus [Wear & Fielder 1985]
PORTUNIDAE
Liocarcinus corrugatus [Wear & Fielder 1985]
Nectocarcinus antarcticus [Wear & Fielder 1985]
Ovalipes catharus [Wear & Fielder 1985]
Portunus pelagicus [Wear & Fielder 1985]
Scylla serrata [Wear & Fielder 1985]
RANINIDAE
Lyreidus tridentatus [Wear & Fielder 1985]
VARUNIDAE
Austrohelice crassa [Wear & Fielder 1985]
Cyclograpsus insularum [Wear & Fielder 1985]
Cyclograpsus lavauxi [Wear & Fielder 1985]
Hemigrapsus crenulatus [Wear & Fielder 1985
Hemigrapsus sexdentatus [Wear & Fielder 1985]