COSEWIC

List of Prioritized Crustaceans

and

Related Groups at Risk

in Canada

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COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

OBJECTIVE OF CONTRACT:

Develop a prioritized candidate species list of crustaceans and related groups potentially at risk in Canada. This prioritized candidate list will serve as the primary basis for prioritizing crustaceans and related groups for future COSEWIC assessments.

PART 1: ANNOTATED LISTS

A general assessment of the following crustaceans and related groups listed below:

1. Phoronida – horseshoe worms
2. Pentastomida – tongue worms
3. Symphyla – Symphylans
4. Pauropoda - Pauropods
5. Chilopoda – Centipedes
6. Diplopoda – Millipedes
7. Crustacea – Ostracoda
8. Crustacea – Branchiopoda
9. Crustacea – Maxillopoda
10. Crustacea – Malacostraca

PART 2: CANDIDATE SPECIES FORMS:

List of 10 of the species in the crustaceans and related groups listed in Part 1 that are most likely to be at risk. Assessment of the species was done using the one page criteria form currently used by COSEWIC in assessing candidate wildlife species

PART 3: LIST OF KNOWLEDGEABLE PEOPLE:

List of knowledgeable persons (with address, email and phone) with respect to the crustaceans and related groups listed in Part 1

PART4: REFERENCES:

List of references with respect to the crustaceans and related groups listed under deliverable (1) as well as a list of general information sources including people and websites as well as primary literature.

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PART 1: ANNOTATED LISTS OF CRUSTACEANS AND RELATED GROUPS

1. Phoronida- Horseshoe Worms

The phylogenetic position of Phoronida is currently unresolved. Two classification schemes for the taxonomic group have been proposed:

Phylum: Lophophorata (Emig 1977) – phoronids (horseshoe worms), brachiopods, bryozoans

Class: Phoronida – horseshoe worms

Order: none

Family: none

Genus: *Phoronis* (Wright 1856), *Phoronopsis* (Gilchrist 1907)

Phylum: Brachiopoda (Duméril 1806) – phoronids, brachiopods

Subphylum: Phoroniformea (Cohen 2000)

Class: Phoronida – horseshoe worms

Order: none

Family: none

Genus: *Phoronis* (Wright 1856), *Phoronopsis* (Gilchrist 1907)

Phoronids, commonly known as horseshoe worms, are exclusively marine organisms. Ten species are recognized within two genera: *Phoronis* and *Phoronopsis*; no order or family designations exist. Larval phoronids maintain a separate generic (and sometimes specific) name from the adult form, since they were originally considered separate organisms and association of adults with their larval forms is difficult. All larvae are classified in the genus *Actinotrocha* (Emig 1985).

Phoronids are relatively small cylindrically shaped animals that secrete a rigid chitinous tube around their bodies for protection. They range in length from a few millimetres to almost 20 centimetres, and body diameter varies from 0.15-5 millimetres (Emig 2003). All phoronids are characterized by a crown of tentacles, known as the lophophore, which is used for feeding, respiration and protection. Adult phoronids are sedentary infaunal animals that embed themselves singly in soft sediments, such as sand, mud or fine gravel, or form dense tangles of many individuals anchored to rocks or shells (Emig 2003). They are benthic suspension feeders, orienting their lophophores into water currents to feed on algae, diatoms, flagellates and small invertebrate larvae (Emig 2003; Johnson 1988).

Phoronids typically have a prolonged breeding period from spring to fall. Species are either hermaphroditic or dioecious. Asexual reproduction has also been documented (Emig 2003). Larvae complete a planktonic phase of approximately 20 days, followed by a ‘catastrophic’ metamorphosis into the adult form within 30 minutes of settling on substrate (Emig 2003). Phoronids typically have a one year life span. Little is known of their predators, but they are likely commonly eaten by fish and gastropods.

Phoronids are found in all oceans and seas, except the Antarctic Ocean. All species have wide geographic ranges and most are probably cosmopolitan (Emig 2003). They occur from the intertidal zone to depths of 400 m. In some areas they can reach densities exceeding 10 000 individuals/m^2 (Emig 2003). No species of phoronid are listed by the IUCN.

Phoronids in Canada

Information on the occurrence and distribution of Phoronids in Canada is scarce. The Global Biodiversity Information Facility (GBIF 2009) lists one record of a *Phoronis spp*. in British Columbia (Haida Gwaii) and another in Nova Scotia (Sydney Harbour). The GBIF has a single record of *Phoronis vancouverensis* (the valid name is actually *P. ijimai* Oka) from Nanaimo, as well as a *Phoronopsis californica* Hilton from BC.

The Canadian Museum of Nature has several Phoronid specimens in its collections. *P. vancouverensis* (or *P. ijimai*) is listed from Nanoose Bay and Nanaimo BC. Several unidentified *Phoronis spp.* are listed from the Nanaimo area, and one *Phoronopsis sp.* is listed from east of Walbran Island, BC. Over 30 samples of unidentified Phoronids are recorded from BC in the Museum’s collection (J-M. Gagnon, J. Price, pers. comm., 25 March 2010). The Royal British Columbia Museum also has several Phoronid specimens from BC: *P. vancouverensis* (or *P. ijimai*) from Nanaimo and several unidentified *Phoronis* spp. from Saltspring and Saturna Islands (M. Frederick, pers. comm., 31 March 2010).

According to the Phoronida world database (Emig 2007) seven species occur in Canada. The following distributional information, unless otherwise stated, comes from this database.

Phoronis ijimai is found in BC, including around Vancouver Island, and has also been documented along the U.S. east coast from the intertidal zone to 10 m water depth. It encrusts on hard substrates in calm waters and burrows into rocks and corals in currents. The larval form is known as *Actinotrocha vancouverensis* Zimmer.

P. ovalis Wright is found in BC and along the U. S. east coast. It occurs from 0-55 m depths, commonly in depth ranges of 20-50 m. The species burrows into empty and decaying shells and carbonate rocks. The larval form has not been formally named.

P. muelleri Selys-Longchamps occurs along the east coast of North America, in both Canada and the U. S. The species has been documented in the Gaspé region of Quebec, and in the Gulf of St. Lawrence, but is rare throughout its range (Brunel et al. 1998; Van Guelpen et al. 2005). *P. muelleri* embeds itself into muddy or sandy sediments with high organic content and also attaches to detritus suspended in the water column. It is frequently found in *Macoma* (saltwater clam) and *Amphiura* (brittlestar) colonies from the intertidal zone to 400 m (but mainly from 10-60 m). Densities of up to 3000 individuals/m^2 have been recorded. The larval form is known as *A. branchiate* Mueller.

P. psammophila Cori is found along both the east and west coasts of North America, including BC and NB (Bay of Fundy; Van Guelpen et al. 2005). It prefers fine to very fine sand mixed with mud and occurs from the intertidal zone up to 70 m depths, but is most common from 0-10 m depths. It has been recorded at densities of 18 000 to 20 000 individuals/ m^2. The larval form is known as *A. sabatieri* Roule.

P. pallida Silén has been documented along the west coast of North America in both Canada and the U. S. It embeds itself in sand or muddy sand in the upper subtidal to 25 m depths. In Washington State it has been recorded in a commensal relationship with the thalassinid shrimp *Upogebia pugettensis* (Dana) (Santagata 2004). The species can reach densities of up to 74 000 individuals/ m^2. The larval form is known as *A. pallida*.

Phoronopsis harmeri Pixell is recorded in BC (in Hecate Strait; Burd and Brinkhurst 1987), as well as further down the west coast in the U. S. It prefers soft sediments (sand and mud) and occurs from the intertidal zone to 100 m, most commonly at depths of 0-20 m. Up to 28 000 individuals/ m^2 have been recorded. The larval form is known as *A. harmeri*.

Pp. californica is found along the U. S. west coast, embedded in soft to coarse sands and muds from the intertidal zone to 30 m depths. Its larval form is known as *A. californica*.

No conservation threats have been identified for any of the species documented in Canada.

Table 1. Taxa of Canadian phoronids showing distribution and status. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental.

Scientific Name	Larval Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Phoronis ijimai	*Actinotrocha vancouverensis*	5				5									
Phoronis ovalis	Creeping larva	5				5									
Phoronis muelleri	*Actinotrocha branchiate*	5									5				
Phoronis psammophila	*Actinotrocha sabatieri*	5				5						5			
Phoronis pallida	*Actinotrocha pallida*	5				5									
Phoronopsis harmeri	*Actinotrocha harmeri*	5				5									
Phoronopsis californica	*Actinotrocha californica*	5				5									

References

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the Marine Invertebrates of the Estuary and Gulf of Saint Lawrence. Canadian Special Publication of Fisheries and Aquatic Sciences 126. 405 p.

Burd, B. J. and R. O. Brinkhurst. 1987. Macrobenthic infauna from Hecate Strait, British Columbia. Can. Tech. Report of Hydrography and Ocean Sciences. No. 88. Institute of Ocean Sciences, Department of Fisheries and Oceans, Sidney, BC.

Cohen, B. L. 2000. Monophyly of brachiopods and phoronids: reconciliation of molecular evidence with Linnean classification (the subphylum Phoroniformea nov.). *Proc. R. Soc. Lond.* B. 267: 225-231.

Duméril, A. M. 1806. Zoologie analytique ou méthode naturelle de classification des animaux. Paris: Allais.

Emig, C. C. 1977. Un nouvel embranchement: les Lophophorates. *Bull. Soc. Zool. France* 102: 341-344.

Emig, C. C. 1985. Phylogenetic systematics in Phoronida (Lophophorata). *Z. Zool. System. Evolut.-forsch.* 23: 184-193.

Emig, C. C. 2003 Phoronida. *In* Protostomes. Grzimek's Animal Life Encylopedia, ed. 2, vol. 2, PUBLISHER, LOCATION, 491-497.

Emig, C. C. 2007. Phoronida world database. World wide web electronic publication http://www.marinespecies.org/phoronida. Accessed on 26 February 2010.

Gilchrist, J. D. 1907. New forms of the Hemichordata from South Africa. *Trans. S. Afr. Phil. Soc.* 17: 151-176.

GBIF 2009. Data portal of the Global Biodiversity Information Facility. World wide web electronic publication http://data.gbif.org. Accessed on 26 February 2010.

Johnson, A. S. 1988. Hydrodynamic study of the functional morphology of the benthic suspension feeder *Phoronpsis viridis* (Phoronida). *Marine Biology* 100: 117-126.

Santagata, S. 2004. A waterborne behavioral cue for the actinotroch larva of *Phoronis pallida* (Phoronida) produced by *Upogebia pugettensis* (Decapoda: Thalassinidea). *Biol. Bull.* 207: 103-115.

Van Guelpen, L., G. Pohle, E. Vanden Berghe and M. J. Costello (eds.). 2005. Marine Species Registers for the Northwest North Atlantic Ocean. World Wide Web electronic publication http://www.marinebiodiversity.ca/nonNARMS, version 1.0/2005. Accessed on 26 February 2010.

Wright, T. S. 1856. Description of two tubicolar animals. *Proc. R. Soc. Edinb.* 1: 165-167.

2. Pentastomida- Tongue Worms

Phylum: Arthropoda

Subphylum: Crustacea

Class: Pentastomida

Orders: Cephalobaenida, Porocephalida

The pentastomids, or tongue worms, are a small group of vermiform obligate parasites. Recent molecular studies have identified pentastomids as modified crustaceans, although their placement within the subphylum is unresolved since the group shows affinities with branchiopods, cephalocarids and maxillopods (Abele et al. 1989; Lavrov et al. 2004). Eight families and approximately 100 species are divided between two orders, the Cephalobaenida and the Porocephalida (Riley 1986).

All pentastomids parasitize the respiratory tract of terrestrial vertebrates as adults (they are the only crustaceans to do so), feeding on blood in the lungs, or in the case of *Linguatula spp.*, on cells and mucus lining the nasal sinuses (Riley 1986). Most pentastomids occur in the tropics and sub-tropics and reptiles are the definitive host for at least 90 % of species (Riley 1986). Larval development typically occurs in intermediate hosts, such as fish, amphibians, lizards, snakes, insects and mammals, although a few species have a direct life cycle (Abele et al. 1987). Both larval and adult forms are highly specialized parasites, lacking internal organs for respiration, circulation or excretion (Riley 1986).

Few direct records of pentastomids exist in Canada and the number and distribution of species here are unknown. *Reighardia sternae*, a cosmopolitan species found in the body cavity and air sacs of avian hosts, has been found in breeding gulls and terns in the Canadian arctic (Gyorkos and Kevan 1979). One case of *Lingulata serrata* infecting a human in Canada is also recorded (Gyorkos and Kevan 1979). This cosmopolitan species usually has canine hosts, although humans can act as accidental intermediate hosts worldwide (but are rare hosts in North America; Tappe and Büttner 2009). One unidentified pentastomid *spp.* from the Toronto area exists in the Canadian Museum of Nature's collections (no host is mentioned; J-M. Gagnon, pers. comm. 25 March 2010). Gyorkos and Kevan (1979) speculated that *Raillietiella ssp.* and *Porocephalus crotali* likely occur in Canada, based on similar reptile hosts and habitats here as in their U. S. range.

No pentastomid species are currently listed by the IUCN.

Table 2. Distribution and status of Pentastomida in Canada. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental.

Scientific Name	**Ca**	**YT**	**NT**	**NU**	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**NS**	**PE**	**NL**
Reighardia sterna	5													
Lingulata serrata	5								5					

<u>References</u>

Abele, L. G., W. Kim, and B. E. Felgenhauer. 1989. Molecular evidence for the inclusion of the Phylum Pentastomida in the crustacean. *Mol. Biol. Evol.* 6: 685-691.

Gyorkos, T. W. and D. K. McE. Kevan. 1979. Pentastomida. *Mem. Ent. Soc. Canada* 108: 290-291.

Lavrov, D. V., W. M. Brown, J. L. Boore. 2004. Phylogenetic position of the Pentastomida and (pan) crustacean relationships. *Proc. R. Soc. Lond.* 271: 537-544.

Riley, J. 1986. The biology of pentastomids. *Adv. Parasitol.* 25: 45-128.

3. Symphyla

Phylum: Arthropoda

Subphylum: Myriapoda

Class: Symphyla

Familes: Scutigerellidae, Scolopendrellidae

Symphylans are small soil arthropods that resemble centipedes. They have a whitish body, 14 body segments, 12 pairs of legs and three pairs of mouthparts, but lack eyes (Scheller 2003). They live in both natural and agricultural habitats and can penetrate down to 1 m or more below the soil surface. Most species appear to prefer moist soil (e.g., up to 98-100% relative humidity), and exhibit both vertical and horizontal migration when soil conditions change (Waterhouse 1968; Scheller 2003). Symphylans are likely omnivorous, and their main foods include fungal hyphae and spores and living plant roots. Several species are considered agricultural pests, causing damage to crops in both field and greenhouse plots (e.g., *Scutigerella immaculata,* Newport; Scheller 2003). Population densities of 1000 individuals/m^2 or more are common (Waterhouse 1967; Scheller 2003).

Little is known about the distribution and taxonomy of symphylans. Two families are recognized: the swift-moving Scutigerellidae, comprised of five genera and approximately 125 species 4-8 mm long, and the slow-moving Scolopendrellidae, comprised of eight genera and approximately 75 species 2- 4 mm long (Scheller 2003). As a group, symphylans are considered relatively species poor, although this is likely due to a lack of study of non-pest forms (Behan-Pelletier 1993; Scheller 2003). Endemism is believed to be common, but as yet largely undocumented (Scheller 2003). No species are listed by the IUCN.

Two species of symphylans have been described in Canada: *S. immaculata,* Newport and *Symphylella vulgaris,* Hanson. Behan-Pelletier (1993) speculated that at least another five species probably occur here based on their distributions in the U. S. Scheller (1979) estimated there may be up to 10 undescribed species in Canada. No conservation threats have been identified for symphylans in Canada, although significant gaps exist in our knowledge of them here (Behan-Pelletier 1993).

Scutigerella immaculata, also known as the garden symphylan, is common in agricultural landscapes and is a serious pest of vegetable crops. Its predators include beetles, centipedes, nematodes and mites (Peachey et al. 2002). The species thrives under a range of temperature and moisture levels, and is commonly found in the top 25-35 cm of soil (Shanks 1966; Waterhouse 1967). It generally avoids sandy soils (Waterhouse 1967). In the Pacific Northwest, populations were found to increase in agricultural plots with reduced tillage, probably because mechanical disturbance of the soil crushes individuals and destroys the soil channels they use for movement (Peachey et al. 2002).

Table 3. Distribution and status of Symphyla in Canada. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental.

Scientific Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Scutigerella immaculate	5				5	5			5	5				
Symphylella vulgaris	5									5				

<u>References</u>

Behan-Pelletier, V. M. 1993. Diversity of soil arthropods in Canada: systematic and ecological problems. *Mem. Ent. Soc. Can.* 165: 11-50.

Peachey, R. E., A. Moldenke, R. D. William, R. Berry, E. Ingham and E. Groth. 2002. Effect of cover crops and tillage system on symphylan (Symphyla: *Scutigerella immaculata,* Newport) and *Pergamasus quisquiliarum* Canestrini (Acari: Mesostigmata) populations, and other soil organisms in agricultural soils. *App. Soil Ecol.* 21: 59-70.

Scheller, U. 1979. Symphyla. *Mem. Ent. Soc. Can.* 108: 299.

Scheller, U. 2003. Symphyla (Symphylans). *In* Protostomes. Grzimek's Animal Life Encylopedia, ed. 2, vol. 2, Gale Group, Farmington Hills, MI, pp.371-373.

Shanks, C. H. Jr. 1966. Factors that affect reproduction of the garden symphylan, *Scutigerella immaculata*. *J. Econ. Ent.* 59: 1403-1406.

Waterhouse, J. S. 1967. Population studies of the garden symphylan *Scutigerella immaculata* (Symphyla: Scutigerellidae). *Can. Ent.* 99: 696-702.

Waterhouse, J. S. 1968. Studies on the garden symphylan, *Scutigerella immaculata* (Symphyla: Scutigerellidae). *Can. Ent.* 100: 172-178.

4. Pauropoda

Phylum: Arthropoda

Subphylum: Myriapoda

Class: Pauropoda

Order: Pauropodina

Families: Brachypauropodidae, Pauropodidae

Pauropods are extremely small (less than 1.5 mm long) soil arthropods that inhabit forest and agricultural landscapes (Scheller 1979). Adults are distinguished by having 9-11 legs on 11-12 body segments, and branched antennae. There are four immature stages in which individuals successively acquire 3, 5, 6 and 9 pairs of legs (Tomlin 1982). Pauropods lack eyes and a tracheal system (Scheller 2003). They move rapidly with frequent abrupt changes in direction. Pauropods have anal plates, on the pygidium, which appear to vary by species and are thus useful in identification (Scheller 2003).

Pauropods typically have patchy distributions, with low population densities, although concentrations of up to 5600 individuals/m^2 have been recorded in agricultural and hedgerow habitats (Tomlin 1982; Scheller 2003). They are found in a variety of environments and soil types, and are most abundant at soil depths of 10-20 cm (Scheller 2003). Pauropods exhibit negative phototropism and vertically migrate through the soil in response to moisture levels. They often aggregate under stones or tree branches, and commonly inhabit leaf litter. The diet of pauropods is largely unstudied, but some species are known to eat mold, fungal hyphae and root hairs (Scheller 2003).

Very little is known about the conservation status of pauropods. While some species have sub-cosmopolitan ranges, many (if not most) are believed to have extremely restricted ranges and endemism is likely common (Scheller 2003). No pauropod species are listed by the IUCN.

Only one study has systematically documented the pauropod fauna in Canada, and its focus was restricted to samples from Ontario, Quebec and British Columbia (Scheller 1983). Twenty-three pauropod species, representing two families (Brachypauropodidae and Pauropodidae), were described. Seven of these species, all belonging to the family Pauropodidae, are new to science: *Allopauropus remigatus*, *A. marshalli*, *A. tomlini*, *A. asperosus*, *Pauropus mixtus*, *Stylopauropus canadensis*, and *Amphipauropus sp.* (Scheller was unable to describe this final species fully due to incomplete material, but did suggest it represented a new genus as well). Of the remaining 18 species, 17 are in the family Pauropodidae (nine of these *Allopauropus spp.*) and one, a tentative identification of *Aletopauropus lentus*, belongs to the family Brachypauropodidae. Scheller (1983) speculated that representatives of the family Eurypauropodidae also likely occur in Canada since they are found in neighbouring regions of the eastern United States.

Most Canadian pauropod species described to date are members of the genus *Allopauropus* the largest and most cosmopolitan pauropod genus, with over 300 species worldwide. Most *Allopauropus* species in Canada have wide distributions beyond the Nearctic region. The four new members of the genus described in Canada appear to belong to cosmopolitan species groups (i.e., the new species have strong morphological affinities with previously described species from Africa, Asia, and South America; Scheller 1983). The other two new pauropod species show strong affinities with species from Texas, Argentina and Chile (*Pauropus mixtus*) and California (*Stylopauropus canadensis*). In general, Canadian pauropods seem more closely related to west Palearctic fauna than with Neotropical species, and several Canadian species have morphological similarities to north African species (Scheller 1983). Several Canadian species had not previously been documented in the Americas (e.g., *A. broelmanni*, *A. tenellus*, *A. multiplex*).

Almost half of the total Canadian pauropod fauna have restricted ranges, either because they are new to science, have only been found in the Nearctic (e.g., *A. carolinensis*, *S. californianus*, *S. gladiator*, *Aletopauropus lentus*) or appear to have small, disjunct distributions globally (e.g., *A. bouini*, *Fagepauropus hesperius*). Despite incomplete knowledge of the Canadian fauna, it appears more diverse than pauropod species assemblages from similar geographic regions (e.g., previously glaciated parts of Europe). Most specimens sampled in Scheller's (1983) study came from human-modified habitats (e.g., farmland) and thus it is anticipated that many additional species are yet to be discovered in less disturbed habitats.

Table 4. Distribution and status of Canadian pauropods. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental.

Scientific Name	Worldwide Distribution	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Allopauropus remigatus	New to science	5								5					
A. marshalli	New to science	5				5									

Scientific Name	Worldwide Distribution	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
A. tomlini	New to science	5								5					
A. asperosus	New to science	5									5				
A. aristatus	Western Palearctic, tropical Africa, Madeira, U. S., Jamaica	5								5					
A. carolinensis	Eastern U. S.	5								5					
A. bouini	Angola, Florida	5								5					
A. gracilis	U. S., Chile	5								5	5				
A. broelemanni	Western Palearctic	5				5									
A. tenellus	Norway, Sweden, Finland, France	5									5				
A. multiplex	Europe, Morocco	5								5					
A. cuenoti	Europe, north Africa, Madeira, Reunion, U. S.	5								5	5				
Pauropus mixtus	New to science	5				5									
P. lanceolatus	Europe, U. S.	5								5					
Stylopauropus pedunculatus	Western Palearctic, Australia	5									5				
S. californianus	Northern California	5				5									
S. canadensis	New to science	5				5									
S. gladiator	Northern California	5				5									
Amphipauropus sp.	New to science									5	5				
Polypauropus duboscqi	Sub-cosmopolitan	5								5					
Fagepauropus hesperius	Morocco, Gambia, Mongolia	5								5					
Aletopauropus lentus	California	5				5									

References

Scheller, U. 1979. Pauropoda. *Mem. Ent. Soc. Can.* 108: 294.

Scheller, U. 1983. Pauropoda (Myriapoda) from Canada. *Can. J. Zool.* 62: 2074-2091.

Scheller, U. 2003 Pauropoda (Pauropods). *In* Protostomes. Grzimek's Animal Life Encylopedia, ed. 2, vol. 2, PUBLISHER, LOCATION, 375-377.

Tomlin, A. D. 1982. Pauropoda (Arthropoda: Myriapoda) do occur in Canada. *Can. Entomol.* 114: 655-657.

5. Chilopoda

Phylum: Arthropoda

Subphylum: Myriapoda

Class: Chilopoda – centipedes

Subclasses: Notostigmophora, Pleurostigmophora

Orders: Scutigeromorpha, Lithobiomorpha, Craterostigmomorpha, Scolopendromorpha,

Geophilomorpha

Families: 23

Centipedes are grouped with millipedes, pauropoda and symphyla in the subphylum Myriapoda, although some biologists consider the latter three to be more closely related to insects than to centipedes (Edgecombe 2003). Five centipede orders are recognized worldwide: the Scutigeromorpha (sole member of the Subclass Notostigmophora), and the Lithobiomorpha, Craterostigmomorpha, Scolopendromorpha, and Geophilomorpha (all members of the Subclass Pleurostigmophora). A total of 3200 species have been described globally, but at least 10 000 species are estimated to exist around the world (Shelley 1999).

Centipedes occur on every continent except Antarctica. They are commonly found in wet forests but also occur in dry forest, caves, grasslands and desert (Edgecombe 2003). They are tolerant of a wide range of elevations, from sea level to high mountain peaks. Some species have very specific microhabitat requirements (e.g., rotting logs) but most inhabit a variety of microhabitats including logs, bark, leaf litter and under stones (Edgecombe 2003). Many centipede species have broad geographic distributions, in part due to their widespread accidental introduction to new areas by human trade and travel (e.g., in soil or on plants). At the same time, however, many other species are restricted to relatively narrow ranges and some are known only from single locations. Introduced mammals and snakes have decimated island populations of some species (Edgecombe 2003). The centipede *Scolopendra abnormis* (Serpent Island centipede), found on Mauritius, is listed as vulnerable by the IUCN (IUCN 2010). No other centipesed are listed.

Adult centipedes range in length from 4- 300 mm. They have an odd number of pairs of legs, between 15 and 191, one per trunk segment (Shelley 1999). The first pair of legs are modified “poison claws” (also known as “prehensors” or “forciples”) used for feeding and defence. Located below the head, these claws contain internal glands that inject toxic venom into prey or potential predators (Shelley 1999). The final pair of legs are modified for sensory, defensive or prey capture functions. Some centipedes also produce defensive secretions. Many centipede species are dull in colour, but some have bright colouring, presumably a form of aposematism. Most Lithobiomorpha and all Scolopendromorpha are sighted and have either simple or compound eyes. All Geophilomorpha and many smaller Scolopendromorpha lack eyes altogether (Edgecombe 2003).

All centipedes are carnivorous. They prey on soft-bodied arthropods (including other centipedes) and worms, and larger species in the family Scolopendridae are known to feed on mice, birds, lizards, small snakes and toads (Shelley 1999). Members of the order Geophilomorpha will switch to eating plants if animal prey is unavailable for long periods (Edgecombe 2003). Most centipedes are nocturnal and few species occur above ground during the day. Some species respond to seasonal changes by burrowing deeper into soil or litter (i.e., during dry seasons) or migrating from litter to logs or between different forest types (Edgecombe 2003).

Centipedes are solitary except when females brood their eggs or young. Fertilization is external, with females collecting sperm packets left by males (Shelley 1999). Some species are also parthenogenetic, at least in parts of their geographic ranges (Edgecombe 2003). Centipedes display both epimorphic (eggs and early post-embryonic stages brooded by female) and anamorphic (eggs laid singly and not brooded) growth and development (Shelley 1999).

Centipedes have been poorly studied in Canada compared with other large arthropods, even though they are relatively abundant and conspicuous (Kevan 1979). This may be partly because the superficial similarity of many genera and species makes identification challenging, and the taxonomy of many groups has not been clarified (Kevan 1983). Furthermore, centipedes are not viewed as economically important, although they are important predators of insects and other terrestrial arthropods (Kevan 1983). Information on the life histories and population dynamics of Canadian centipedes is lacking (Behan-Pelletier 1993).

The only national study of the Canadian chilopod fauna was published in 1983 as a preliminary survey (Kevan 1983). Four orders (all except Craterostigmomorpha), represented by 45 species, were documented. Of these, 15 species were identified as being introduced to Canada and another two were considered possible introductions, for a total of 33-38% of the total described fauna being non-native. Additionally, 11 (24%) of the total described species were based on unconfirmed or unpublished reports and six species (13%) had confused taxonomy (e.g., specimens possibly represented another similar species). Many of the described species were listed with several synonyms. Kevan (1983) estimated that the total number of centipede species in Canada was likely around 70, based on known distributions of species close to the Canadian border in Alaska and the contiguous United States. An updated catalog of the centipedes of North America was published in 2010 and provides additional information on species recorded in Canada (Mercurio 2010). Based on both the Kevan (1983) and Mercurio (2010) publications, a total of 53 centipede species have been documeted from Canada, with 18 of these recognized as introductions, and another two as possible introductions.

Little information is available on the biology of the 33 centipede species native to Canada. *Tomotaenia parviceps* Wood seems to be rare in Canada, where it reaches its northern limit in southern B. C. (Kevan 1983). Its range extends south to Mexico. It is the longest centipede known in Canada, commonly reaching 7-10 cm (Kevan 1983). *Scolopocryptops sexspinosus* Say has a disjunct distribution in Canada, occurring in both B. C. and Ontario, but so far has not been documented elsewhere in the country (Shelley 1992). It appears to be the only indigenous member of the order Scolopendromorpha in Canada, which contrasts markedly with the situation in neighbouring states, where the order is represented by two to five different species (Shelley 1992). *Pacymerium ferrugineum* Koch (also known as the earth centipede) is common in coastal and grassland habitats. It feeds on insect larvae and collembolans and burrows in the soil. It reaches lengths of 30-50 mm and lives for three or more years. It may be introduced in North America (Edgecombe 2003). No specific conservation threats have been identified for Canadian centipedes, although habitat loss and introductions of invasive alien species of centipedes likely negatively affect native populations (Mercurio 2010).

Table 5. Distribution and status of Canadian Chilopoda, based on Kevan (1983) and Mercurio (2010). 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental; * = based on unpublished or unconfirmed accounts; ? = status needs further clarification. For species having several synonyms the currently accepted name as listed by Kevan (1983) or Mercurio (2010) is provided.

Scientific Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Scolopendra alternans Leach*	7									7				
S. viridis viridis Say*	7											7		
Cryptops anomalans Newport*[1]	7								7	7				
C. hortensis Donovan	7				7									
C. parisi Brölemann	7?													7?
Scolopocryptops rubiginosus Chamberlin*[2]	5							5	5					
Sy. sexspinosus Say	5				7?				5					
Sy. spinicaudus Wood	5				5									
Stigmatogaster subterraneus Shaw	7													7
Escaryus ethopus Chamberlin	5	5												
E. urbicus Meinert	5										5			
Schendyla nemorensis L. Koch*	7													7
Chaetechelyne vesuviana Newport*	7								7					
Strigamia acuminata Leach[3]	7									7				
Sg. chionophila Wood	5		5			5			5					
Sg. fulva Sager*	5									5				
Sg. parviceps Wood	5				5									
Arctogeophilus insularis Attems	5				5									
Taiyuna occidentalis Meinert*[4]	5				5									
T. opita Chamberlin*	5				5			5	5					
Pachymerium ferrugineum C. L. Koch[5]	7?	?												
Arenophilus bipuncticeps Wood	5								5			5		
Geophiles carpophagus Leach[6]	7													
G. electricus Linnaeus	7													7
G. flavus De Geer	7								7					7
G. proximus C. L. Koch	7								7					
G. terraenovae Palmén	5													5
G. vittatus Rafinesque	5								5	5				
Lamyctes emarginatus Newport	7								7					7
Bothropolys columbiensis Chamberlin	5				5									
B. hoples Brölemann	5				5									
B. multidentatus Newport	5								5		5			
B. victorianus Chamberlin	5				5									
Ethopolys californicus Daday	5				5									
E. spectans Chamberlin	5				5									

Scientific Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Zytethopolys pugetensis tiganus Chamberlin & Wang	5				5									
Lithobius forficatus Linnaeus	7								7	7		7		7
L. lindrothi Palmén	5													5
L. melanops Newport	7													7
L. microps Meinert	7								7	7				7
Zygethobius columbiensis Chamberlin	5				5									
Nadabius aristeus Chamberlin	5								5					
N. eigenmanni Bollman	5				5				5					
N. jowensis Meinert	5								5					
Nampabius lundii Meinert	5								5					
Paobius albertanus Chamberlin	5					5								
P. columbiensis Chamberlin	5				5									
P. orophilus Chamberlin	5				5									
Pokabius eremus Chamberlin	5				5									
Sigibius microps Meinert	7													7
Simobius ginampus Chamberlin*	5				5									
Sonibius politus McNeill	5				5	5			5	5				
Scutigera coleoptrata Linnaeus	7				7	7	7		7	7				

[1]Possibly confused with *C. hortensis*
[2]Possibly a subspecies of *S. sexspinosa*
[3]Could be confused with *S. crassipes*
[4]Kevan (1983) presumed this to be *T. occidentalis*, although it was listed only by genus in the original record (Crabill 1958).
[5]Described as occurring in the Canadian subarctic, possibly referring to the Yukon (Kevan 1983). Edgecombe (2003) suggests that *P. ferrugineum* may be introduced to North America.
[6]No particular locality is given (Mercurio 2010).

References

Behan-Pelletier, V. M. 1993. Diversity of soil arthropods in Canada: systematic and ecological problems. *Mem. Ent. Soc. Can.* 165: 11-50.

Edgecombe, G. D. 2003. Chilopoda (Centipedes). *In* Protostomes. Grzimek's Animal Life Encylopedia, ed. 2, vol. 2, Gale Group, Farmington Hills, MI, pp. 353-362.

IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1 http//:www.iucnredlist.org. Downloaded on April 30, 2010.

Kevan, D. K. McE. 1979. Chilopoda. *Mem. Ent. Soc. Canada* 108: 296-298.

Kevan, D. K. McE. 1983. A preliminary survey of known and potentially Canadian and Alaskan centipedes (Chilopoda). *Can. J. Zool*. 61: 2938-2955.

Mercurio, R. J. 2010. An Annotated Catalog of Centipedes (Chilopoda) from the United States of America, Canada and Greenland (1758-2008). Xlibris Corp. USA.

Shelley, R. M. 1992. Distribution of the centipede *Scolopocryptops sexspinosus* (Say) in Alaska and Canada (Scolopendromorpha: Cryptopidae). *Insecta Mundi* 6(1): 23-27.

Shelley, R. M. 1999. Centipedes and millipedes with emphasis on North American fauna. *The Kansas School Naturalist* 45(3): 1-15.

6. Diplopoda

Phylum: Arthropoda

Subphylum: Myriapoda

Class: Diplopoda

Subclasses: Chilognatha, Penicillata (both in Canada)

Orders: 15 (6 in Canada)

Families: 148 (20 in Canada)

Millipedes are one of the most diverse arthropod groups, with an estimated 80, 000 species worldwide (Shelley 1999). Of these, only 12, 000 species have been described (Sierwald and Bond 2007). Approximately 1400 species have been identified in North America (Shelley 1999). The majority of millipede taxa are distributed in sub-tropical and tropical zones (Kevan and Scudder 1989). Compared with other arthropod groups, remarkably little information exists on the taxonomy, phylogeny, morphology and ecology of the Diplopoda, despite its important ecological role in many ecosystems (Sierwald and Bond 2007).

Millipedes have two pairs of legs per body segment. Millipedes move slowly and most are adapted for burrowing, although some are too thin and weak for this behaviour and inhabit cracks and crevices in the substrate. Others have lost the burrowing ability altogether and have become surface dwellers (Shelley 1999), and some live in caves (Shear 2004). Lacking waxy cuticle on their exoskeleton to protect them from dessication, millipedes are typically found in dark damp habitats, such as in leaf litter, wood piles or in the top few layers of soil in moist deciduous forest (Shelley 1999). They range in length from 3 mm to more than 270 mm (Shelley 1999).

Most millipedes are phytosaprophagous, feeding on decaying plant material. Some also eat tender shoots and roots, fungi and animal detritus, and a few are carnivorous (Kevan and Scudder 1989). Millipedes play an important role in organic decomposition and soil nutrient cycles (Shelley 1999; Cárcamo et al. 2000; Snyder et al. 2009). They primarily fragment dead plant material, thereby stimulating microbial activity needed for nutrient cycling (Sierwald and Bond 2007). A study in British Columbia estimated that a native millipede species (*Harpaphe haydeniana haydeniana* Wood) consumed 36% of annual litter fall in coniferous forests, contributing significantly to litter decomposition and nitrogen mineralization in coastal habitats (Cárcamo et al. 2000).

The main predators of millipedes include amphibians, reptiles, birds, shrews and carnivorous invertebrates (Shelley 1999). Millipedes also play host to a variety of parasites, such as nematodes and dipterans and are commonly associated with mites, in an apparently commensal relationship (Sierwald and Bond 2007). Many millipede species defend themselves from danger by coiling into spirals or balls to protect their softer ventral side. Millipedes also use chemical defence by releasing noxious secretions from glands along the sides of their bodies which deters or even kills predators (Shelley 1999). Members of the order Polydesmida produce cyanide in these secretions. Some millipede species have aposematic colouration to warn and deter potential predators (Shelley 1999).

Most millipedes reproduce sexually, although some species are also parthenogenetic. Eggs are laid in nests in the soil and in some species are guarded by either the female or male. Young millipedes molt into sexual maturity usually within one to two years, although some take longer. The lifespan varies depending on the species, ranging from one to eleven years, or possibly longer.

Millipedes have limited vagility but they have been spread accidentally by human travel and trade to many parts of the world. For example, close to 50 % of the British millipede fauna has established in North America (Sierwald and Bond 2007). Many millipede introductions likely go undetected, however, since taxonomic studies and monitoring of the group are scarce worldwide (Sierwald and Bond 2007). Currently there are 31 species listed on the IUCN Red List (1 critically endangered, 6 endangered, 7 vulnerable, 10 least concern, and 7 data deficient; IUCN 2010), all of them from southern Africa.

Research on the Canadian diplopod fauna has been limited. Several recent surveys of the class have taken place (Kevan 1983; Shelley 1988, 1990, 2002a; Shelley et al. 2007, Shelley et al. 2009; Whitney and Shelley 1995) and Shelley (2002a) pronounced that Canada was the first large country in the world to have its millipedes more or less completely identified. Yet, detailed knowledge of the life histories and population dynamics of all Canadian species are lacking (Kevan 1983; Behan-Pelletier 1993). Furthermore, most species are known only from a few localities and information on the distribution of the country’s millipedes remains incomplete and generalized (Hoffman 1979). The millipede fauna in many areas of the country is still poorly studied (e.g., the coastal region of British Columbia; Shear 2004).

The lack of attention given to millipedes in Canada is undoubtedly related to their cryptic habits and because they have little direct economic importance (Kevan 1983). Some millipedes are considered crop pests (e.g., targeting carrots, corn, potatoes, strawberries) but damage appears to occur mainly under adverse environmental conditions for the plant, millipede, or both, and economic costs are probably negligible (Kevan 1983; Brunke et al. 2009). While millipede pests are rarely identified to species, several pest species have been recognized, and in Canada all but one are introduced (Table 6; Kevan 1983; Brunke et al. 2009). Kevan (1983) reported a range of population densities in different habitat types: 700/m^2 in soil of a melon field in Ontario, 160-215/ m^2 in a potato field in New Brunswick, 130/m^2 in forest soil in the Alberta Rockies.

Canada's northern climate likely leads to a relatively depauperate diplopod fauna (Hoffman 1979; Shelley 1988). The adaptation of many millipede species to life in the leaf litter of deciduous forests may limit their occurrence here and few species may be capable of surviving Canadian winters (Hoffman 1979; Shelley 1988). Indeed, only a few species have been described in taiga and prairie habitats, and, to date, no millipedes have ever been collected from the Northwest Territories or the Yukon (Shelley 2002a; R. M. Shelley pers. comm., 13 May 2010). Nevertheless, Shelley (1988) speculated that two areas of Canada should be diversity hotspots for millipedes: British Columbia (especially along the Pacific coast) and southern Ontario. Whitney and Shelley (1995) further predicted that the dense relatively moist forests around Rossland and Trail BC were the most likely area in Canada to harbour new millipede species.

Sixty-six millipede species have been described in Canada, representing two subclasses (Penicillata and Chilognatha), six orders (Polyxenida, Polyzoniida, Spirobolida, Julida, Chordeumatida and Polydesmida), 20 families and 45 genera. Of these, 20 (30%) species are introduced, mainly from Europe, and 7 (11%) have unresolved taxonomy (e.g., pending confirmation of range, or identification of male specimens). *Polyxenus lagurus* Linnaeus is the only species of the subclass Penicillata found in Canada.

Shelley (2002a) suggested that a further eleven species are likely to be documented in Canada, based on their proximity to the border with the U. S. (*Julus scandinavicus* Latzel, an introduced Palearctic species likely occurring in New Brunswick; *Californiulus euphanus* Chamberlin and *C. parvior* Chamberlin likely occurring in BC; *Piyoiulus impressus* Say, likely in New Brunswick, Quebec and Ontario; *Aniulus (Hakiulus) diversifrons diversifrons* Wood, likely in Manitoba; *Conotyla fischeri* Cook and Collins, likely in Ontario; *Abacion magnum* Loomis and *A. tesselatum* Rafinesque, likely in Ontario; *Montaphe elrodi* Chamberlin, likely in BC; *Nannaria fowleri* Chamberlin, likely in Ontario; and *Semionellus placidus* Wood, likely in Ontario). In BC alone, at least six undescribed species may exist (W. A. Shear, pers. comm., 18 May 2010, based on collections he has seen or made himself).

Two endemic species, *Austrotyla borealis* Shear and *Taiyutyla lupus* Shear[1], appear to have extremely restricted ranges. To date, *A. borealis* Shear has only been documented on the northwestern slope of Mt. Edith Cavell in Jasper National Park, Alberta, and *T. lupus* only from Wolf Creek Cave, near Lake Cowichan, Vancouver Island, British Columbia (Shelley 1990; Shear 2004). Based on its endemicity, Shelley (2002a) considered *A. borealis* Shear "a significant component of the Canadian biota and a worthy candidate for consideration as a rare and endangered species "(p.1867). At least three other species also have apparently restricted distributions, *Tubaphe levii* Causey (found only in rainforest habitat on the western coast of Vancouver Island and the Olympic Peninsula, Washington; Shelley 1994), *Taiyutyla shawi* n. sp. (found only from a cave near Port McNeil, Vancouver Island, BC and from surface localities in Washington; Shear 2004) and *Octoglena anura* Cook (found along the Pacific Coast from northern Oregon to southwest BC, ranging inland to the western slope of the Cascade Mountains; Shelley 1996). *Tubaphe levii* was collected only in deciduous litter in dense, primarily coniferous forest along the western periphery of Vancouver Island (only up to 5-10 km inland), from Bamfield to China Beach Provincial Park (Shelley 1990). Shelley (1990) believed that the heavy logging occurring in this habitat on Vancouver Island posed a threat to the species in its Canadian range. Because *T. levii* relies on deciduous litter, it is unlikely it would be found in monoculture coniferous forests planted to replace clearcut native forests (Shelley 1990).

Other native millipede species are relatively common across Canada. *Underwoodia iuloides* Harger, a widespread North American species occurring over much of the continent, has the most northerly distribution of the fauna, extending from northern Newfoundland west to Saskatchewan (Shelley 1993). It is adapted for living in extremely wet conditions, occurring in thick litter of damp wooded areas and in coastal barrens with heavy fog and rain (Shelley 1993). *Aniulus garius* Chamberlin is found across Canada in a variety of habitats, including leaf litter in maple woods, under decaying oak logs, in leaf mold and in cornfields (where it is commonly known as the "corn millipede"; McAllister et al. 2009). *Polyxenus lagurus* Linnaeus, also known as the "bristly millipede" is a common species worldwide, from Europe, to North Africa, Asia and North America. Instead of burrowing in the soil, the bristly milliped lives beneath loose pieces of tree bark, or on tree trunk moss and lichens, where it feeds on algae (Davis and Wright 2002). *Oriulus venustus* Wood has the largest distribution of any known diplopod in North America, ranging from southern Quebec to central Alberta in Canada and across much of the United States to the south. It has been found living under rocks, in pine litter, in rotten logs and in houses (Shelley 2002b).

[1] In the case of both *Taiyutyla lupus* and *T. shawi* the restricted distribution may simply be due to a lack of study (W. A. Shear, pers. comm.. 28 May 2010).

Introduced millipede species are primarily synanthropic. *Bracydesmus superus* Latzel and *Polydesmus inconstans* Latzel occur in urban environments in Alberta and BC (Shelley 1990). *Oxidus gracilis* C. L. Koch is common in greenhouses and buildings in eastern and western Canada (Shelley 2002a). *Cylindroilus caeruleocinctus* Wood ("European millipede") is abundant in agricultural fields growing corn, ginseng, sweet potato and carrots in Ontario (Brunke et al. 2009). A study of leaf litter fauna in Kejimkujik National Park, Nova Scotia revealed the recent introduction of a large European millipede, *Ophyiulus pilosus* Newport, to mature hardwood forest in the park (Davis and Wright 2002). Its appearance at Kejimkukik coincided with an apparent decline in *Trichopetalum lunatum* Harger, suggesting that the alien species may be adversely affecting native millipede biodiversity (Davis and Wright 2002).

Information on the conservation status of Canadian diplopods is unavailable. As in other parts of the world, millipedes in Canada may be threatened by a variety of factors, including habitat destruction (R. M. Shelley, pers. comm., 13 May 2010), disease, parasites, introduced species (B. Wright, pers. comm., 29 May 2010), pesticides (Adamski et al. 2009) and heavy metal contamination of soils (Grelle et al. 2000).

Table 6. Distribution and status of Canadian Diplopoda. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental; † = identified pest species.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Polyxenus lagurus Linnaeus	Bristly millipede	5				5				5	5		5		
Octoglena anura Cook		2				2									
Petaserpes cryptocephalus McNeil		5								5	5				
P. mutabile Causey		5								5					
Narceus americanus annularis Rafinesque		5								5	5				
Brachyiulus pusillus Leach		7								7	?		7		7
Cylindroiulus britannicus Verhoeff		7													7
C. caeruleocinctus Wood†		7				7				7	7	7	7	7	7
C. latestriatus Curtis†		7				7	7			7	7		7		
C. punctatus Leach		7													7
C. truncorum Silvestri		7													7
C. vulnerarius Berlese		7				7									
Ophyiulus pilosus Newport†		7				7				7	7		7		7
Archiboreoiulus pallidus Brade-Birks		7				7		7		7					
Blaniulus guttulatus Fabricius		7								7	7		7		7
Choneiulus palmatus Němec		7								7	7		7		7

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Nopoilus kochii Gervais		7				7	7			7			7		7
Proteroiulus fuscus Am Stein		7											7		7
Orinisobates expressus Chamberlin		5				5	5								
Okeanobates americanus Enghoff		5								5	5				
Aniulus garius Chamberlin	Corn millipede	5					5	5	5	5	5				
A. paludicolens Causey		5								5					
Bollmaniulus hewitti Chamberlin		5				5									
B. spenceri Chamberlin		5				5									
Litiulus alaskanus Cook		5				5									
Oriulus venustus Wood		5					5	5	5	5	?				
Parajulus perditus Chamberlin[2]		?				?	?								
Uroblaniulus canadensis Newport[3]		5								5	5				
U. idahoanus Chamberlin[4]		5				5									
U. stolidus Causey		5								5					
Opiona columbiana Chamberlin		5				5									
Underwoodia iuloides Harger		5						5	5	5	5		5		5
Uw. tida Chamberlin		5				5	5								
Vasingtona irritans Chamberlin		5				5									
Cleidognona sp.[5]		5								5					
Austrotyla borealis Shear		2					2								
Brunsonia albertana Chamberlin		5				5	5								

[2] Shelley (2002) indicated that the taxonomy of this organism was uncertain since only a female specimen had been collected. He assigned '*perditus'* to the specimen based on Hoffman (1999)'s classification of "Parajulidae of uncertain generic position or validity".

[3] Also known by the synonym *Uroblaniulus immaculatus* Wood.

[4] Shelley (2002) used this name provisionally because he was unsure whether the species' distribution extended into British Columbia.

[5] This probably represents an undescribed species, but identification was made only with female specimens. Confirmation with male specimens is needed.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Br. atrolineata Bollman[6]		5				5									
Conotyla blakei Verhoeff		5									5				
Conotyla sp.[7]		5								5					
Craspedosoma raulinsii Leach		7									7				
Rhincosomides mineri Silvestri		5				5									
Trichopetalum lunatum Harger		5								5	5		5		5
Ophiodesmus albonanus Latzel		7													7
Ergodesmus compactus Chamberlin		5				5									
Nearctodesmus insulanus Chamberlin[8]		5				5									
Oxidus gracilis C. L. Koch†		7				7				7	7		7		7
Bracydesmus superus Latzel		7				7				7	7		7		7
Polydesmus angustus Latzel		7				7							7		
Po. denticulatus C. L. Koch		7													7
Po. inconstans Latzel		7				7	7			7	7		7		7
Pseudopolydesmus canadensis Newport[9]		5								5	?				
Ps. serratus Say†		5								5	5				
Scytonotus bergrothi Chamberlin		5				5									
S. columbianus Chamberlin		5				5									
S. granulatus Say		5								5	5				
S. insulanus Attems		5				5									
S. sp.[10]		5					5								
Apheloria virginiensis corrugata Wood		5								5	5				
Harpaphe haydeniana haydeniana Wood		5				5									
Pleuroloma flavipes Rafinesque		5								5					
Sigmoria (Rudiloria) trimaculata trimaculata Wood[11]		5								5	5				

[6] Also known by the synonym *Zygotyla phana* Chamberlin.

[7] Females of an unknown species have been collected in Ontario. Shelley (2002) believed they were unlikely to belong to *C. blakei* or *C. fischeri* (which occur in the U. S.) but considered it a new *Conotyla* species for Canada. Confirmation with male specimens is needed.

[8] Also known by the synonym *N. amissus* Chamberlin.

[9] Also known by the synonym *P. branneri* Bollman.

[10] Shelley (2007) proposed that an undescribed species, based on female specimens, was found in Jasper National Park, Alberta, and was unlikely to be *S. columbianus*. Confirmation with male specimens is needed.

[11] Hoffman (1999) and Shelley (2002) disagree on whether the organism belongs to the genus *Sigmoria* or *Rudiloria*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Tubaphe levii Causey[12]		2				2									
Taiyutyla shawi Shear		2				2									
T. lupus Shear		2				2									
Bollmanella sp.[13]		5				5									

References

Adamski, Z., J. Błoszyk, K. Piosik and K. Tomczak. 2009. Effects of diflubensuron and mancozeb on soil microarthropods: a long-term study. *Bio. Lett.* 46(1): 3-13.

Behan-Pelletier, V. M. 1993. Diversity of soil arthropods in Canada: systematic and ecological problems. *Mem. Ent. Soc. Can.* 165: 11-50.

Brunke, A. J., C. A. Bahlai, M. K. Sears and R. H. Hallett. 2009. Generalist predators (Coleoptera: Carabidae, Staphylinidae) associated with millipede populations in sweet potato and carrot fields and implications for millipede management. *Env. Ent.*. 38(4): 1106-1116.

Cárcamo, H. A., T. A. Abe, C. E. Prescott, F. B. Holl, and C. P. Chanway. 2000. Influence of millipedes on litter decomposition, N mineralization, and microbial communities in a coastal forest in British Columbia, Canada*. Can. J. For. Res.* 30: 817-826.

Davis, D. S., and B. Wright. 2002. Further studies of the leaf litter fauna in Kejimkujik National Park, Biodiversity Monitoring Plots 1 & 2. Final Report, April 2002.

Grelle, C., M. C. Fabre, A. Leprete and M. Descamps. 2000. Myriapod and isopod communities in soils contaminated by heavy metals in northern France. *Eur. J. Soil Sci.* 51(3): 425-433.

Hoffman, R. L. 1979. Diplopoda. *Mem. Ent. Soc. Canada* 108: 294-296.

IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1 http//:www.iucnredlist.org. Downloaded on April 16, 2010.

Kevan, D. K. McE. 1983. A preliminary survey of known and potentially Canadian millipedes (Diplopoda). *Can. J. Zool*. 61: 2956-2975.

Kevan, D. K. McE., and G. G. E. Scudder. 1989. Illustrated keys to the families of terrestrial arthropods of Canada. I Myriapods (Millipedes, Centipedes, etc.). Biological Survey of Canada Taxomonic Series No. 1.

[12] Also known by the junior synonym *Metaxycheir pacifica*.

[13] Shelley et al. 2009 did not identify these specimens to species.

McAllister, C. T., R. M. Shelley, and S. E. Trauth. 2009. *Aniulus garius* (Chamberlin, 1912), a widespread millipede in Central and Eastern North America (Julida: Parajulidae: Aniulini). Pp. 223-231 *in* S. M. Roble and J. C. Mitchell (eds.) A Lifetime of Contributions to Myriapodology and the Natural History of Virginia: A Festschrift in Honor of Richard L. Hoffman's 80th Birthday. Virginia Museum of Natural History Special Publication No. 16, Martinsville, VA.

Shear, W. A. 2004. Two new species in the millipede genus *Taiyutla* from British Columbia, Canada, and Washington, USA (Diplopoda, Chordeumatida, Conotylidae). *Myriapodologica* 8(2): 13-20.

Shelley, R. M. 1988. The millipeds of eastern Canada (Arthropoda: Diplopoda). *Can. J. Zool*. 66: 1638-1663.

Shelley, R. M. 1990. A new millipede of the genus *Metaxycheir* from the Pacific coast of Canada (Polydesmida: Xystodesmidae), with remarks on the tribe Chonaphini and the western Canadian and Alaskan diplopod fauna. *Can. J. Zool*. 68: 2310-2322.

Shelley, R. M. 1993. The millipede genus *Underwoodia* (Chordeumatida: Caseyidae). *Can. J. Zool*. 71: 168-176.

Shelley, R. M. 1994. The Chonaphini, a biogeographically significant Milliped tribe in Eastern and Western North America (Polydesmida: Xystodesmidae). *Brimleyana* 20: 111-200.

Shelley, R. M. 1996. The millipede family Hirudisomatidae in the New World (Polyzoniida) *Brimleyana* 23: 103-143.

Shelley, R. M. 1999. Centipedes and millipedes with emphasis on North American fauna. *The Kansas School Naturalist* 45(3): 1-15.

Shelley, R. M. 2002a. The millipeds of central Canada (Arthropoda: Diplopoda), with reviews of the Canadian fauna and diplopod faunistic studies. *Can. J. Zool*. 80: 1863-1875.

Shelley, R. M. 2002b. The millipede genus *Oriulus* Chamberlin (Julida: Parajulidae). *Can. J. Zool*. 80: 100-109.

Shelley, R. M. 2007. Occurrence of the millipede genus *Scytonotus* C. L. Koch, 1847 (Polydesmida: Polydesmidae) in Alberta Canada. *Ent. News* 118 (3): 319-320.

Shelley, R. M., W. A. Shear, W. P. Leonard and K. Ovaska. 2007. Diplopoda, Chordeumatida, Caseyidae, *Opiona columbiana* Chamberlin, 1951: Distribution extensions into the Alexander Archipelago, Alaska, USA, Queen Charlotte Islands, British Columbia, Canada, and eastern & southern Washington State, USA; additional new records from British Columbia and Washington. *Check List* 3(1): 14-17.

Shelley, R., M. Medrano, W. Shear, K. Ovaska, K. J. White, E. Havard. 2009. Distribution extensions of the millipede families Conotylidae and Rhiscosomididae (Diplopoda: Chordeumatida) into northern coastal British Columbia and Southern Alaska. *Insecta Mundi* 0071: 1-6.

Sierwald, P. and J. E. Bond. 2007. Current status of the myriapod class diplopoda (millipedes): taxonomic diversity and phylogeny. *Ann. Rev. Ent.* 52: 401-420.

Snyder, B. A., B. Boots, and P. F. Hendrix. 2009. Competition between invasive earthworms (*Amynthas cortices,* Megascolecidae) and native North American millipedes (*Pseudopolydesmus erasus*, Polydesmidae): Effects on carbon cycling and soil structure. *Soil Biol.Biochem*. 41: 1442-1449.

Whitney, C. L. and R. M. Shelley. 1995. Occurrence of the millipede *Ergodesmus compactus* Chamberlin in Canada (Polydesmida: Nearctodesmidae*). Insecta Mundi* 9(3-4): 277-278.

7. Ostracoda (Seed or Mussel Shrimps)

Phylum: Arthropoda

Subphylum: Crustacea

Class: Ostracoda

Subclasses: Mydocopa, Podocopa

Orders: Halocyprida, Myodocopida, Platycopida, Podocopida

Families: 46 worldwide, 24 in Canada (1 in Family Myodocopida; 23 in Family Podocopida)

Species: ~13 000 species worldwide, ~163 described in Canada

Background

Ostracods are small crustaceans commonly known as “seed shrimps” or “mussel shrimps” that occur in both freshwater and marine habitats worldwide. They are the oldest known microfauna, with a continuous fossil record stretching back to the Cambrian period in marine sediments, and the early Pennsylvanian period in freshwater swamps and ponds (Delorme 2001). Ostracods preserve well in sediment because most species have calcified carapaces. As a result, ostracod fossil shells (or ‘valves’) are widely used as indicators for reconstructing paleo-environmental and climatic conditions and for evolutionary studies (Delorme 2001; Martens et al. 2008).

Ostracods have a unique body form among crustaceans. The entire body is enclosed within a chitinous and calcified bivalved shell, and body segments and appendages are much reduced (Delorme 2001). Ostracods have a head and thorax but the abdomen is regressed or absent. Four pairs of appendages (including antennae) occur on the head, and two to three pairs on the thorax. Unlike other crustaceans, ostracods use their antennae for locomotion and to aid in feeding (Watling 2003). The shell can be tightly closed with adductor muscles located throughout the body and attached to the inside of each valve. When the shell opens, ostracods extend appendages for movement and feeding (Green 2010). Most species have a single eye capable of detecting light intensity, shape and motion, although cave-dwelling species are blind (Delorme 2001). Many ostracods are microscopic; overall, they range in size from 0.2 mm to 30 mm.

Ostracods occur in almost all aquatic environments throughout the world. These include marine, brackish and freshwater habitats such as oceans, estuaries, temporary and permanent ponds and rivers, lakes, ditches, irrigation canals, groundwater and cave pools. Some species are capable of living in semi-terrestrial habitats, such as moist organic mats in fens, leaf litter, or moss in splash zones of waterfalls (Martens et al. 2008). Individual species may occur in more than one habitat type (e.g., ocean/estuary or temporary/permanent freshwater). All ostracods are free-living, except for members of the Family Entocytheridae, which are parasitic or commensal on freshwater amphipods, crayfishes and isopods (Watling 2003; Martens et al. 2008). The majority of ostracods are benthic or epibenthic, although some species are pelagic (more common in marine forms; Watling 2003). Ostracods can be divided into swimmers and non-swimmers. The former usually swim around aquatic plants and drop to the bottom if disturbed. Some may also move up the water column and along the surface of the water. Non-swimmers typically crawl along the sediment-water interface using their antennae and thoracic legs, although some are infaunal, occuring within the sediment (Delorme 2001).

The distribution and abundance of ostracods is strongly influenced by the physical and chemical characteristics of their environment. For example, most types of freshwater ostracods occur in bicarbonate waters, since they rely on calcium carbonate to form their shells (Delorme 2001). Freshwater ostracods also have specific pH and dissolved oxygen requirements. Delorme (1989) found that Canadian species tended to occur in aquatic habitats with a pH of 7-9.2, while their dissolved oxygen demands ranged on average from 7.3-9.5 mg/L.

Most ostracods feed on organic detritus and algae, although a few species are predatory on snails and other smaller ostracods (Delorme 2001). While some species filter feed, most feed primarily by grazing and scavenging along or within the sediment (Watling 2003). Predators of ostracods include a variety of taxa, such as fish, copepods, midges, caddisflies and oligochaetes (Delorme 2001).

Reproduction in ostracods occurs both sexually and asexually, depending on the species (some species adopt both breeding strategies). Eggs have a thick wall of chitin and calcium carbonate, which allow them to withstand physical and chemical extremes (e.g., freezing, dessication, ingestion by fish and waterfowl). Time of hatching may occur soon after being laid, or may be delayed several months if environmental conditions are not favourable (Delorme 2001). Once the eggs hatch, nauplii go through five to eight molts, with appendages being added with each successive stage (Watling 2003). In temperate regions, most freshwater ostracods begin hatching in the spring. Populations that live in temporary waterbodies have relatively short life cycles (e.g., one month in *Cypridopsis vidua* Müller) (Delorme 2001). Those living in permanent water can produce several generations annually (Delorme 2001). Besides producing resting eggs, ostracods can become torpid to survive harsh conditions, such as the drying up of vernal pools (Delorme 2001).

Ostracods are one of the most common extant arthropod groups, yet research on them is scarce worldwide. This may be due, in part, to the difficulty of identifying ostracods to species and genus (i.e., a full dissection is typically required; Martens et al. 2008). The ostracod fauna of many geographic regions have not been fully explored, and many cryptic species remain unrecognized, and endemic forms undescribed (Martens et al. 2008; Bunbury and Gajewski 2009). European research on ostracods is far more advanced than work in North America. In particular, the systematics of North American ostracods is poorly known. In all areas of the world, a thorough understanding of ostracod ecology is lacking (Delorme 2001).

While ostracods are widely distributed worldwide, in a variety of habitat types, cosmopolitan species, at least in freshwater forms, appear to be rare. Martens et al. (2008) found that 90% of freshwater ostracod species globally were restricted to one zoogeographic region, and only 10% showed intercontinental distributions. In the Nearctic region, approximately 70% of species were endemic (Martens et al. 2008). Habitats free of predation pressures (e.g., groundwater, temporary pools) appear to be hotspots for ostracod diversity and endemicity (Martens et al. 2008).

Ten species of freshwater ostracods are currently listed as at risk by the IUCN: two vulnerable species from Australia; one critically endangered species from Bermuda; four vulnerable species from Slovenia and one vulnerable, one critically endangered and one extinct species from South Africa (IUCN 2010).

Ostracods in Canada

Little information is available on Canadian ostracods. A comprehensive inventory of the nation's marine and freshwater ostracod fauna is lacking, although several studies have focused on particular geographic areas. The most extensive survey of freshwater species was published in a series of papers by Delorme (1969, 1970a-d, 1971) and dealt mainly with occurrences on the Prairies. Similary, Brunel et al. (1998) documented the ostracod fauna (among other invertebrates) of the estuary and Gulf of St. Lawrence. More recently, Bunbury and Gajewski (2009) described the biogeography of freshwater ostracods throughout Nunavut. Most papers published on Canadian ostracods focus on freshwater forms.

The tally of the distribution and status of described ostracod species in Canada presented in Table 7 was compiled from the following sources: (i) the aforementioned studies (Delorme 1969, 1970a-d, 1971; Brunel et al. 1998; Bunbury and Gajewski 2009) and (ii) online catalogues (Green 2007; Appeltans et al. 2010; the Global Biodiversity Information Facility Data Portal [GBIF], accessed 2010). Note that many records of species occurrence were fairly broad in their geographic description, indicating, for example that a species was found "throughout the interior plains" or "in the mixed woods zone" (i.e., in Delorme 1969, 1970a-d, 1971). Where provinces were not identified in Delorme's descriptions I have interpreted 'interior plains" as Alberta, Saskatchewan and Manitoba and "mixed woods zone" as Ontario and Quebec. Likewise, Brunel et al.'s (1998) survey of marine fauna in the estuary and Gulf of St. Lawrence does not indicate in what province observations were made. In this case, I have considered that all records occur in each of the five provinces that border the St. Lawrence ecosystem (i.e., Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador). Consequently, my interpretations of geographic areas may have underestimated or overestimated the distribution of some species in Canada.

A total of 163 species of ostracod, representing 24 families, are documented in Canada (Table 7). None of the Canadian species are listed as at risk nor are any considered invasive alien species. Some have only been described in fossil sediment, and therefore may no longer be extant here (e.g., *Candona bretzi* Staplin, *Ilyocypris dentifera* Sars). Delorme (1970b) identified *Cypridopsis vidua* Müller as the most common ostracod in Canada. Several of the freshwater species described by Delorme (1970a,b) are listed as rare or sporadic in Canada (e.g., *Cypria curvifurcata* Klie, *Dolerocypris fasciata* Müller, *Eucypris virens* Jurine), while others are known to have widespread North American (e.g., *Candona decora* Furtos, *Thermastrocythere harti* Hobbs) or worldwide (e.g., *Fabaeformiscandona acuminata* Fischer, *Pseudocandona albicans* Brady) distributions (Delorme 1970c,d). However, some of the apparently cosmopolitan species (e.g., *Pseucocandona compressa* Koch) may actually represent several cryptic species (Delorme 1970c). Some species were described from single localities, such as *Heterocypris salina* Brady (only in Lake Winnipegosis) and *Isocypris quadrisetosa* Rome (in Alberta, although it has since been recorded in British Columbia as well; Green 2007). A number of species were described as occurring only in ephemeral waterbodies, such as vernal pools, temporary ponds and intermittent streams (Delorme 1969, 1970a-d, 1971). Since these habitats are increasingly under threat from development and climate change, the status of ostracods restricted to such habitats has been listed as 'may be at risk' in Table 7 (although see discussion below on protection provided by resting stages).

In arctic areas, Bunbury and Gajewski (2009) found that ostracod taxa were neither abundant nor diverse. The most common freshwater taxa were *Candona rectangulata* Alm, *Cytherissa lacustris* Sars and *Limnocythere liporeticulata* Delorme. *Limnocythere liporeticulata* is endemic to the Canadian arctic (Bunbury and Gajewski 2009).

Ostracods face a variety of potential threats both in Canada and globally. Habitat loss and degradation is of particular concern for species reliant on ephemeral waterbodies, such as seasonal wetlands and vernal pools. Increasingly these hotspots for crustacean biodiversity are vanishing or deteriorating due to urbanization, agricultural activity and climate change (Williams 2002). However, the ability of ostracod eggs and adults to dessicate and rehydrate in response to environmental conditions may shield them from such threats. For example, resting stages may be blown by the wind to permanent waterbodies when ephemeral sites dry up (Bunbury pers. comm. April 28 2011). Ostracods decrease in abundance in agricultural habitats subject to herbicides and pesticides (Takamura and Yasuno 1986). Atmospheric pollution and eutrophication may also upset the chemical requirements of ostracods in freshwater environments. However a recent study demonstrated that ostracods actually increased in abundance in a creek experiencing nutrient enrichment, likely because they benefited from increases in an algal food source (Fleeger et al. 2008). Nevertheless, excess eutrophication can lead to anoxic conditions: in Lake Erie, Delorme (1978) found that repeated periods of anoxia every year resulted in the extirpation of two ostracod species, *Candona subtriangulata* Benson and MacDonald, and *Cytherissa lacustris*.

Ostracods can be secondary hosts to parasites, which may negatively affect ostracod fecundity. For example, *Herpetocypris reptans* Baird is commonly infected with a helminth that causes reduced egg production in females (Dezfuli 1996).

Invasive alien species may have varying effects on native ostracods in Canada. Ostracod density and biomass in Lake Erie increased following the invasion of zebra mussels (*Dreissena bugensis*), potentially due to the new food source provided by mussel faeces and pseudofaeces (Dermott and Kerec 1997). Yet, the invasive benthic fish, the round goby (*Negobius melansotomus*), is a major predator of ostracods in the Great Lakes (Walsh et al. 2007). The ongoing decline of native crayfish in North America caused by invading rusty crayfish (*Orconectes rusticus*) may have indirect negative effects on ostracod symbionts and parasites in the only member of the family Entocytheridae known from Canada: *Thermastrocythere harti* Hobbs and Walton (Watling 2003).

Calcium decline in boreal lakes is emerging as a conservation issue for many freshwater crustacea dependent on the mineral for carapace development (Jeziorski et al. 2008). No research has yet looked at the effects of this phenomenon on Canadian ostracods, but it is likely a major future threat for populations here.

Table 7. Distribution and status of Canadian ostracoda. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental; ? = status needs further clarification.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Family Philomedidae															
Philomedes Brenda Baird		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Darwinulidae															
Darwinula stevensoni Brady and Robertson[14]		5	-	-	-	5	-	-	5	-	-	-	-	-	-
Family Pontocyprididae															
Argilloecia sp.[15]		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Candonidae															
Candocyprinotus ovatus Delorme		2	-	-	-	2	-	-	2	2	2	-	-	-	-
Candona acuta Hoff		5	-	-	-	-	5	5	5	-	-	-	-	-	-
C. acutula Delorme		5	-	-	-	-	5	-	5	-	-	-	-	-	-
C. bretzi Staplin		?[16]	?	-	-	-	-	-	-	-	-	-	-	-	-
C. candida Müller[17]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
C. crogmaniana Turner		5	-	-	-	-	-	-	-	5	-	-	-	-	-
C. decora Furtos		5	-	-	-	5	-	-	-	5	5	-	-	-	-
C. distincta Furtos		2	-	-	-	2	-	-	2	2	2	-	-	-	-
C. elliptica Furtos		5	-	-	-	-	-	-	5	5	-	-	-	-	-

[14] Synonyms are *Polycheles improvisa* and *Polycheles stevensoni*.

[15] Brunel et al. (1998) did not identify to species.

[16] Delorme (1970c) indicated that the speices was found in Pleistocene sediments in the Yukon.

[17] Synonyms are *Monoculus candidus*, *Eucandona candida*, *Cypris lucens*, *Cypris candida*, *Cypris pellucida*, and *Cypris lucida*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
C. facetus Delorme		2	-	-	-	-	-	-	2	2	-	-	-	-	-
C. ikpikpukensis Swain[18]		?[19]	?	-	-	-	-	-	-	-	-	-	-	-	-
C. inopinata Furtos[20]		5	-	-	-	-	-	-	-	5	-	-	-	-	-
C. ohioensis Furtos		5	-	-	-	-	-	-	5	5	5	-	-	-	-
C. paraohioensis Staplin		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. patzcuaro Tressler[21]		5	-	-	-	-	5	-	-	-	-	-	-	-	-
C. protzi Hartwig		?[22]	?	-	-	-	-	-	-	-	-	-	-	-	-
C. punctata Furtos		5	-	-	-	-	-	-	5	-	-	-	-	-	-
C. rawsoni Tressler		5	-	5	-	5	5	5	5	-	-	-	-	-	-
C. rectangulata Alm		5	5	5	5	-	-	-	5	-	-	-	-	-	-
C. renoensis Gutentag and Benson		2	-	-	-	2	2	2	2	-	-	-	-	-	-
C. sigmoides Sharpe		2	-	-	-	-	-	-	-	2	-	-	-	-	-
C. subacuminata Delorme		5	-	-	-	5	5	5	5	5	5	-	-	-	-
C. subtriangulata Benson and Macdonald[23]		5	-	-	-	-	-	-	-	5	-	-	-	-	-
C. suburbana Hoff		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Fabaeformiscandona acuminata Fischer[24]		5	-	-	-	-	5	-	-	-	-	-	-	-	-
F. caudata Kaufmann[25]		5	-	-	-	5	5	5	5	5	-	-	-	-	-
F. rawsoni Tressler		5	-	-	-	-	5	-	-	-	-	-	-	-	-
Paracandona euplectella Brady and Norman		?[26]	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudocandona albicans Brady[27]		2	-	-	-	2	2	2	2	-	-	-	-	-	-
P. compressa Koch[28]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
P. hartwigi Müller[29]		2	-	-	-	-	-	-	-	2	2	-	-	-	-
P. rostrata Brady and Norman[30]		2	-	-	-	-	-	-	-	2	2	-	-	-	-
P. sarsi Hartwig[31]		5	-	-	-	-	-	-	5	-	-	-	-	-	-
P. stagnalis Sars[32]		2	-	-	-	-	2	-	-	-	-	-	-	-	-
Family Cyprididae															

[18] Synonym is *Pseudocandona ikpikpukensis*.

[19] Delorme (1970c) indicated that a Pleistocene fossil record was found in the Yukon.

[20] Synonym is *Candona indigena*.

[21] Synonyms are *Candona verretensis*, *Candona sappaensis*, *Candona hipolitensis*, *Candona marchica*, and *Candona obtusa*.

[22] Delorme (1970c) indicated that a Pleistocene fossil record was found in the Yukon.

[23] Synonym is *Candona houghi*.

[24] Synonyms are *Cypris acuminata* and *Candona acuminata*.

[25] Synonyms are *Candona caudata* and *Candona novacaudata*.

[26] Delorme (1970c) indicated that the species was found only rarely in the southern fringes of the boreal forest.

[27] Synonyms are *Candona albicans* and *Candona parallela*.

[28] Synonyms are *Cypris compressa*, *Candona leightoni*, *Candona fossulensis*, *Candona compressa*, *Candona fallax*, *Cypris setigera*, *Candona fossulensis*.

[29] Synonym is *Candona hartwigi*.

[30] Synonyms are *Candona rostrata*, *Eucandona marchica*, *Candona limbata*.

[31] Synonyms are *Candona dentata* and *Candona sarsi*

[32] Synonyms are *Candona rara*, *Candona stagnalis*, *Candona zenckeri*, *Candona quadrata*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Bradleystrandesia reticulata Zaddach[33]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Chlamydotheca arcuata Sars		?[34]	-	-	-	-	?	-	-	-	-	-	-	-	-
Cyclocypris ampla Furtos		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Cy. globosa Sars[35]		5	5	5	-	-	-	-	-	-	-	-	-	-	-
Cy. kincaidia Dobbin		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Cy. laevis Müller		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Cy. ovum Jurine[36]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Cy. serena Koch[37]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Cy. sharpei Furtos		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Cypria curvifurcata Klie[38]		5	-	-	-	-	?	?	?	-	-	-	-	-	-
Cp. obesa Sharpe		5	-	-	-	-	-	5	5	-	-	-	-	-	-
Cp. ophtalmica Jurine[39]		5	-	-	-	5	5	5	5	5	5	5	-	-	-
Cp. palustera Furtos		5	-	-	-	-	-	5	5	-	-	-	-	-	-
Cypricercus deltoidea Delorme		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Cc. fuscatus Jurine		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Cc. horridus Sars		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Cc.tuberculatus Sharpe		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Cypridopsis canadensis Ferguson		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Cd. okeechobei Furtos		5	-	-	-	-	5	-	-	5	-	-	-	-	-
Cd. vidua Müller[40]		5	-	-	-	5	5	5	5	5	-	-	5	-	-
Cyprinotus carolinensis Ferguson		5	-	-	-	-	5	5	-	-	-	-	-	-	-
Ct. glaucus Furtos		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Cypris pubera Müller		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Dolerocypris fasciata Müller		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Eucypris crassa Müller[41]		2	-	-	-	-	2	2	2	-	-	-	-	-	-
E. foveata Delorme		5	?[42]	-	-	-	-	-	5	-	-	-	-	-	-
E. serrata Müller		5	-	-	-	-	5	5	5	-	-	-	-	-	-
E. virens Jurine[43]		5	-	-	-	5	5	-	-	-	-	-	-	-	-
Heterocypris incongruens Ramdohr[44]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
H. salina Brady[45]		5	-	-	-	-	-	-	5	-	-	-	-	-	-

[33] Synonyms are *Cypricercus reticulatus* and *Cypris reticulata.*

[34] Delorme (1970a) found a fossil specimen in Alberta.

[35] Synonym is *Cypris globosa*.

[36] Synonym is *Monoclus ovum*.

[37] Synonym is *Cypris serena*.

[38] Delorme (1970b) indicated the species was very rare in Canada, with only sporadic occurrences in the southern part of the interior plains.

[39] Synonyms are *Cypria ophthalmica* and *Monoculus ophtalmica*.

[40] Synonym is *Cypris vidua*.

[41] Synonyms are *Cypris crassa*, and *Eucypris dromedarius*.

[42] Delorme (1970a) found a fossil specimen in the Yukon.

[43] Synonym is *Monoculus virens*.

[44] Synonyms are *Cyprinotus incongruens* and *Cypris incongruens*.

[45] Synonyms are *Cyprinotus salinus*, *Cypris salina*, and *Heterocypris fretensis*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Herpetocypris reptans Baird[46]		5	-	-	-	5	-	-	5	-	-	-	-	-	-
Isocypris quadrisetosa Rome		5	-	-	-	5	5	-	-	-	-	-	-	-	-
Megalocypris alba Dobbin[47]		2	-	-	-	-	?	?	-	-	-	-	-	-	-
M. barbata Forbes		5	-	-	-	-	5	5	-	-	-	-	-	-	-
M. ingens Delorme		5	-	-	-	-	-	5	-	-	-	-	-	-	-
M. macra Blake		5	-	-	-	-	5	5	-	-	-	-	-	-	-
M. pseudoingens Delorme		?	-	-	-	-	-	-	-	-	-	-	-	-	-
M. gnathostoma Ferguson		?	-	-	-	-	-	-	-	-	-	-	-	-	-
Physocypria pustulosa Sharpe		5	-	-	-	5	-	5	5	-	-	-	-	-	-
Potamocypris granulosa Daday		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Po. pallida Alm		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Po.smaragdina Vávra		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Po. unicaudata Schäfer		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Prionocypris canadensis Sars		5	-	-	-	5	5	-	-	-	-	-	-	-	-
Pr. glacialis Sars		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Sarsicypridopsis aculeata Lilljeborg[48]		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Scottia pseudobrowniana Kempf		5	-	-	-	-	5	-	-	-	-	-	-	-	-
Tonnacypris glacialis Sars		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Family Ilyocyprididae															
Ilyocypris biplicata Koch[49]		5	5	-	-	-	5	5	5	-	-	-	-	-	-
I. bradyi Sars[50]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
I. dentifera Sars		?[51]	-	-	-	-	-	-	?	-	-	-	-	-	-
I. gibba Ramdohr[52]		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Pelocypris alatabulbosa Delorme		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Family Notodromadidae															
Notodromas monacha Müller[53]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Cyprois marginata Straus[54]		2	-	-	-	2	2	2	2	-	-	-	-	-	-
Family Bythocytheridae															
Bythocythere bilobata Hulings		5	-	-	-	-	-	-	-	-	5	5	5	5	5
B. turgida Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5

[46] Synonyms are *Cypris reptans* and *Cypris repetans*.
[47] Delorme (1969) indicated that the species occurred in the central prairies.
[48] Synonyms are *Cypridopsis aculeata* and *Cypris aculeata.*
[49] Synonyms are *Jeiocypris biplicata* and *Cypris biplicata*.
[50] Synonyms are *Ilyocypris repens*, *Ilyocypris gibba subsp. repens*.
[51] Delorme (1970d) indicated that a Pleistocene fossil record was found in Manitoba.
[52] Synonyms are *Jliocypris gibba* and *Cypris gibba*.
[53] Synonyms are *Cypris monacha*, *Notodromus monacha*, and *Cypris nubilosa*
[54] Synonyms are *Cypris flava* and *Cypris marginata*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Jonesia acuminata Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Sclerochilus contortus Norman[55]		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Cushmanideidae															
Pontocythere elongata Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Cytherideidae															
Cythere lutea Müller		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Cytherissa lacustris Sars[56]		5	-	5	-	5	-	-	5	5	-	-	-	-	-
Heterocyprideis sorbyana Jones		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Sarsicytheridea punctillata Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Sa. punctillata expunctillata Hulings		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Cytheruridae															
Cytheropteron angulatum Brady and Robertson		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Cn. arcuatum Brady, Crosskey and Robertson		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Cn. hamatum Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Cn. nodosum Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Cytherura rudis Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Hemicytherura cellulosa Norman		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Semicytherura mainensis Hazel and Valentine		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Sm. nigrescens Baird		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Sm. similis Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Entocytheridae															
Thermastrocythere harti Hobbs and Walton		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Family Eucytheridae															
Eucythere argus Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Eucytheridea papillosa Bosquet		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Ed. punctillata Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Halocyprididae															
Conchoecia borealis Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Discoconchoecia elegans Sars[57]		5	-	-	5	-	-	-	-	-	5	5	5	5	5
Obtusoecia obtusata Sars[58]		5	-	-	5	-	-	-	-	-	5	5	5	5	5
Family Hemicytheridae															
Baffinicythere emarginata Sars[59]		5	-	-	-	-	-	-	-	-	5	5	5	5	5

[55] Synonym is *Cythere contorta*.
[56] Synonyms are *Cytheridea lacustris*, *Cythere lacustris*, *Acanthopus resistans*.
[57] Synonym is *Conchoecia elegans*.
[58] Synonym is *Conchoecia obtuse*.
[59] Synonym is *Cythereis emarginata*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Ba. howei Hazel		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Elofsonella concinna Jones		5	-	-	-	-	-	-	-	-	5	5	5	5	5
El. granulata Hulings		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Hemicythere villosa Sars[60]		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Muellerina abyssicola Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Mu. canadensis Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Normanicythere leioderma Norman		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Krithidae															
Krithe praetexta Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Leptocytheridae															
Callistocythere badia Norman		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Leptocythere pellucida Baird		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Limnocytheridae															
Limnocythere camera Delorme[61]		5	?	-	5	-	-	?	-	-	-	-	-	-	-
Li. ceriotuberosa Delorme		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Li. friabilis Benson and MacDonald[62]		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Li. herricki Staplin		2	-	-	-	-	2	2	2	-	-	-	-	-	-
Li. illinoisensis Sharpe		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Li. inopinata Baird[63]		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Li. iowensis Danforth		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Li.itasca Cole		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Li. liporeticulata Delorme		2	2	2	-	-	-	-	-	-	-	-	-	-	-
Li. paraornata Delorme		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Li. parascutariensis Delorme[64]		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Li. platyforma Delorme		5	-	-	-	-	5	-	-	-	-	-	-	-	-
Li. posterolimba Delorme		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Li. pseudoreticulata		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Li. reticulata Sharpe		5	-	-	-	-	-	-	5	-	-	-	-	5	-
Li. sanctipatricii Brady and Robertson		2	-	-	-	-	-	-	2	-	-	-	-	-	-
Li. sappaensis Staplin		5	-	-	5	5	5	5	-	-	-	-	-	-	-
Li. sharpei Staplin		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Li. staplini Gutentag		5	-	-	-	5	5	5	5	-	-	-	-	-	-
Li. varia Staplin		5	-	-	-	-	5	5	5	-	-	-	-	-	-
Li. verrucosa Hoff		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Family Loxoconchidae															

[60] Synonym is *Cythere villosa*.
[61] Delorme (1971) indicated that fossil records existed in the Yukon and Saskatchewan.
[62] Synonym is *Limnocythere chippewaensis*.
[63] Synonym is *Cythere inopinata*.
[64] Synonym is *Limnocythere parascutariense*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Cytheromorpha fuscata Brady		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Loxoconcha impressa Baird		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Neocytherideidae															
Neocytherideis foveolata Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Paradoxostomatidae															
Paracytherois arcuata Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Redekea sp.[65]		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Schizocytheridae															
Palmenella limicola Norman		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Trachyleberidae															
Actinocythereis dawsoni Brady		5	-	-	-	-	-	-	-	-	5	5	5	5	5
A. dunelmensis Norman		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Carinocythereis whitei Baird		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Pterygocythereis jonesi Baird		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Robertsonites tuberculatus Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Family Xestoleberididae															
Aspidoconcha limnoriae DeVos		5	-	-	-	-	-	-	-	-	5	5	5	5	5
Xestolebris depressa Sars		5	-	-	-	-	-	-	-	-	5	5	5	5	5

References

Appeltans W., P. Bouchet, G. A. Boxshall, K. Fauchald, D. P. Gordon, B. W. Hoeksema, G. C. B. Poore, R. W. M. van Soest, S. Stöhr, T. C. Walter, M. J. Costello, (eds.) 2010. The World Register of Marine Species. Worldwide web publication http://www.marinespecies.org. [Accessed on September 28 and 29, 2010].

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the marine invertebrates of the Estuary and Gulf of Saint Lawrence. Can. Special Publ. Fish. Aquat. Sci. No. 126, p. i-xi, 1-405. National Research Council Research Press, National Research Council of Canada, Ottawa.

Bunbury, J. and K. Gajewski. 2009. Biogeography of freshwater ostracodes in the Canadian arctic archipelago. Arctic 62(3): 324-332.

Delorme, L. D. 1969. On the identity of the ostracode genera *Cypriconcha* and *Megalocypris*. Can. J. Zool. 47: 271-281.

Delorme, L. D. 1970a. Freshwater ostracodes of Canada. Part I. Subfamily Cypridinae. Can. J. Zool. 48: 153-168.

[65] Brunel et al. (1998) did not identify to species.

Delorme, L. D. 1970b. Freshwater ostracodes of Canada. Part II. Subfamilies Cyrpidospinae and Herpetocypridinae, and family Cyclocyprididae. Can. J. Zool. 48: 253-266.

Delorme, L. D.1970c. Freshwater ostracodes of Canada. Part III. Family Candonidae. Can. J. Zool. 48: 1099-1127.

Delorme, L. D. 1970d. Freshwater ostracodes of Canada. Part IV. Families Ilyocyprididae, Notodromadidae, Darwinulidae, Cytherideidae, and Entocytheridae. Can. J. Zool. 48: 1251-1259.

Delorme, L. D. 1971. Freshwater ostracodes of Canada. Part V. Families Limnocytheridae, Loxoconchidae. Can. J. Zool. 49: 43-64. Can. J. Zool. 49: 43-64.

Delorme, L. D. 1978. Distribution of freshwater ostracodes in Lake Erie. J. Great Lakes Research 4(2): 216-220.

Delorme, L. D. 1989. Methods in Quaternary ecology. No. 7: Freshwater Ostracoda. Geosciences Canada 16: 85-90.

Delorme, L. D. 2001. Ostracoda. Pp. 811-848. *In* Ecology and Classification of North American Freshwater Invertebrates, second edition,. J. H. Thorp and A. P. Covich (eds.). Academic Press, New York, NY.

Dermott. R. and D. Kerec. 1997. Changes to the deepwater benthos of eastern Lake Erie since the invasion of *Dreissena*: 1979-1993. Can. J. Fish. Aquat. Sci. 54: 922-930.

Dezfuli, B. S. 1996. *Cypria reptans* (Crustacea: Ostracoda) as an intermediate host of *Neoechinorhynchus rutili* (Acanthocephla: Eoacanthocephala) in Italy. Journal of Parasitology 82(3): 503-505.

Fleeger, J. W., D. S. Johnson, K. A. Galván and L. A. Deegan. 2008. Top-down and bottom-up control of infauna varies across the saltmarsh landscape. J. Expt. Mar. Biol. Ecol. 357: 20-34.

GBIF 2010. Data portal of the Global Biodiversity Information Facility. Biodiversity occurrence data provided by the Ocean Biogeographic Information System (OBIS Canada), the National Museum of Natural History, and the University of Alberta. World wide web electronic publication http://data.gbif.org. [Accessed on September 25, 2010].

Green, G. 2007. Freshwater Ostracods of British Columbia. Royal British Columbia Museum. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia [www.efauna/bc/ca]. Lab for Advanced Spatial Analysis, Dept. of Geography, University of British Columbia, Vancouver. [Accessed on July 29, 2010].

Green, G. 2010. Ostracods of British Columbia *In* Klinkenberg, B. (editor). E-Fauna BC: Electronic Atlas of the Fauna of British Columbia [www.efauna/bc/ca]. Lab for Advanced Spatial Analysis, Dept. of Geography, University of British Columbia, Vancouver. [Accessed on July 29, 2010].

IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1 http://www.iucnredlist.org. [Accessed on July 28, 2010].

Jeziorski, A., N. D. Yan, A. M. Paterson, A. M. DeSellas, M. A. Turner, D. S. Jeffries, B. Keller, R. C. Weeber, D. K. McNicol, M. E. Palmer, K. McIver, K. Arseneau, B. K. Ginn, B. F. Cumming and J. P. Smol. 2008. The widespread threat of calcium decline in fresh waters. Science 322: 1374-1377.

Martens, K., I. Schön, C. Meisch and D. J. Horne. 2008. Global diversity of ostracods (Ostracoda, Crustacea) in freshwater. Hydrobiologia 595: 185-193.

Takamura, K. and M. Yasuno. 1986. Effects of pesticide application on chironomid larvae and ostracods in rice fields. Applied Entomology and Zoology 21(3): 370-376.

Walsh, M. G., D. E. Dittman and R. O'Gorman. 2007. Occurrence and food habits of the round goby in the profundal zone of southwestern Lake Ontario. Journal of Great Lakes Research 33: 83-92.

Watling, L. 2003. Ostracoda (Mussel shrimps). Pp. 311-315 *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI.

Williams, D. D. 2002. Temporary water crustaceans: biodiversity and habitat loss. Modern Approaches to the Study of Crustacea, pp. 223-233. E. Escobar-Briones and F. Alvarez (eds.) Conference Proceedings of the Summer Meeting of the Crustacea Society, Puerto Vallarta, Mexico, June 26-30.

<u>Personal Communication</u>

Dr. Joan Bunbury, Department of Geography, University of Toronto, Toronto, ON. April 28, 2011.

8. Branchiopoda

Phylum: Arthropoda

Class: Branchiopoda

Subclasses: Phyllopoda, Sarsostraca

Orders: Anostraca (brine and fairy shrimps), Notostraca (tadpole shrimps), Diplostraca (water fleas and clam shrimps)

Suborders: Anostracina, Aremiina (brine and fairy shrimps), Cladocera (water fleas), Cyclestherida, Laevicaudata, Spinicaudata (clam shrimps)

Families: 24 worldwide

Background

Branchiopods are and ancient class of crustaceans, with fossils dating back to the Upper Cambrian period (Walossek 1993). The class exhibits exceptional diversity in morphology, body segmentation patterns and limb function (deWaard et al. 2006). Virtually the only common feature among different branchiopod orders is the “gilled feet”, from which the class gets its name (Rincones and Arab 2003a). Approximately 1200 species have been described worldwide, although at least twice as many may actually exist (Adamowicz and Purvis 2005). Branchiopod systematics is far from resolved, and phylogenetic relationships at both higher and lower taxonomic levels within the class continue to be debated (Mills 2003; Brendonck et al. 2008). Until fairly recently, the three clam shrimp suborders, Cyclestherida, Laevicaudata, and Spinicaudata, were grouped together in the single order Conchostraca (Rincones and Arab 2003a; deWaard et al. 2006).

Branchiopods are exclusively aquatic organisms. They are characterized by having gills on many of their appendages, and typically have compound eyes, and a carapace. The Anostraca are medium sized branchiopods, usually from 1 to 3 cm long (although some reach up to 10 cm). They have elongated bodies and lack a carapace. Anostraca usually have 11 pairs of limbs, but may have 10, 17 or 19 pairs (Dumont 2003). Notostraca are similarly sized, ranging from 1 to 4 cm long (although some reach up to 11 cm). They are flattened dorso-ventrally and have a carapace which covers most of their body, including the head. Notostraca are considered living fossils, because their basic body plan has remained the same for the last 300 million years (Rincones and Arab 2003b). The clam shrimps are bivalved branchiopods. They are laterally flattened, with a hinged shell that envelopes the entire body and limbs. The trunk is divided into 10-32 segments. Clam shrimps range in size from a few millimeters up to just over 1 cm (Rincones and Arab 2003a). Cladocera are small transparent zooplankton, ranging in length from 0.2 to 3.0 mm. Unlike other crustaceans, they are not obviously segmented, but do have a head, thorax and abdomen. A thin transparent carapace encloses the thorax and abdomen of most cladoceran species. They have large compound eyes and five pairs of appendages on the head: two pairs of antennae (with a sensory function) and three pairs of legs used for locomotion and feeding. The thorax contains four to six leaf-like legs used for sweeping food to the mouth, and in breeding (Mills 2003).

Branchiopods are globally distributed, occurring in both northern and southern hemispheres and in tropical, temperate and polar environments (Brendonck et al. 2008). Most species live in freshwater, although a few Cladocera are marine (Mills 2003). The large branchiopods (i.e., clam, fairy and tadpole shrimps) are typically associated with temporary waterbodies, such as vernal pools, puddles, salt flats, alkali pans, and seasonal wetlands, that periodically dry up for several months or even years, at a time (Brendonck et al. 2008). Cladocerans occur in a variety of freshwater ecosystems, including lakes, ponds, streams, rivers, and ground water, from sea level up to alpine elevations (Mills 2003).

Branchiopods are mainly filter-feeders that eat plankton and detritus. Clam shrimp also scrape and tear off food from substrates. Some species of fairy shrimp, tadpole shrimp and water fleas are predatory as well, actively pursuing other crustacean zooplankton, insect larvae and even amphibian tadpoles (Dumont 2003; Mills 2003; Rincones and Arab 2003a). Tadpole shrimp require roughly 40% of their body mass in food daily due to their rapid development and have a varied diet, which includes bacteria, algae, protozoa, plant roots and shoots and animal prey (Rincones and Arab 2003b).

Branchiopods inhabit littoral, limnetic and benthic microhabitats. Anostraca typically occur in the water column, where they swim upside down (Dumont 2003). Notostraca and clam shrimps are usually found in the benthos, although the latter sometimes swims through the water column upside down, with jerky spiral movements (Rincones and Arab 2003a, b). Cladocera are both benthic and planktonic.

Branchiopods face many predators, including amphibians, birds, fish, insects and predaceous zooplankton. Consequently, members of the group have evolved many strategies to minimize the risk of becoming prey. The adaptation of many large branchiopods to inhabit ephemeral waterbodies allows them to escape fish predation altogether. Some Anostraca and Cladocera exhibit diel vertical migration, rising to the water surface only at night to minimize risk of predation (Dumont 2003; Mills 2003). Anostraca also form swarms in the water column, which stir up sediment, potentially providing not only food, but protection from visual predators (Dumont 2003).

Reproduction in branchiopods can be both sexual and asexual, and breeding systems range from dioecy to androdioecy, parthenogenesis and cyclic parthenogenesis (Brandonck et al. 2008). Anostraca reproduce sexually and most species are oviparous, although some members of the genus *Artemia* are viviparous. Notostraca, clam shrimps and Cladocera reproduce sexually and/or parthenogenetically. Many members of these groups employ both strategies, with populations varying reproductive behaviour depending on environmental conditions (Mills 2003; Rincones and Arab 2003b). For example, in Cladocera most reproduction is asexual, and most eggs develop into females. However, if conditions deteriorate due to over-crowding, lack of food or oxygen depletion, males are produced and females switch to sexual reproduction (Green 2010). Many branchiopods produce two types of eggs, ‘summer eggs’, which are thin-shelled and develop rapidly, and ‘winter eggs’, which have thicker shells, are resistant to drought and freezing, and can remain dormant for long periods (Rincones and Arab 2003a). Production of the winter eggs may be stimulated by external factors such as population density, temperature or photoperiod. In Notostraca, however, both egg types may occur in the same brood with some eggs hatching immediately, others after one drought, and still others after two or more droughts (Rincones and Arab 2003b). The resting eggs (also known as cysts) of branchiopods can remain dormant for decades or even over a century, until environmental conditions become favourable (Dumont 2003).

Many branchiopods are of economic and research significance to humans. The cysts of fairy shrimp (*Artemia* spp.) are harvested for fish food in the aquarium industry, and to feed fish larvae in aquaculture operations. In Libya and Thailand, these resting eggs are also eaten by humans (Dumont 2003). The cysts of tadpole shrimps (*Triops* spp.) are sold as aquatic pets under the name “sea monkeys”. In Japan, farmers use *Triops longicaudatus* LeConte as a biological control against weeds in rice paddies, while in other countries (e.g., U. S.) the same species is seen as an agricultural pest (Rincones and Arab 2003b). Cladocera are recognized as a critical component of aquatic food webs in freshwater ecosystems, enabling such habitats to support a variety of fish species (Mills 2003). Cladocerans are also extensively used in toxicological and paleolimnological studies, as they act as sensitive indicators of environmental conditions. In particular, the short generation times, and widely varying environmental preferences and tolerances of this group make them excellent tools for environmental studies (Strecker et al. 2008).

A number of branchiopod families have cosmopolitan distributions, but individual species’ ranges may be extremely small. For example, the distribution of some Anostraca species appears to be restricted to the type locality (Dumont 2003). Some clam shrimp also have limited ranges. Despite restricted distributions, very few branchiopods are actually recognized as endangered, probably because the group has not been well studied (Rincones and Arab 2003a). Presently 29 species of Anostraca are listed on the IUCN Red List, two of which occur in North America (but not in Canada; IUCN 2010). Five Anostraca species are currently on the U. S. Endangered Species List, all endemic to the west coast of the United States (Dumont 2003). One species of Notostraca, *Lepidurus packardi* (which is found only in California) is listed as endangered on the IUCN Red List, and the U. S. Endangered Species List, (IUCN 2010; McLaughlin et al. 2005).

Large branchiopods are particularly vulnerable to the loss and deterioration of temporary waterbodies worldwide caused mainly by urban and agricultural development (Brendonck et al. 2008). On the other hand, many cladocera species’ populations are stable or expanding, largely due to human activity introducing species into new areas (Mills 2003).

Branchiopods in Canada

The State of Our Knowledge

Despite the ubiquity of branchiopods in freshwater ecosystems, ranging from rain puddles to wetlands, lakes and rivers, very little is known about the distribution and systematics of this crustacean class in Canada. Patalas et al. (1994) attributed our lack of knowledge on Canadian aquatic fauna in general to the immensity of the country, combined with the numerous, often difficult-of-access lakes. Yet it is still surprising that for groups such as the Cladocera, which are well studied in limnological research, we have only an incomplete understanding of taxonomy and distribution (Brandlova et al. 1972; Chengalath 1987; Green 2010). Within Cladocera, the littoral species are even less well documented, with only sporadic species lists and little to no morphological or ecological data available (Chengalath 1982). Knowledge gaps are particularly pronounced in arctic regions of the country (Chelengalath 1987). A further problem is that many branchiopod species assumed to be cosmopolitan may actually represent different species in different biogeographical regions. This is thought to be the case for many Cladoceran species found both in Europe and North America (e.g., *Daphnia middendorffiana* Fischer, *D. similis* Claus, *D. rosea* Sars, *Sida crystallina* Müller; Chengalalth 1982, 1987; Adamowicz and Purvis 2005). Unfortunately the intercontinental phylogeography of other branchiopod taxa (i.e., Anostraca, Notostraca and clam shrimps) is virtually unstudied (Adamowicz and Purvis 2005). Gaining a thorough understanding of branchiopod systematics both globally and in Canada is seriously threatened by "the rapidly diminishing resources of taxonomic expertise" here and abroad (Brunel, pers. comm., 25 August 2010).

Only a handful of systematic surveys of branchiopod fauna have occurred in Canada, all of which have focused on Cladocera. The most wide-ranging study to date, both spatially and temporally, was conducted by Patalas et al. (1994). Over a 30 year period (1961-1991), these researchers sampled 878 lakes for pelagic cladocera across 24 regions of the country, representing most of the nation's geological and climatic zones. Chengalath (1982, 1987) conducted surveys of all provinces and territories for littoral Cladocera (1982) and chydorid Cladocera (1987) between 1978 and 1984. Carter et al. (1980) sampled 696 lakes in glaciated eastern North America, including sites in Ontario, Quebec and the Maritimes for planktonic cladocerans from 1969-1978. More recently, Swadling et al. (2000) examined cladoceran diversity in 30 lakes along a 900 km transect stretching from Whitehorse to Inuvik. Provincial surveys of cladocerans have included Brandlova et al.'s (1972) study of 244 lakes and ponds in Ontario between 1967-1970 and Hann's (1981) littoral sampling of Ontario cladocera in 1972 and 1973.

The tally of total number of described branchiopod species in Canada presented in Table 8 was compiled from a variety of sources: (i) the aforementioned studies (Brandlova et al. 1972; Carter et al. 1980; Hann 1981; Chengalath 1982, 1987; Patalas et al. 1994; Swadling et al 2000), (ii) additional publications (Billington et al. 1989; Donald 1989; Hann 1990; Belk and Brtek 1995; Brunel et al. 1998; Korovchinsky 2002; Bernier and Locke 2006; Green 2007; Lui et al. 2008, McLaughlin et al. 2005, Samchyshyna et al. 2008; Strecker et al. 2008; Rautio et al. 2009), (iii) the Global Biodiversity Information Facility Data Portal (accessed 2010), and (iv) personal communication with P. Brunel, M. Frederick and C. Rogers.

A total of 154 species of branchiopods have been documented from Canada: 20 Anostraca, 3 Notostraca, 1 clam shrimp and 129 Cladocera (including two subspecies of *Daphnia galeata* Sars) (Table 8). Although none of these species have been formerly recognized as species at risk in Canada, several are considered potentially at risk (18 species total: 8 Anostraca, 2 Notostraca and 9 Cladocera), because they are apparently endemic, have limited ranges, and/or are declining due to specific threats (e.g., invasive alien species).

Species at Risk

The Anostraca and Notostraca species identified as potentially at risk are generally uncommon to very rare and may have been extirpated across parts of their range (e.g., *Branchinecta campestris* Lynch, *Eubranchipus vernalis* Verrill). Most of these species need to be evaluated in Canada (Rogers, pers. comm., 25 August 2010). The Cladocera species identified as potentially at risk include three described by Chengalath and Hann (1981a,b): *Alona borealis* Chengalath and Hann, *A. lapidicola* Chengalath and Hann, and *Chydorus canadensis* Chengalath and Hann. These species appear to be endemic to Canada, with the two *Alona* species recorded only in Ontario, Alberta and Saskatchewan (Chengalath 1982), and the *Chydorus* species apparently restricted to its type locality off Beausoleil Island, Georgian Bay, Ontario (Chengalath 1987).

The remaining Cladoceran species identified as potentially at risk are all threatened by the invasive alien species *Bythotrephes longimanus* Leydig, commonly known as the spiny waterflea. Recent studies of this invader in Ontario lakes have revealed significant negative impacts on native zooplankton communities. Cladoceran species, in particular, appear to be extremely vulnerable to spiny waterflea invasion, probably because they are a preferred food item (Boudreau and Yan 2003). Lakes invaded by *Bythotrephes* in Ontario exhibit significantly reduced Cladoceran species richness, diversity and abundance (Strecker et al. 2006). Some small Cladoceran species disappear completely from lakes where *Bythotrephes* is present (i.e., *Bosmina longirostris* Müller, *Chydorus sphaericus* Müller, *Daphnia retrocurva* Forbes, *Diaphanosoma birgei* Korinek, *Eubosmina tubicen* Brehm; Yan et al. 2001; Yan et al. 2002). The mean abundance of other Cladoceran species also declined severely in invaded *vs.* non-invaded lakes (e.g., *Daphnia catawba* Coker is 10 times lower; *Sida crystallina* Müller is 7 times lower; Boudreau and Yan 2003). Yan (pers. comm., 2 October 2010) suggests that almost all native *Daphnia* species in Ontario (except for *Daphnia mendotae* Birge and *D. longiremis* Sars) are potentially at risk due to the predatory effects of *Bythotrephes*.

The native pelagic predator *Leptodora kindtii* Focke also experiences precipitous declines in the presence of *Bythotrephes*. Weisz and Yan (2010) found that a widespread replacement of *Leptodora* by *Bythotrephes* is occurring in lakes in the Muskoka region of Ontario. It is unclear whether competition or predation is responsible for the reduction in *Leptodora* populations. However, if this trend continues, the disappearance of a common native Cladoceran species could have drastic repercussions for inland lake food webs in Canada. In particular, Weisz and Yan (2010) predicted that *Leptodora* will suffer drastic losses if *Bythotrephes* continues its spread across the Canadian Shield.

Introduced Species

Six Cladocera species are listed as introduced in Canada (Table 8), all of which probably arrived in the ballast water of commercial shipping vessels from their native ranges. *Bythotrephes longimanus*, a predatory cladoceran, is native to northern Europe and Asia. It arrived in the Laurentian Great Lakes in the early 1980s and has since spread to many inland lakes in Ontario and the northern U. S. (Barbiero and Tuchman 2004). *Bythotrephes* has had profound effects on zooplankton communities not only from inland lakes (as discussed above), but also within the Great Lakes. For example, several cladoceran species have declined significantly in Lakes Erie and Huron since its invasion, including *Daphnia pulicaria* Forbes, *D. retrocurva*, *Holopedium gibberum* Zaddach, and *Leptodora kindtii* (Barbiero and Tuchman 2004). In general, the total zooplankton biomass of Ontario lakes invaded by *Bythotrephes* is significantly lower than in non-invaded lakes, primarily because of reductions in the abundance of all common epilimnetic Cladoceran species (Boudreau and Yan 2003).

Another introduced predatory cladoceran in Canada is *Cercopagis pengoi* Ostroumov, the fishhook waterflea. A native of the Ponto-Caspian region of Eurasia, this species was first recorded in Lake Ontario in 1998 and has since spread into the St. Lawrence, Lake Erie and the northern U. S. (Lui et al. 2008). *Cercopagis* feeds on small native zooplankton, including cladocerans, and may have led to declines in some species in Lake Ontario (Lui et al. 2008).

The herbivore *Eubosmina coregoni* Baird was introduced to North America from Eurasia in the 1960s, first appearing in the Great Lakes, then gradually colonizing nearby inland lakes. In the 1990s it was recorded in Lake of the Woods, Ontario and Lake Winnipeg (Suchy and Hann 2007). The herbivore *Eubosmina maritima* Müller, another Eurasian cladoceran species, is a more recent arrival to North America, first detected in Lake Michigan in 1988. Since then it has spread to the rest of the Great Lakes. The impact of both of these introduced *Eusbomina* species on the native branchiopod fauna in Canada is as yet unknown (Suchy and Hann 2007; Kipp 2010a).

Daphnia galeata galeata is a palaearctic species, with a native range that covers northern Africa, Europe and Asia north of the Himalayas. It was likely introduced to Lake Erie in the late 1970s or early 1980s and has expanded its range to include Lake Ontario and inland lakes in southern Ontario and upper New York state (Kipp 2010b). The species has hybridized extensively with the native *D. galeata mendotae* and hybrid clones are now commonly found in Lake Erie (Taylor and Hebert 1993). These hybrid forms appear to have higher fitness than the parent clones, particularly under harsh environmental conditions, which may expain why the hybrid population has expanded so rapidly in Lake Erie (Taylor and Hebert 1993).

The final branchiopod listed as introduced in Canada is the marine cladoceran *Penilia avirostris* Dana. This species was first reported in PEI coastal waters in 2000. Although the species is widely distributed along the Atlantic coast of the U. S. from North Carolina to southern Massachusetts, its occurrence in the Maritimes is unlikely to be the result of natural dispersal. The PEI record represents a disjunct population, separated by over 1100 km from its nearest neighbours to the south (Bernier and Locke 2006). *Penilia* probably hitch-hiked in ballast water, in which it can survive for up to a week. Over a one year period, *Penilia* increased in density almost 100 fold in PEI waters, shifting from comprising 0.28% of the total zooplankton in 2000 to 8% of the total zooplankton in 2001 (Bernier and Locke 2006). Its recent establishment in Canadian waters may be linked to climate change, since *Penilia* requires a mean sea surface temperature of at least 21ºC to survive and reproduce (Bernier and Lock 2006). The effect of *Penilia* on native marine zooplankton in Atlantic Canada is not yet known.

Threats

Native branchiopods in Canada face a variety of conservation threats. The reliance of many large branchiopod species on temporary waterbodies makes them acutely vulnerable to habitat loss and deterioration caused by agricultural and urban development, combined with climate change (Williams 2002; Angeler et al. 2008). Branchiopods are well represented in ephemeral freshwater habitats and many rare species may be present. Yet the rich crustacean biodiversity found in temporary pools is increasingly threatened by conversion of wetland habitat, as well as by insecticide spraying, mining and other human activities (Brendonck et al. 2008).

Anthropogenic acidification has caused extensive damage to zooplankton communities in eastern North America (Havens et al. 1993; Gray and Arnott 2009). Despite widespread chemical recovery of lakes from acid rain, evidence of a concurrent biological recovery is scarce (Walseng et al. 2003; Gray and Arnott 2009). Daphnia species appear to be the most sensitive of all crustacean zooplankton to acidity, especially *Daphnia galeata mendotae*, and *D. retrocurva*, which decline sharply in lakes of pH < 6.5 and 5.6 respectively (Havens et al. 1993). Even once lake pH is restored to ph$>$6, the typical lag time for zooplankton recovery can be from 3-10 years (Gray and Arnott 2009). Yan et al. (2003) speculated that this delay could be caused by three types of factors: water quality (e.g., episodes of re-acidification caused by drought, calcium limitation, increased UV light penetration), dispersal limitation (i.e., the ability of colonists to reach acidified lakes) and community-level barriers (e.g., predation by recovering fish populations, introduction of predatory *Bythotrephes longimanus*).

Calcium decline has recently been highlighted as another emerging threat to freshwater zooplankton (Jeziorski et al. 2008). Calcium concentrations are declining in soft-water boreal lakes due to acidification and intensive forest harvesting. Daphnia species, which have high calcium demands, suffer reduced survival and fecundity when levels drop below 1.5 mg/L in lake water. Jeziorski et al. (2008) documented that calcium concentrations in many Canadian shield lakes now approach or fall below this threshold.

Climate change is also expected to have profound effects on branchiopods in Canada, especially in the arctic. Rising temperatures in polar regions over the past few decades has led to melting permafrost, causing many arctic lakes to drain completely and disappear (Samchyshyna et al. 2008). Climate warming is expected to bring more biological invasions to the region from the south. It also may upset existing food webs, through the decoupling of trophic levels (e.g., phytoplankton *vs.* zooplankton) responding differently to climate change signals (Sweetman et al. 2008).

As mentioned previously, the introduction of non-native predatory cladocerans poses a particularly serious threat for native zooplankton in Canada. *Bythotrephes* has caused rapid and long-lasting reductions in the species richness and abundance of crustacean zooplankton, especially cladoceran taxa in Canadian Shield lakes (Yan et al. 2001; Yan et al. 2002). The spiny waterflea is easily dispersed from one lake to another through human activity (e.g., boating, fishing) and tolerates a wide range of environmental conditions. *Bythotrephes* is in the early stages of its invasion, and has the potential to invade many lakes in North America. Its continued spread through the Canadian shield and beyond means that Cladoceran biodiversity across a wide area of eastern Canada may be threatened in the future (Boudreau and Yan 2003; Strecker et al. 2006)..

Finally, the interactive effects of multiple threats are hard to predict, but may have pronounced effects on branchiopod taxa in coming years. For example, climate change is likely to provide numerous opportunities for invasive species not presently in Canada to expand their ranges here. Calcium decline is restricting the recovery of lakes from acid rain. Ozone thinning is expected to accelerate in the arctic as atmospheric carbon dioxide levels rise, potentially exposing aquatic biota to harmful levels of UV radiation (Rautio et al. 2009).

Next Steps

More detailed information on the distribution and status of the Canadian branchiopod fauna is available from Christopher Rogers, a specialist in freshwater crustacea, and a world authority on fairy shrimp, tadpole shrimp and clam shrimp. Mr. Rogers is currently preparing a monograph on the nearctic Anostraca, which will have distributional information for the entire North American continent. He also has occurrence records for the other large Branchiopod orders and suborders (i.e., Notostraca, Laevicaudata, Spinicaudata), including relevant publications (dating back to the early 1800s), museum specimen data and data from many private collections.

Table 8. Distribution and status of Canadian branchiopoda. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental; ? = status needs further clarification.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Anostraca															
Artemia franciscana Kellogg[66]	San Francisco brine shrimp	5?	?	?	?	?	?	?	?	?	?	?	?	?	?
A. salina Linnaeus		5	-	-	-	5	5	5	-	-	-	-	-	-	-
Artemiopsis stefanssoni Johansen[67]	Nearctic artemiopsis	5	-	5	5	-	-	-	-	-	-	-	-	-	-
Branchinecta campestris Lynch	Pocket-pouch fairy shrimp	2	-	-	-	2	2	2	-	-	-	-	-	-	-
B. coloradensis Packard[68]	Colorado fairy shrimp	5	-	-	-	-	5	-	-	-	-	-	-	-	-

[66] Belk and Brtek (1995) simply listed the species as in Canada.
[67] Synonym is *Aremiopsis stephanssoni*.
[68] Synonym is *Branchinecta shantzi*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
B. gigas Lynch	Giant fairy shrimp	2	-	-	-	-	2	2	-	-	-	-	-	-	-
B. lateralis Rogers		2	-	-	-	-	2	2	-	-	-	-	-	-	-
B. lindahli Packard	Versatile fairy shrimp	5	-	-	-	-	5	-	-	-	-	-	-	-	-
B. mackini Dexter	Alkali fairy shrimp	5	-	-	-	5	5	5	-	-	-	-	-	-	-
B. packardi Pearse	Packard fairy shrimp	5	-	-	-	-	5	5	-	-	-	-	-	-	-
B. paludosa Müller	Circumpolar fairy shrimp	5	-	5	5	-	5	5	-	-	-	-	-	-	5
Eubranchipus bundyi Forbes[69]	Knob-lip fairy shrimp	5	5	-	-	5	5	-	-	-	5	-	-	-	-
E. intricatus Hartland-Rowe	Smooth-lipped fairy shrimp	2	-	-	-	-	2	2	2	-	-	-	-	-	-
E. neglectus Garman	Neglected fairy shrimp	2	-	-	-	-	-	-	-	2	-	-	-	-	-
E. oreganus Creasor	Oregon fairy shrimp	5	-	-	-	5	-	-	-	-	-	-	-	-	-
E. ornatus Holmes	Ornate fairy shrimp	2	-	-	-	-	2	-	2	-	-	-	-	-	-
E. serratus Forbes	Ethologist fairy shrimp	5	-	-	-	5	-	-	-	-	-	-	-	-	-
E. vernalis Verrill	Eastern fairy shrimp	2	-	-	-	-	-	-	-	2	-	-	-	-	-
Polyartemiella hazeni Murdoch	Arctic fairy shrimp	5	-	-	5	5	5	-	-	-	-	-	-	-	-
Streptocephalus sealii Ryder	Spiny-tail fairy shrimp	2	-	-	-	-	2	2	-	-	-	-	-	-	-
Notostraca															
Lepidurus arcticus Pallas	Arctic tadpole shrimp	2	2	-	2	-	-	-	-	-	2	-	-	-	-
L. lemmoni Holmes	Lynch tadpole shrimp	2	-	-	-	-	2	-	-	-	-	-	-	-	-
L. couesii Packard	Couse tadpole shrimp	5	-	-	-	-	5	5	-	-	-	-	-	-	-
Diplostraca															
Spinicaudata															
Cyzicus belfragei Packard[70]	Belfrage clam shrimp	5	-	-	-	-	5	-	-	-	-	-	-	-	-
Cladocera															
Acantholeberis curvirostris Müller		5	-	-	-	5	-	-	5	5	5	5	5	-	5
Acroperus harpae Baird		5	-	5	-	5	5	5	5	5	5	5	5	5	5
Alona affinis Leydig		5	-	5	-	5	5	5	5	5	5	5	5	5	5
Al. barbulata Megard		5	-	-	-	5	5	-	-	5	-	-	-	-	-
Al. bicolor Frey		5	-	-	-	-	-	-	-	5	5	-	5	-	-
Al. borealis Chelengath and Hann		2	-	-	-	-	2	2	-	2	-	-	-	-	-
Al. circumfimbriata Megard		5	-	5	-	5	5	5	5	5	-	5	5	5	5
Al. costata Sars		5	-	-	-	-	5	5	5	5	5	5	5	5	5
Al. guttata Sars		5	-	-	-	5	5	-	-	5	-	-	-	-	-
Al. intermedia Sars		5	-	-	-	5	-	-	-	5	5	-	5	-	5
Al. lapidicola Chengalath and Hann		2	-	-	-	-	2	2	-	2	-	-	-	-	-
Al. quadrangularis Müller		5	-	5	-	5	5	5	5	5	5	-	5	5	5
Al. rectangula Sars[71]		5	-	-	-	5	5	-	-	-	-	-	-	-	-
Al. rustica Scott		5	-	-	-	-	5	-	-	5	5	5	-	5	5
Al. setulosa Megard		5	-	5	-	5	5	5	5	5		5	5	5	5
Alonella excisa Fischer		5	-	-	-	5	5	5	5	5	5	5	5	-	5

69 Synonym is *Chirocephalopsis bundyi*.
70 Synonym is *Caenestheriella belfragei*.
71 Synonym is *Alona rectangulata*.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Ae. exigua Lilljeborg		5	-	-	-	5	5	5	5	5	5	-	5	5	5
Ae. nana Baird		5	-	5	-	5	5	5	5	5	5	5	5	-	5
Ae. pulchella Herrick		5	-	-	-	-	-	-	-	5	-	-	5	-	5
Alonopsis americana Kubersky		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Anchistropus minor Birge		5	-	-	-	-	-	-	-	5	5	5	5	-	5
Bosmina freyi DeMelo and Hebert		2	-	-	-	-	-	-	-	2	-	-	-	-	-
Bosmina freyi/liederi DeMelo and Hebert[72]		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Bo. longirostris Müller		2	5	2	2	5	2	2	2	2	2	5	5	-	2
Bunops scutifrons Birge		5	-	-	-	-	5	-	-	-	-	-	-	-	-
Bythotrephes longimanus Leydig	Spiny waterflea	7	-	-	-	-	-	-	-	7	-	-	-	-	-
Camptocercus rectirostris Schoedler[73]		5	-	5	-	5	5	5	5	5	5	5	5	-	5
Cercopagis pengoi Ostroumov	Fishhook waterflea	7	-	-	-	-	-	-	-	7	-	-	-	-	-
Ceriodaphnia acanthina Ross		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. affinis Lilljeborg		5	5	5	-	5	5	5	5	5	-	5	-	-	-
C. lacustris Birge		5	-	5	-	5	5	5	5	5	5	5	5	-	5
C. laticaudata Müller		5	-	-	-	5	-	-	-	5	-	-	-	-	-
C. megops Sars		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. pulchella Sars		5	-	-	-	5	-	5	-	5	-	-	-	-	-
C. quadrangula Müller		5	-	5	-	5	5	5	5	5	5	5	5	-	5
C. reticulata Jurine		5	-	5	-	5	5	5	5	5	5	-	5	5	5
C. scitula Sars		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Chydorus bicornutus Doolittle		5	-	-	-	-	-	-	-	5	5	5	5	-	5
Ch. brevilabris Frey		5	-	5	-	5	5	5	5	5	5	5	5	5	5
Ch. canadensis Chengalath and Hann		2	-	-	-	-	-	-	-	2	-	-	-	-	-
Ch. faviformis Birge		5	-	-	-	-	-	-	5	5	-	-	5	-	5
Ch. gibbus Sars		5	-	-	5	5	5	5	-	5	5	5	-	-	-
Ch. latus Sars		5	-	-	-	-	5	5	-	5	5	-	5	5	-
Ch. ovalis Kurz		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Ch. sphaericus Müller		2	5	2	2	5	2	2	2	2	2	5	5	-	2
Daphnia ambigua Scourfield		5	5	-	-	5	-	-	5	5	5	5	5	-	-
D. catawba Coker		2	-	-	-	-	-	-	-	2	5	5	5	-	5
D. dubia Herrick		2	-	-	-	-	-	-	-	2	5	5	5	-	5
D. galeata galeata Sars[74]		7	5?	5?	-	5?	-	-	-	7	-	-	-	-	-
D. galeata mendotae Birge		5	5	5	-	5	5	5	5	5	5	5	5	-	5
D. laevis Birge		5	-	-	-	5	-	-	-	-	-	5	5	-	-
D. longispina hyalina Leydig		5	5	5	5	5	-	-	-	-	-	-	-	-	-
D. longiremis Sars		5	5	5	5	5	5	5	5	5	5	5	5	-	5
D. magna Straus		5	-	5	-	5	5	5	5	-	5	-	-	-	-
D. middendorffiania Fischer		5	5	5	5	5	5	5	?[75]	5	-	-	-	-	5
D. parvula Fordyce		5	-	-	-	-	5	5	5	5	5	5	5	-	-
D. pulex Leydig		5	5	5	5	5	5	5	5	5	5	-	-	-	5
D. pulicaria Forbes		5	-	-	-	5	5	-	-	5	-	-	-	-	-
D. retrocurva Forbes		2	5	-	-	5	2	2	2	2	2	5	5	-	-
D. rosea Sars		5	-	-	5	5	5	5	5	5	5	5	5	-	-
D. schodleri Sars[76]		5	5	5	5	5	5	5	5	5	5	-	-	-	-

[72] Strecker et al. (2008) were unable to distinguish between the two species.
[73] Chelengath (1982) speculated that Canadian specimens could be a different species since they are morphologically different from the European form.
[74] Patalas et al. listed *D. galeata galeata* as present in western Canada (BC, YK and NT). However more recent records (Kipp 2010b) indicate that the range of this Palearctic species is so far restricted to the Laurentian Great Lakes.
[75] Brandlova et al. (1972) speculated that *D. middendorffiana* likely exists in northern Ontario near Hudson Bay.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
D. similis Claus		5	-	-	-	5	5	5	-	-	-	-	-	-	-
D. thorata Forbes		5	-	-	-	5	-	-	5	5	5	-	-	-	-
D. umbra Taylor et al.		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Diaphanosoma birgei Korinek		2	-	-	-	5	-	-	-	2	-	-	-	-	5
Di. brachyurum Liéven		5	-	5	-	5	5	5	5	5	5	5	5	-	5
Di. heberti Korovchinsky		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Di. leuchtenbergianum Fischer		5	-	-	-	-	-	5	-	-	5	-	-	-	-
Disparalona acutirostris Birge[77]		5	-	-	-	-	-	-	-	5	5	5	5	-	5
Ds. hamata Birge[78]		5	-	-	-	-	-	-	-	5	-	5	-	-	-
Ds. rostrata Koch		5	-	-	-	-	-	-	-	5	5	-	-	-	-
Drepanothrix dentata Euren		5	-	-	-	5	-	-	-	5	-	-	5	-	-
Dunhevedia crassa King		5	-	-	-	-	-	5	5	5	-	-	-	-	-
Eubosmina coregoni Baird		7	-	-	-	7	-	-	7	7	-	-	-	-	-
Eu. hagmanni Stingelin		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Eu. longispina Leydig[79]		5	5	5	5	5	5	5	5	5	5	5	5	-	5
Eu. maritima Müller[80]		7	-	-	-	-	-	-	-	7	7	-	-	-	-
Eu. tubicen Brehm		2	-	2	-	-	-	-	-	2	2	5	5	-	-
Eurycercus nigracanthus Hann		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Er. glacialis Lilljeborg		5	5	-	5	-	-	-	-	-	-	-	-	-	5
Er. lamellatus Müller		5	-	-	-	5	-	-	-	5	-	-	-	-	5
Evadne nordmanni Lovén		5	-	-	-	5	-	-	-	-	-	5	5	-	-
Ev. spinifera Müller		5	-	-	-	-	-	-	-	-	5	-	-	-	-
Graptoleberis testudinaria Fischer		5	-	5	-	5	5	5	5	5	5	-	5	5	5
Holopedium gibberum Zaddach		5	5	5	5	5	5	5	5	5	5	5	5	-	5
Ilyocryptus acutifrons Sars		5	-	-	-	5	-	-	-	-	-	-	-	-	-
I. cuneatus Liéven		5	-	-	-	5	-	-	-	-	-	-	-	-	-
I. gouldeni Liéven		5	-	-	-	5	-	-	-	-	-	-	-	-	-
I. sordidus Liéven		5	-	-	-	5	-	-	5	5	5	5	5	-	5
I. spinifer Herrick		5	-	-	-	-	-	-	-	5	5	-	5	-	-
I. spinosus Liéven		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Kurzia latissima Kurz		5	-	-	-	-	5	5	5	5	5	-	5	-	-
Lathonura rectirostris Müller		5	-	-	-	5	5	5	-	5	-	-	5	-	5
Latona setifera Müller		5	-	-	-	5	-	-	5	5	5	-	5	-	5
Leptodora kindtii Focke		2	5	2	2	2	2	2	2	2	5	5	5	-	2
Leydigia acanthocercoides Fischer		5	-	-	-	-	5	-	-	5	-	-	-	-	-
Ly. leydigi Schödler		5	-	-	-	5	-	5	5	5	-	-	5	-	-
Ly. louisi Jenkin		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Macrothrix laticornis Jurine		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Ma. rosea Liéven		5	-	-	-	5	-	-	-	5	-	-	-	-	-
Megafenestra nasuta Birge		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Moina hutchinsoni Brehm		5	-	-	-	5	-	5	-	?[81]	-	-	-	-	-
Monospilus dispar Sars		5	-	-	-	-	-	-	-	5	5	-	5	-	-
Ophryoxus gracilis Sars		5	-	5	5	-	5	-	5	5	5	5	5	-	5

76 Synonym is *Daphnia schoedleri*.
77 Synonyms are *Alonella acutirostris* and *Pleuroxus acutirostris*.
78 Synonyms are *Alonella hamulata* and *Pleuroxus hamulatus*.
79 Synonym is *Bosmina longispina*.
80 Synonym is *Bosmina maritima*.
81 Chelengath (1982) recorded a *Moina* sp. from Ontario which may be this species.

Scientific Name	Common Name	CA	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Oxyurella tenuicaudis Sars[82]		5	-	-	-	5	-	-	-	5	-	-	5	-	-
Paralona pigra Sars[83]		5	-	-	-	5	5	5	-	5	5	5	5	5	5
Parophryoxus tubulatus Doolittle		5	-	-	-	-	-	-	-	5	-	-	5	-	-
Penilia avirostris Dana		7	-	-	-	-	-	-	-	-	-	-	-	7	-
Picripleuroxus denticulatus Birge[84]		5	-	5	-	5	5	5	5	5	5	-	5	5	5
Pc. laevis Sars[85]		5	-	5	-	-	5	5	5	5	5	-	-	-	5
Pc. striatus Schödler[86]		5	-	5	-	5	5	-	5	5	-	5	5	5	5
Pleopsis polyphemoides Leuckart		5	-	-	-	5	-	-	-	-	5	5	5	-	-
Pleuroxus aduncus Jurine		5	-	-	-	-	5	5	5	-	-	-	-	5	5
Px. procurvus Birge		5	-	5	-	5	5	5	5	5	5	5	5	5	5
Px. trigonellus Müller		5	-	-	-	-	5	5	5	5	5	-	-	-	5
Podon intermedius Lilljeborg		5	-	-	-	5	-	-	-	-	5	-	5	-	-
Pd. leukarti Sars		5	-	-	-	5	-	-	-	-	5	5	5	-	-
Polyphemus pediculus Linnaeus		5	5	5	5	5	5	5	5	5	5	5	5	-	5
Pseudochydorus globosus Baird		5	-	5	-	5	-	5	5	5	5	-	-	-	-
Pseudosida bidentata Herrick		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Pseudovadne tergestina Claus[87]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Rhynchotalona falcata Sars		5	-	-	-	-	-	-	-	5	5	-	5	5	5
Scapholeberis aurita Fischer		5	-	-	-	-	5	-	-	5	-	-	-	-	-
Sc. kingi Sars		5	-	5	-	5	5	5	5	5	5	5	5	5	-
Sc. mucronata Müller[88]		5	-	-	5	5	-	5	-	-	-	-	-	-	-
Sc. rammneri Dumont and Pensaert		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Sida crystallina Müller		2	-	5	-	5	5	5	5	2	5	5	5	-	5
Simocephalus exspinosus Koch		5	-	-	-	-	-	-	5	5	-	-	-	-	-
Sm. serrulatus Koch		5	-	5	-	5	5	5	5	5	-	5	5	5	5
Sm. vetulus Müller		5	-	5	-	5	5	5	5	5	5	5	5	5	5
Streblocerus serricaudatus Fischer		5	-	-	-	5	-	-	-	5	-	-	5	-	5
Wlassicsia kinistinensis Birge		5	-	-	-	-	-	-	-	5	-	-	-	-	-

References

Adamowicz, S. J. and A. Purvis. 2005. How many branchiopod crustacean species are there? Quantifying the components of underestimation. Global Ecol. Biogeo. 14(5): 455-468.

[82] Synonym is *Alona tenuicaudis*.
[83] Synonym is *Chydorus piger*.
[84] Synonym is *Pleuroxus denticulatus*.
[85] Synonyms are *Pleuroxus hastatus* and *Pleuroxus laevis*.
[86] Synonym is *Pleuroxus striatus*.
[87] Synonym is *Evadne tergestina*.
[88] Synonym is *Daphne mucronata*.

Angeler, D. G., O. Viedma, S. Sànchez-Carrillo and M. Alvarez-Cobelas. 2008. Conservation issues of temporary wetland Branchiopoda (Anostra, Notostraca: Crustacea) in a semiarid agricultural landscape: what spatial scales are relevant? Biol. Cons. 141: 1224-1234.

Barbiero, R. P. and M. L. Tuchman. 2004. Changes in the crustacean communities of Lakes Michigan, Huron, and Erie following the invasion of the predatory cladoceran *Bythothrephes longimanus*. Can. J. Fish. Aquat. Sci. 61: 2111-2125.

Belk, D. and J. Brtek. 1995. Checklist of the Anostraca. Hydrobiologia 298: 315-353.

Bernier, R. and A. Locke. 2006. New record of *Penila avirostris* Dana, 1849 (Cladocera) in the Gulf of St. Lawrence. Crustaceana 79(8): 949-959.

Billington, N., M. G. Boileau and P. D. N. Hebert. 1989. Range extension of the fairy shrimp *Polyartemiella hazeni* (Murdoch 1884) (Crustacea: Anostraca) to the eastern Canadian arctic, with notes on the distribution of other eastern arctic Anostraca. Can. Field-Nat. 103(3): 404-405.

Boudreau, S. A. and N. D. Yan. 2003. The differing crustacean zooplankton communities of Canadian Shield lakes with and without the nonindigenous zooplanktivore *Bythotrephes longimanus*. Can. J. Fish. Aquat. Sci. 60: 1307-1313.

Brandlova, J., Z. Brandl, and C. H. Fernando. 1972. The Cladocera of Ontario with remarks on some species and distribution. Can. J. Zool. 50: 1373-1403.

Brendonck, L., D. C. Rogers, J. Olesen, S. Weeks, W. R. Hoeh. 2008. Global diversity of large branchiopods (Crustacea: Branchiopoda) in freshwater. Hydrobiologia 595: 167-176.

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the marine invertebrates of the Estuary and Gulf of Saint Lawrence. Can. Special Publ. Fish. Aquat. Sci. No. 126, p. i-xi, 1-405. National Research Council Research Press, National Research Council of Canada, Ottawa.

Carter, J. C. H., M. J. Dadswell, J. C. Roff, and W. G. Sprules 1980. Distribution and zoogeography of planktonic crustaceans and dipterans in glaciated eastern North America. Can. J. Zool. 58: 1355-1387.

Chengalath, R. 1982. A faunistic and ecological survey of the littoral Cladocera of Canada. Can. J. Zool. 60: 2668-2682.

Chengalath, R. 1987. The distribution of chydorid Cladocera in Canada. Hydrobiologia 145: 151-157.

Chengalath, R. and B. J. Hann. 1981a. Two new species of *Alona* (Chydoridae, Cladocera) from western Canada. Can. J. Zool. 59: 377-389.

Chengalath, R. and B. J. Hann. 1981b. A new species of *Chydorus* (Cladocera: Chydoridae) from Ontario, Canada. Trans. Am. Microsc. Soc. 100(3): 229-238.

deWaard, J. R., V. Sacherova, M. E. A. Cristescu, E. A. Remigio, T. J. Crease and P. D. N. Hebert. 2006. Probing the relationships of the branchiopod crustaceans. Mol. Phyl. Evol. 39: 491-502.

Donald, D. B. 1989. First Canadian record for the clam shrimp *Caenestheriella belfragei* (Crustacea: Conchostraca). Can. Field. Nat. 103(4): 593-594.

Dumont, H. J. 2003. Anostraca. Pp. 135-140 *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI.

GBIF 2010. Data portal of the Global Biodiversity Information Facility. Biodiversity occurrence data provided by the Ocean Biogeographic Information System (OBIS Canada), the National Museum of Natural History, and the University of Alberta. World wide web electronic publication http://data.gbif.org. [Accessed on September 28, 2010].

Gray, D. K. and S. E. Arnott. 2009. Recovery of acid damaged zooplankton communities: measurement, extent, and limiting factors. Environ. Rev. 17: 81-99.

Green, G. 2007. Cladocerans of British Columbia. Royal British Columbia Museum. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia [www.efauna/bc/ca]. Lab for Advanced Spatial Analysis, Dept. of Geography, University of British Columbia, Vancouver. [Accessed on July 30, 2010].

Green, G. 2010. Cladocerans (water fleas) of British Columbia *In* Klinkenberg, B. (editor). E-Fauna BC: Electronic Atlas of the Fauna of British Columbia [www.efauna/bc/ca]. Lab for Advanced Spatial Analysis, Dept. of Geography, University of British Columbia, Vancouver. [Accessed on July 30, 2010].

Hann, B. J. 1981. Occurrence and distribution of littoral Chydoridae (Crustacean, Cladocera) in Ontario, Canada, and taxonomic notes on some species. Can. J. Zool. 59: 1465-1474.

Hann, B. J. 1990. Redescription of *Eurycercus (Teretifrons) glacialis* (Cladocera, Chydoridae) and description of a new species, *E. (T.) nigracanthus*, from Newfoundland, Canada. Can. J. Zool. 68: 2146-2157.

Havens, K. E., N. D. Yan and W. Keller. 1993. Lake acidification: effects on crustacean zooplankton populations. Environ. Sci. Technol. 27: 1621-1624.

IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1 http://www.iucnredlist.org. [Accessed on July 30, 2010].

Jeziorski, A., N. D. Yan, A. M. Paterson, A. M. DeSellas, M. A. Turner, D. S. Jeffries, B. Keller, R. C. Weeber, D. K. McNicol, M. E. Palmer, K. McIver, K. Arseneau, B. K. Ginn, B. F. Cumming and J. P. Smol. 2008. The widespread threat of calcium decline in fresh waters. Science 322: 1374-1377.

Kipp, R. M. 2010a. *Eubosmina maritima*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=2370 RevisionDate: 2/6/2007. [Accessed on September 5, 2010].

Kipp, R. M. 2010b. *Daphnia galeata galeata*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=2732 RevisionDate: 2/13/2007. [Accessed on September 5, 2010].

Korovchinsky, N. M. 2002. Description of two new species of *Diaphanosoma* Fischer, 1850 (Crustacea, Branchiopoda, Sididae) from the United States and Canada and species richness of the genus in North America. Hydrobiologia 489: 45-54.

Lui, K., M. Butler, M. Allen, J. da Silva and B. Brownson. 2008. Field Guide to Aquatic Invasive Species: Identification, collection and reporting of aquatic invasive species in Ontario waters. Ontario Ministry of Natural Resources, Queen's Printer for Ontario, ON.

McLaughlin, P. A., D. K. Camp, M. V. Angel, E. L. Bousfield, P. Brunel, R. C. Brusca, D. Cadien, A. C. Cohen, K. Conlan, L. G. Eldgredge, D. L. Felder, J. W. Goy, T. Haney, B. Hann, R. W. Heard, E. A. Hendryks, H. H. Hobbs III, J. R. Holsinger, B. Kensley, D.R. Laubitz, S. E. LeCroy, R. Lemaitre, R. F. Maddocks, J. W. Martin, P. Mikkelsen, E. Nelson, W. A. Newman, R. M. Overstreet, W. J. Poly, W. W. Price, J. W. Reid, A. Robertson, D. C. Rogers, A. Ross, M. Schotte, F. R. Schram, C-T. Shih, L. Watling, G. D. G. Wilson and D. D. Turgeon. 2005. Common and scientific names of aquatic invertebrates from the United States and Canada: crustaceans. Amer. Fish. Soc. Spec. Publ. 31, Bethesda, MD.

Mills, K. E. 2003. Cladocera. Pp. 153-159 *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI.

Patalas, K., J. Patalas and A. Salki. 1994. Planktonic crustaceans in lakes of Canada (Distribution of species, bibliography). Can. Tech. Rep. Fish. Aquat. Sci. 1954: v+ 218 p.

Rautio, M., S. Bonilla and W. F. Vincent. 2009. UV photoprotectants in arctic zooplankton. Aquatic Biology 7: 93-105.

Rincones, J. and A. Arab. 2003a. Conchostraca. Pp. 147-151. *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI.

Rincones, J. and A. Arab. 2003b. Notostraca. Pp. 141-146 *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI.

Samchyshyna, L., L-A. Hansson and K. Christoffersen. 2008. Patterns in the distribution of Arctic freshwater zooplankton related to glaciation history. Polar Biology 31: 1427-1435.

Strecker, A. L., S. E. Arnott, N. D. Yan and R. Girard. 2006. Variation in the response of crustacean zooplankton species richness and composition to the invasive predator *Bythotrephes longimanus*. Can. J. Fish. Aquat. Sci. 63: 2126-2136.

Strecker, A. L., R. Milne and S. E. Arnott. 2008. Dispersal limitation and climate-related environmental gradients structure microcrustacean composition in freshwater lakes, Ellesmere Island, Canada. Can. J. Fish. Aquat. Sci. 65: 1905-1918.

Suchy, K. D. and B. J. Hann. 2007. Using microfossil remains in lake sediments to examine the invasion of *Eubosmina coregoni* (Cladocera, Bosminidae) in Lake of the Woods, Ontario, Canada. J. Great Lakes Res. 33: 867-874.

Swadling, K. M., R. Pienitz and T. Nogrady. 2000. Zooplankton community composition of lakes in the Yukon and Northwest Territories (Canada): relationship to physical and chemical limnology. Hydrobiologia 431: 211-224.

Sweetman, J. N., E. LaFace, K. M. Rühland and J. P. Smol. 2008. Evaluating the response of cladocera to recent environmental changes in lakes from the Central Canadian Arctic treeline region. Arctic, Antarctic, and Alpine Research 40(3): 584-591.

Taylor, D. J. and P. D. N. Hebert. 1993. Cryptic intercontinental hybridization in *Daphnia* (Crustacea): the ghost of introductions past. Proc. Roy. Soc. Lond. Ser. B. 254: 163-168.

Walossek, D. 1993. The Upper Cambrian *Rehbachiella* and the phylogeny of Branchiopoda and Crustacea. Fossils and Strata 32: 1-202.

Walseng, B., N. D. Yan and A. K. Schartau. 2003. Littoral microcrustacean (Cladocera and Copepoda) indicators of acidification in Canadian Shield Lakes. Ambio 32 (3): 208-213.

Weisz, E. J. and N. D. Yan. 2010. Shifting invertebrate zooplanktivores: watershed-level replacement of the native *Leptodora* by the non-indigenous *Bythotrephes* in Canadian Shield lakes. Biological Invasions DOI 10.1007/s10530-010-9794-8.

Williams, D. D. 2002. Temporary water crustaceans: biodiversity and habitat loss. Modern Approaches to the Study of Crustacea, pp. 223-233. E. Escobar-Briones and F. Alvarez (eds.) Conference Proceedings of the Summer Meeting of the Crustacea Society, Puerto Vallarta, Mexico, June 26-30.

Yan, N. D., A. Blukacz, W. G. Sprules, P. K. Kindy, D. Hackett, R. E. Girard and B. J. Clark. 2001. Changes in zooplankton and the phenology of the spiny water flea, *Bythotrephes*, following its invasion of Harp Lake, Ontario, Canada. Can. J. Fish. Aquat. Sci. 58: 2341-2350.

Yan, N. D., R. Girard and S. Boudreau. 2002. An introduced invertebrate predator (*Bythotrephes*) reduces zooplankton species richness. Ecol. Letters 5: 481-485.

Yan, N. D., B. Leung, W. Keller, S. E. Arnott, J. M. Gunn and G. G. Raddum. 2003. Developing conceptual frameworks for the recovery of aquatic biota from acidification. Ambio 32(3): 165-169.

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9. Maxillopoda

Phylum: Arthropoda

Class: Maxillopoda

Subclasses: Thecostraca (includes barnacles), Tantulocarida, Branchiura (includes fish lice), Mystacocarida, Copepoda, Ostracoda (?), Pentastomida (?)

The Maxillopoda is an extremely diverse class of crustaceans both morphologically and ecologically, comprised of barnacles, fish lice, copepods and related organisms. Maxillopod taxonomy is unresolved and controversial. The class does not appear to be monophyletic, although this may simply be due to limited sampling of taxa to date (Richter et al. 2009). Much debate revolves around which groups belong in Maxillopoda. Both Ostracoda and Pentastomida have been suggested as members since they appear to be sister taxa to Branchiura based on molecular studies (Abele et al. 1992; Regier et al. 2005)[89]. The ecology and phylogenetic relationships of many Maxillopod taxa remain largely unknown. For example, the infraclass Facetotecta (Thecostraca) may actually represent the larval form of Tantulocarida (Martin and Davis 2001).

All maxillopods are aquatic organisms, although some (e.g., barnacles) are able to withstand periods out of water. While the class exhibits significant morphological variation, some common features do exist among members, such as a shortened body typically lacking appendages, and a reduced carapace (Lecointre and LeGuyader 2006). Many maxillopods are parasitic, including members of the Branchiura (fish lice), Cirripedia (barnacles), Copepoda and Tantulocarida. Most species occur in marine environments, although most branchiurans and many copepods inhabit freshwater and brackish habitats (Covich and Thorp 2001).

[89] Since Ostracoda and Pentastomida have been covered in previous reports they will not be addressed here.

Cirripedia (Thecostraca)

Barnacles are the only crustaceans that have a sessile adult form. This peculiarity led to initial taxonomic confusion, with adult forms being classified as molluscs and larval forms as ostracods (Armstrong 2004). Today, late-stage larvae are referred to as 'cyprids' after the ostracod genus *Cypris* with which they were once associated. Approximately 1000 species exist worldwide; classified into four groups: Thoracica ('true barnacles' including acorn and gooseneck barnacles), Acrothoracica (shell-boring barnacles), and the parasitic Ascothoracica and Rhizocephala (Armstrong 2004). Barnacles are among the best preserved crustacean fossils, due to the tough calcareous plates produced by members of the Thoracica and Acrothoracica. Fossils have been found dating back to the mid-Cambrian period (~520 million years ago) in the Burgess Shale of western Canada (Armstrong 2004).

Most barnacles are specialized to live on or within marine substrates (e.g., mollusc shells, coral skeletons, logs, rocks, whales, boat hulls), although some are parasitic on invertebrates. Barnacles are the dominant life form in the intertidal area of rocky seashores worldwide, but also have adapted to live in a variety of other marine habitats, including deep ocean trenches and coral reefs (Armstrong 2004). Commensal and parasitic forms are limited in their distribution by the range of their hosts.

Approximately 2/3 of all barnacles belong to the order Thoracica. These are widespread on rocky substrates in the intertidal zone worldwide, although they also occur in other marine habitats, and some live commensally on vertebrate hosts (e.g., whales, manatees, turtles) (Armstrong 2004; Lecointre and LeGuyader 2006). Inhabiting the intertidal zone exposes barnacles to periodic fluctuations in temperature and moisture levels. The calcareous plates that surround the soft body parts (e.g., mouthparts and feeding appendages) close up during low tide, allowing barnacles to withstand extremes in temperature while protecting them from dessication. Both Thoracica and Acrothoracica are suspension feeders that sweep food particles out of the water with their cirri (modified thoracic appendages).

Ascothoracica are sucking ectoparasites of sea anemones, corals and echinoderms, while Rhizocephalans are endoparasites of crabs and shrimp. Rhizocephalans are unique in that the adult form has a completely unsegmented body, lacking appendages, mouth, stomach or gut (Armstrong 2004). Only female cyprids directly infect their host, using a hollow piercing appendage known as the stylus. Once attached, the female injects her internal tissues into the host and disposes of the external sac-like body. Rhizocephalan infections last for the life of the parasite, but do not kill the host.

Barnacles are hermaphroditic but individuals only function as one sex. Fertilization is internal and the naupilus larvae are typically released into the water column in late winter, where they live for several months. After completing a series of moults, larvae develop into the cyprid form, which is specialized for seeking out suitable habitat for settling. Cyprids investigate substrates with their antennae and fasten themselves to the chosen site in spring or early summer. Once settled, the larvae metamorphize into the adult form. In the case of Thoracica and Acrothoracica, the cyprid's paired swimming legs metamorphize into cirri, while the carapace thickens to form the body wall or mantle. The front antennae that initially attach to the substrate spreads to become the barnacle's base or stalk, and is secured to the surface by extremely strong cement produced by glands in the barnacle's head (Armstrong 2004). Acrothoracica burrow into their shellfish or coral host, and secrete calcareous plates to cover the opening of their burrows. Thoracica remain on the surface of the substrate, completely covering their body with calcareous plates as protection from predation and dessication. Rhizocephalan adult females grow roots (or internae) that invade the host tissue, including the limbs and abdomen. Eventually an external reproductive part develops on the host abdomen (the externa) which attracts male cyprids for mating. Rhizocephalan infections cause sterility in the host, but interestingly, both female and male hosts are tricked into caring for the parasite's eggs, which develop externally on the host abdomen (Armstrong 2004). Sexual maturity in barnacles is usually reached in about two years.

Branchiura

Branchiura are ectoparasites, predominantly on fish, although a few also parasitize amphibians. They are most abundant in freshwater habitats, but also occur in marine and brackish waters. The subclass contains one family (Argulidae) and four genera: *Argulus, Chonopeltis, Dipteropeltis* and *Dolops*. The group is widely distributed worldwide and approximately 150 species have been described globally (Covich and Thorp 2001). Eighteen species are found in North America, all belonging to the genus *Argulus* (Poly 2008).

Branchiurans have flattened oval bodies that are almost completely covered by a broad carapace. They have unusually prominent compound eyes and mouthparts modified into a proboscis with hooks, spines and suckers. Branchiurans have four pairs of swimming legs on the thorax (Poly 2008). Individuals attach to their fish host behind the operculum or on a fin and either pierce the skin to suck blood or feed on mucus and skin from the fish. Adults detach from their host and live freely within the water column for up to three weeks at a time to look for a mate, to lay eggs and to find a new host. Females lay their eggs on rocks, plants or sticks, attached with a sticky substance. Larvae are free swimming and search out fish hosts on which to settle (Covich and Thorp 2001).

Copepoda

Copepods are a cosmopolitan group, occurring in a wide variety of aquatic and semi-terrestrial environments, ranging from oceans, to lakes, creeks, puddles, groundwater and moist leaf litter (Williamson and Reid 2001). Most of the over 10 000 species described worldwide are found in marine habitats and collectively, marine copepods make up the largest biomass of the world's oceans and play a crucial role in marine food webs, where they are a key source of protein for whales and fish (Lecointre and LeGuyader 2006). Copepods are also major components of many freshwater and semi-terrestrial systems. For example, in Lake Baikal, Russia, copepods constitute over 90% of the freshwater zooplankton (Williamson and Reid 2001). Densities of over 100,000 individuals/m^2 have been recorded in wet organic soils (Reid 1986). Copepods are important primary and secondary consumers in a diversity of aquatic food webs (Williamson and Reid 2001).

Ten orders have been identified: Platycopioida, Calanoida, Misophrioida, Cyclopoida, Gelyelloida, Mormonilloida, Harpacticoida, Poecilostomatoida, Siphonostomatoida, and Monstrilloida. Three of these orders (Poecilostomatoida, Siphonostomatoida and Monstrilloida) are mainly parasitic on fish and invertebrates and largely marine in their distributions. Three other orders (Platycopioida, Misophroioida and Mormonilloida) consist mainly of marine free-living benthic or planktonic forms. Calanoida, Cyclopoida and Harpacticoida are the most widespread and abundant Copepoda orders and contain mostly free-living species (although many cyclopoids are parasitic). The order Gelyelloida includes species that inhabit subterranean environments (Williamson and Reid 2001).

A total of 2814 freshwater species of copepods have been described worldwide, over 90% of which are endemic to a single biogeographic region.

Copepods are generally cylindrical in shape, and have a segmented body with many segmented appendages on the head and thorax. The defining feature of the subclass is the structure of the swimming legs, which are attached in pairs at their base by a "coupler" or "intercoxal sclerite". The name Copepoda reflects this distinguishing trait, as it derives from the Greek words 'kope' (for oar) and 'podos' (for foot; Williamson and Reid 2001).

The diet of copepods ranges from fish and invertebrates (in the case of parasitic and predatory forms) to detritus, pollen, phytoplankton and bacteria. Many species are filter feeders (e.g., some Calanoida), while others hunt mosquito or fish larvae (e.g. Calanoida and Cyclopoida). In freshwater systems, calanoids are typically planktonic, while cyclopoids and harpacticoids tend to be found on substrates in benthic or littoral habitats (Williamson and Reid 2001).

Copepod larvae go through six naupliar stages, followed by six copepodid states, ending with the adult form. Adults are sexually dimorphic. Some types of copepods (e.g., calanoids and harpacticoids) produce two types of eggs: the normal type which hatch within days of being laid, and the resting type which can remain dormant for years, decades or even centuries (Williamson and Reid 2001). Some species vary the production of each egg type depending on habitat (e.g., the calanoid *Limnocalanus macrurus* Sars). Other types of copepods (e.g., cyclopoids) produce only the normal egg type, but are capable of entering diapause at the copepodid stage (Williamson and Reid 2001). The initiation of diapause (whether in eggs or larvae) can be triggered by a variety of adverse environmental factors, including overcrowding, predation pressure, and photoperiod (Williamson and Reid 2001). Once in the resting stage, copepods are able to resist temperature extremes and dessication.

Significance of Maxillopoda to Humans

One large species of barnacle, *Megabalanus psittacus* Molina, is considered a delicacy in South America (Armstrong 2004) and tastes like crab (Packer, personal communication 2012).

Rhizocephalan parasites of crabs (such as *Briarosaccus callosus* Boschma) affect various economically important crab species worldwide. The parasitic barnacles typically attach to the ventral surface of the crab's abdomen and grow into muscle tissues, resulting in sterilization and the alteration of moulting, behaviour, and growth (Bower and Meyer 1999; Shukalyuk et al. 2005). In Northern British Columbia, 40% of golden king crabs (*Lithodes aequispina* Benedict) sampled from deep fjords were infected with *B. callosus* (Sloan 1984). Currently no control methods exist to deal with the problem.

Biofouling by barnacles (in which they encrust artifical objects such as ship hulls, pipes, cables and fish farm cages) is a major problem around the world. Barnacles attached to ships, or carried in ballast water as larvae, are easily transported to new areas, where they may become invasive alien species (Armstrong 2004). Ballast water is also a common vector for non-native copepods to be introduced into new areas (Levings et al. 2004).

Parasitic copepods are considered pests by commercial fishing and aquaculture industries. Two species (*Caligus clemensi* Parker & Margolis, *Lepeophtheirus salmonis* Krøyer) are common parasites affecting both wild (Pacific salmon and Pacific herring) and farmed (Atlantic salmon) fish populations in British Columbia (Beamish et al. 2009). Parasitic copepods feed on skin, muscle and blood of their hosts, causing morbidity and mortality. Both species have been economically damaging for the B. C. salmon aquaculture industry, and represent a threat to wild salmonid populations (Krkošek 2010).

Copepod species can act as intermediate hosts to a variety of human parasites. In West Africa and India, for example, species of *Mesocyclops* and *Thermocyclops* carry guineaworm (*Dracunculus medinensis*) a serious parasitic nematode (Boxshall and Defaye 2008).

Predatory copepods, such as species of *Mesocyclops* have been used in some parts of the world as biological control agents against mosquito larvae (Boxshall and Defaye 2008).

Branchiuran fish lice have negative impacts on natural fish populations, fish hatcheries, aquaculture operations, as well as the aquarium industry (Poly 2008).

<u>Maxillopod Conservation Issues</u>

Sixty-seven Maxillopod species are currently listed on the IUCN Red List, including 10 North American copepods (none of which are recorded in Canada; IUCN 2010). Maxillopods face a variety of conservation threats worldwide, including climate change, pollution, habitat loss and invasive alien species.

Climate change and atmospheric ozone depletion, for example, are expected to negatively impact intertidal barnacle species due to alterations in levels of salinity, temperature, dessication stress and solar ultraviolet radiation (Gosselin and Jones 2010). A recent climate change simulation study in Britain predicted that the globally widespread acorn or northern rock barnacle (*Semibalanus balanoides* Linnaeus), which inhabits temperate and arctic waters, will almost completely vanish from southwest England by the 2050s (Poloczanska et al. 2008). Another study of the effects of climate change on *S. balanoides* found that CO_2-induced ocean acidification and sea temperature rise will likely threaten embryonic development and adult survival rates (Findlay et al. 2009). Predation pressure on intertidal barnacles may also intensify under climate change. The barnacle *Balanus glandula* Darwin, for example, experienced increased predation by the northern striped dogwinkle (*Nucella ostrina* Gould) in elevated water temperatures (Yamane and Gilman 2009).

Many freshwater copepods inhabit temporary waterbodies and are thus extremely vulnerable to loss or degradation of these habitats occurring as a result of climate change and agricultural and urban development (Williams 2002). Copepods may also be sensitive to various forms of pollution, such as eutrophication, pesticides, and oil spills (Zrum et al. 2000; Williamson and Reid 2001; Kreutzweiser et al. 2002; Seuront 2010), as well as solar ultraviolet radiation (Alonso Rodriguez et al. 2000). Desertification and overexploitation of groundwater are other conservation concerns for freshwater copepods (Boxshall and Defaye 2008).

Maxillopoda in Canada

The State of Our Knowledge

No systematic inventory of the Maxillopoda fauna has been conducted in Canada, but numerous national and regional surveys do exist for the Copepoda, both in marine and freshwater habitats (e.g., Smith and Fernando 1977; Carter et al. 1980; Patalas et al. 1994; Shih and Chengalath 1994; Goldblatt et al. 1999; Swadling et al. 2000; Mackas et al. 2001; Swadling et al. 2001). This focus on a single subclass is perhaps not surprising, given that copepods are the most diverse and abundant of all Maxillopoda taxa globally. Nevertheless, despite the range of studies on Canadian copepods, significant gaps in our knowledge of the group persist. In particular, information on ecology, life history and geographic distribution are sparse for both marine and freshwater species, and in many cases copepod taxonomy is unresolved (Shih and Chengalath 1994).

In the marine realm, diversity of invertebrates in general is poorly known (e.g., Mosquin et al. 1995 estimated that 34 % of Canadian marine invertebrates remain unreported). Many marine habitats have yet to be surveyed in detail, with shallow nearshore areas tending to be studied more than deeper offshore areas, and temperate zones more than arctic ones (Archambault et al. 2010). Benthic invertebrates represent the largest proportion of unstudied taxa in Canada. A major factor contributing to this dearth of knowledge is the decline in the number of Canadian taxonomists and systematists specializing in marine taxa. Experts who retire are not being replaced with newly trained individuals, and researchers working on marine ecosystems often do not receive any formal taxonomic training (Archambault et al. 2010). This situation is likely to result in an increasingly inaccurate taxonomic catalogue of marine diversity in Canada and the “cosmopolitan species syndrome”, in which morphologically similar species from different areas are lumped together as a single species despite subtle differences (Archambault et al. 2010).

Some of the same problems exist with freshwater taxa also. Substantial gaps remain in our knowledge of freshwater copepods, especially harpacticoids. The taxonomy of palearctic copepods is fairly well established, but information on copepod diversity outside Europe is limited (and in particular for non-planktonic species; Williamson and Reid 2001). Little research has been conducted on arctic species, and taxa inhabiting the the littoral zone of lakes and ponds (Shih and Chengalath 1994). Despite ongoing (and increasing) disturbance of freshwater environments, we also lack a basic understanding of the impacts of multiple stressors, and their interactions, on copepod populations (e.g., temperature, pH, solar UV radiation, pollution, habitat degradation; Williamson and Reid 2001).

A recent compilation of marine diversity patterns in Canada's three oceans found that Maxillopods (and more specifically copepods) are the dominant mesozooplankton type in all regions (Archambault et al. 2010). On the east coast, copepods comprised 50% of crustacean diversity, with 153 species. On the west coast nearly 40% of the zooplankton was made up of calanoid copepods (185 species), which may be due in part to numerous range expansions of southern species over the last 15 years (Archambault et al. 2010). In contrast, harpacticoid (four species) and poecilostomatoid (11 species) copepods were relatively under-represented in the Pacific region. Calanoid copepods also dominated the Arctic zooplankton fauna (104 species), while harpacticoid numbers (65 species) were higher here than any other marine region sampled (although this could be due to taxonomic uncertainties; Archambault et al. 2010).

Nearctic freshwater copepods are not as diverse as their Palearctic counterparts, and many species occur in both regions (this may be an artifact of poorer taxonomic knowledge in North America and the cosmopolitan species syndrome mentioned previously). A total of 347 freshwater species have been recorded in North America. While endemism is low at the generic level (with many Holarctic representatives), 225 species (65%) are considered Nearctic endemics (Boxshall and Defaye 2008). Among the most common freshwater copepods found in Canada are the calanoids *Aglaodiaptomus leptopus* Forbes, *Epischura lacustris* Forbes, and *Leptodiamptomus minutus* Lilljeborg, and the cyclopoids *Acanthocyclops vernalis* Fischer, and *Mesocyclops edax* Forbes (Carter et al. 1980). The highest species diversity of freshwater copepods occurs in the central part of the country (i.e., Saskatchewan, northern Manitoba), northern BC and around the Mackenzie Delta (Patalas 1990). Species numbers decline along a southwest to northeast gradient.

The tally of total number of described maxillopod species in Canada (Table 9) was compiled from a variety of sources: (i) national and regional surveys (Smith and Fernando 1977; Carter et al. 1980; Dussart and Fernando 1990; Patalas 1990; Patalas et al. 1994; Shih and Chengalath 1994; Goldblatt et al. 1999; Swadling et al. 2000; Mackas et al. 2001; Swadling et al. 2001); (ii) additional publications (Reed 1991; Flössner 1992; Bresciani and López-González. 2001; Bernier et al. 2002; Buhl-Mortensen and Mortensen 2005; Clement and Moore 2007; Ingólfsson and Steinarsdóttir 2007; Samchyshyna et al. 2008; Strecker et al. 2008; Marcogliese et al. 2009), and (iii) online databases (the Global Biodiversity Information Facility Data Portal, accessed 2010; the Integrated Taxonomic Information System, accessed 2010; World of Copepods (Walter and Boxshall 2008, accessed 2010);World Register of Marine Species (Appeltans et al. 2010, accessed 2011).

A total of 292 species of maxillopods have been described to date in Canada, comprising 37 Thecostraca (all barnacles), 8 Branchiura (including one subspecies), and 247 Copepoda (including 1 subspecies). This tally is likely to be an underestimate, since the country's maxillopodan diversity has not yet been systematically inventoried. Within the copepods, 1 Copepoda *Incertae Sedis*, 90 Calanoida, 54 Cyclopoida, 1 Mormonilloida, 33 Harpacticoida, 22 Poecilostomatoida, 36 Siphonostatoida and 10 Monstrilloida have been documented. Three copepod records are classified only to the genus level (1 calanoid, 1 cyclopoid and 1 poecilostomatoid). Although none of these species have been formally recognized as species at risk in Canada, nine copepods are considered potentially at risk (listed as 'sensitive' or 'may be at risk' in Table 9) because they represent newly described species which may be endemic and/or have limited ranges, or because they may be threatened by an invasive cladoceran species.

Potential Species at Risk

Arthurhumesia canadiensis Bresciani & López-González was first described in 2001 and represents both a new genus and species of parasitic copepod. The species was found parasitizing the colonial tunicate *Aplidium solidum* Ritter & Forsyth in coastal waters off Bamfield, British Columbia (Bresciani and López-González 2001). The species represents the only known member of its genus. This appears to be the sole record of the species to date although the species may be widespread.

A new species of calanoid copepod, *Eudiaptomus yukonensis* Reed, was described in 1991 based on records from a shallow pool (< 7 cm depth) in a tundra depression in the Yukon (Reed 1991). This appears to be the sole record of the species to date although the species may be widespread.

The cyclopoid *Botryllophilus bamfieldensis* Ooishi was first described in 2000 parasitizing a lobed ascidian (*Eudistoma purpuropunctatum* Lambert) in Barkley Sound, British Columbia (Ooishi 2000). This appears to be the sole record of the species to date. This species may also be widespread.

The harpacticoid *Gorgonophilus canadensis* Buhl-Mortensen and Mortensen represents a new genus and species that was first described in 2004 (Buhl-Mortensen and Mortensen 2004). The species was found off the Atlantic coast of Canada parasitizing the deep-water gorgonian *Paragorgia arborea* Linnaeus (or bubblegum coral). The highly modified copepod causes the coral to form galls, in which it lives. The infection appears to have little effect on the host (Buhl-Mortensen and Mortensen 2004). The species represents the only known member of its genus. This appears to be the sole record of the species to date but the species may be widespread.

Two other new species of harpacticoid were described from wet mosses in the Yukon: *Gulcamptus laurentiacus* Flössner and *Maraenobiotus canadensis* Flössner in 1992. The former species was originally assigned to a new genus, *Neomaraenobiotus*, but has since been reclassified as a member of *Gulcamptus* (Appeltans et al. 2010). Harpacticoids are common on wet mosses in temperate and tropical zones, but North American records are rare. The Yukon records represent the first observation of harpacticoids on wet mosses in northern Canada (Flössner 1992).

Finally, three cyclopoid species, *Mesocyclops edax*, *Tropocyclops extensus* Kiefer and *T. prasinus mexicanus* Kiefer, have suffered major declines or complete disappearance from Ontario lakes invaded by the non-native predatory cladoceran *Bythotrephes longimanus* Leydig. Consequently, these cyclopoids may face future widespread population reductions/extirpations if *Bythotrephes* continues to colonize lakes throughout Canada (Yan and Pawson 1997; Dumitru et al. 2001).

Threats

Maxillopods in Canada face a number of conservation threats, including habitat loss and degradation, climate change, pollution and invasive alien species.

Climate change is projected to influence Maxillopoda in Canada in a variety of ways. Intertidal barnacles may be at greater risk of thermal stress as air and water temperatures rise (Bertness et al. 1999). In arctic aquatic ecosystems, shrinking pack ice poses a major threat to benthic fauna, because it will significantly reduce the supply of carbon to the seafloor (Archambault et al. 2010). Copepods that inhabit ephemeral freshwater habitat may be threatened by more frequent and longer droughts under climate change (Williams 2002). Furthermore, a wide range of northern freshwater copepod species, whose centres of distribution are north of the 60th parallel (such as *Eurytemora canadensis* Marsh, *Limnocalanus macrurus* Sars, *Cyclops capillatus* Sars and *C. scutifer* Sars), are predicted to decline in southern Canada under climate change (Patalas 1990). In contrast, southern species, whose centres of distribution are south of the 60th parallel (such as *Aglaodiaptomus saskatchewanenis* Wilson, *Hesperodiaptomus kenai* Wilson, and *E. lacustris*) will likely expand their ranges further north (Patalas 1990). Some copepod species (e.g., *Diacyclops thomasi* Forbes) may be able to adapt to climate change impacts through their ability to enter diapause when environmental conditions are unfavourable (Strecker et al. 2004). However, warmer temperatures could induce resting eggs to hatch in the fall, leaving insufficient time for larvae to mature before freezing (Strecker et al. 2004).

Pesticide run-off into freshwater ecosystems may disproportionately affect some species of copepods. A study to evaluate the use of neem (azadirachtin) as an insecticide for forestry in Canada, for example, found that copepods were more sensitive than cladocerans and rotifers to aquatic contamination. Three common copepod species, *Diacyclops nanus* Sars, *Leptodiaptomus minutus* and *Skistodiaptomus oregonensis* Lilljeborg, were almost entirely eliminated from ponds where neem was applied (Kreutzweiser et al. 2002).

Invasive alien species that compete with, or prey on, maxillopods, are a further threat. Ballast-water is a major vector for these invading species in Canada. One of the most destructive invaders to date for freshwater zooplankton has been the predatory cladoceran *Bythotrephes longimanus*, or spiny waterflea, which arrived in the Laurentian Great Lakes in the 1980s, probably carried in ship's ballast water from the Baltic Sea (Yan et al. 2001). Since then it has spread to many inland lakes in Ontario and the northern U. S. *Bythotrephes longimanus* feeds on both adult and nauplii copepods but its preferred prey is Cladocera. However, some cyclopoids (i.e., *Mesocyclops edax*, *Tropocyclops extensus*, and *T. prasinus mexicanus*) have declined or vanished altogether in lakes it invades (Yan and Pawson 1997; Dumitru et al. 2001). If *Bythotrephes* continues its spread through Canadian Shield lakes and into other areas in North America it could seriously threaten these vulnerable copepod species.

Estuarine ecosystems along the Pacific coast of North America are particularly vulnerable to invasion by non-native copepods. Cordell et al. (2010) found that at least nine copepod species had been introduced by ballast water to this area of the U. S., including the calanoid species *Pseudodiaptomus inopinus* Burkhardt, which is established in Washington and Oregon, but has not yet spread to British Columbia. Mid-ocean exchange of ballast water (which is now recommended under Canadian voluntary guidelines and required under U. S. federal law) may reduce the number of invasive zooplankton arriving in North American waters, but doesn't eliminate them entirely. Levings et al. (2004) identified eight non-native copepod species in ballast water that had undergone this treatment that could colonize B. C. coastal waters if released.

Acidification of tens of thousands of lakes on the Canadian Shield over the last 50 years has caused widespread changes to zooplankton communities in eastern North America (Havens et al. 1993; Gray and Arnott 2009). Although many of these lakes have since experienced a chemical recovery from the effects of acid rain, a full biological recovery has yet to occur (Walseng et al. 2003; Gray and Arnott 2009). Copepod taxa have demonstrated varying responses to acidification. As a group, copepods do not seem as vulnerable to pH declines, and seem more resilient in their recovery to it, than other zooplankton (e.g., daphnid cladocerans). However, some copepod species are among the most sensitive of all zooplankton to lake acidification. For example, the abundance of *Skistodiaptomus oregonensis* Lilljeborg in Ontario lakes began to decline precipitously when pH reached 5.9, and populations experienced over 50% mortality at pH < 5.7 in the laboratory (Havens et al. 1993). In contrast, *Mesocyclops edax* Dussart show no significant changes in abundance at different pH levels, and only experienced 50% mortality at pH < 5.2 in the lab (Havens et al. 1993). Acidified lakes often were dominated by *Leptodiatomus minutes* Lilljeborg, which rapidly developed a tolerance to low pH in affected regions (Derry and Arnott 2007). This local adaptation persists in recovering lakes that have been circum-neutral for six to eight years, although populations appear to be losing the acid tolerance as conditions improve (Derry and Arnott 2007). Copepods (including acid sensitive species like *S. oregonensis*) have shown complete recovery from severe acid and metal emissions contamination in lakes in the Sudbury region of Ontario, while other zooplankton taxa (e.g. cladocerans) lag behind (Yan et al. 2004).

Table 9. Distribution and Status of Canadian Maxillopoda. 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental; ? = status needs further clarification.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Thecostraca															
Cirripedia															
Arcoscalpellum aurivilli Pilsbry[90]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. regium Thomson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. velutinum Hoek		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Balanus balanus Linnaeus[91]		5	-	-	5	5	-	-	-	-	5	5	5	-	5
B. cariosus Pallas		5	-	-	-	5	-	-	-	-	-	-	-	-	-
B. crenatus Brugiere		5	-	-	5	5	-	-	-	-	5	-	5	-	5
B. engbergi Pilsbry		5	-	-	-	5	-	-	-	-	-	-	-	-	-
B. glandula Darwin		5	-	-	-	5	-	-	-	-	-	-	-	-	-
B. improvisus Darwin		5	-	-	-	-	-	-	-	-	-	5	5	-	-
B. nubilis Darwin		5	-	-	-	5	-	-	-	-	-	-	-	-	-
B. perforatus Brugiere		5	-	-	-	-	-	-	-	-	-	-	5	-	-
B. rostratus Hoek		5	-	-	-	-	-	-	-	-	-	-	-	-	5
B. tintinnabulum californicus Pilsbry		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Briarosaccus callosus Boschma	Parasitic barnacle; Rhizocephalan parasite of crabs	5	-	-	-	5	-	-	-	-	-	-	-	-	-

[90] Synonym is *Scalpellum aurivilli*.
[91] Synonym is *Balanus porcatus*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Chirona hameri Ascanius[92]		5	-	-	-	-	-	-	-	-	5	5	5	-	5
Chthamalus dalli Pilsbry		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Clistosaccus paguri Lilljeborg		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Conchoderma aurita Linnaeus		5	-	-	-	-	-	-	-	-	-	-	-	-	5
C. auritum Linnaeus	Rabbit-ear barnacle	5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. virgatum Spengler[93]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Coronula diadema Linnaeus		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Dosima fascicularis Ellis & Solander[94]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Hamatoscalpellum columbianum Pilsbry[95]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Hesperibalanus hesperius Pilsbry[96]5		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Lepas anatifera Linnaeus[97]	Duck barnacle	5	-	-	-	5	-	-	-	-	-	-	5	-	5
L. anserifera Linnaeus	Goose barnacle	5	-	-	-	-	-	-	-	-	-	-	5	-	-
L. hillii Leach		5	-	-	-	-	-	-	-	-	5	5	5	-	-
L. pectinata Spengler		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Megabalanus californicus Pilsbry		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Octolasmis stroemii substroemii Pilsbry[98]		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Ornatoscalpellum stroemii Sars		5	-	-	5	-	-	-	-	-	-	-	5	-	5
Peltogaster paguri Rathke		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Platylepas coriacea Monroe and Limpus[99]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Pollicipes polymerus Sowerby	Leaf barnacle	2	-	-	-	2	-	-	-	-	-	-	-	-	-
Scalpellum stroemii Sars[100]		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Semibalanus balanoides Linnaeus[101]	Acorn barnacle; Northern rock barnacle	5	-	-	5	-	-	-	-	-	5	5	5	-	5
Stomatolepas elegans Costa[102]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Branchiura															
Arguloida															
Argulus alosae Gould	Herring fish louse	5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. borealis Wilson	Black-striped fish louse	5	-	-	-	5	-	-	-	-	-	-	-	-	-

92 Synonym is *Balanus hameri*.
93 Reported attached to a leatherback turtle (*Dermochelys coriacea*; GBIF 2010).
94 Synonym is *Lepas fascicularis*.
95 Synonym is *Scalpellum columbianum*.
96 Synonyms are *Balanus hesperius* and *Solidobalanus hesperius*.
97 Reported in NS attached to a leatherback turtle (GBIF 2010).
98 Unconfirmed name (GBIF 2010).
99 Unconfirmed name; found on a leatherback turtle (GBIF 2010).
100 Synonym is *Scalpellum pressum*.
101 Synonyms are *Balanus balanoides* and *Lepas balanoides*.
102 Reported attached to a leatherback turtle (GBIF 2010).

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
A. flavescens Wilson	Yellow fish louse	5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. funduli Krøyer[103]	Gulf coast fish louse; Toothless fish louse	5	-	-	-	-	-	-	-	-	-	5	5	-	-
A. megalops Smith		5	-	-	-	-	-	-	-	-	5	5	5	5	-
A. megalops spinosus Wilson		5	-	-	-	-	-	-	-	-	-	5	-	-	-
A. piperatus Wilson	Shubenacadie fish louse	5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. pugettensis Dana	Puget fish louse	5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. stizostethii Kellicott[104]	Canadian fish louse	5	-	-	-	-	-	-	-	5	5	5	5	5	-
Copepoda															
Copepoda *incertae sedis*															
Arthurhumesia canadiensis Bresciani & López-González		3?	-	-	-	3?	-	-	-	-	-	-	-	-	-
Calanoida															
Acanthodiaptomus denticornis Wierzejski[105]		5	5	-	-	5	5	5	5	-	-	-	-	-	-
Acartia (Acartiura) longiremis Lilljeborg[106]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. sp.		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Aetideus armatus Boeck[107]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. giesbrechti Cleve[108]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. pacificus Brodsky		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Aglaodiaptomus clavipes Schacht[109]		5	-	-	-	-	-	-	5	-	-	-	-	-	-
Ag. forbesi Light[110]		5	-	-	-	5	5	5	-	-	-	-	-	-	-
Ag. leptopus Forbes[111]		5	-	5	-	5	5	5	5	5	5	5	-	-	-
Ag. pseudosanguineus Turner[112]		5	-	-	-	-	-	-	-	-	5	-	-	-	-
Ag. saskatchewanensis Wilson[113]		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Ag. spatulocrenatus Pearse[114]		5	-	-	-	-	-	-	-	-	5	5	5	-	5
Ag. stagnalis Forbes[115]		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Anomalocera patersoni Templeton[116]		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Arctodiaptomus arapahoensis Dodds[117]		5	-	-	-	-	5	-	-	-	-	-	-	-	-

[103] Synonym is *Argulus latus*.
[104] Synonym is *Argulus canadensis*.
[105] Synonyms are *Diaptomus denticornis* and *D. hamatus*.
[106] Synonyms are *Acartia longiremis* and *Calanus euchaeta*.
[107] Synonyms are *Aetideus tenuirostris* and *Pseudocalanus armatus*.
[108] Synonym is *Euaetideus giesbrechti*.
[109] Synonym is *Diaptomus calvipes*.
[110] Synonym is *Diaptomus forbesi*.
[111] Synonym is *Diaptomus leptopus*.
[112] Synonym is *Diaptomus pseudosanguineus*.
[113] Synonym is *Diaptomus saskatchewanensis*.
[114] Synonym is *Diaptomus spatulocrenatus*.
[115] Synonym is *Diaptomus stagnalis*.
[116] Synonyms are *Anomalocera patersonii* and *A. splendidus*.
[117] Synonym is *Diaptomus arapahoensis*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Ar. novosibiricus Kiefer		5	-	5	-	-	-	-	-	-	-	-	-	-	-
Calanus finmarchicus Gunnerus[118]		5	-	-	5	5	-	-	-	-	-	-	5	-	-
C. glacialis Jaschnov		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. helgolandicus Claus		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. hyperboreus Krøyer[119]		5	-	-	-	-	-	-	-	-	5	-	5	-	-
Candacia armata Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Cn. columbiae Campbell[120]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Centropages abdominalis Sato[121]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Ct. hamatus Lilljeborg		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Ct. typicus Krøyer		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Epischura lacustris Forbes		5	-	5	-	-	-	5	5	5	5	5	5	-	5
E. nevadensis Lilljeborg		5	5	5	-	5	-	5	5	5	-	-	-	-	-
E. nordenskioldi Lilljeborg		5	-	-	-	-	-	-	-	-	-	5	5	-	5
Eudiaptomus gracilis Sars[122]		5	-	5	-	-	-	-	-	-	-	-	-	-	-
Eu. intermedius Steuer[123]		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Eu. yukonensis Reed		3?	3?	-	-	-	-	-	-	-	-	-	-	-	-
Eurytemora affinis Poppe		5	-	-	-	5	-	-	-	5	5	5	-	-	5
Et. arctica Wilson & Tash		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Et. canadensis Marsh		5	-	5	5	-	-	-	-	-	-	-	-	-	-
Et. composita Keiser		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Gaetanus columbiae Park[124]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
G. pungens Giesbrecht[125]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
G. tenuispinus Sars[126]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Gaussia princeps Scott[127]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Hesperodiaptomus arcticus Marsh[128]		5	5	5	5	5	5	5	5	-	5	-	-	-	5
H. breweri Wilson[129]		5	-	-	-	-	-	5	-	-	-	-	-	-	-
H. caducus Light		5	-	-	-	5	-	-	-	-	-	-	-	-	-
H. eiseni Lilljeborg		5	-	5	-	5	5	-	-	-	-	-	-	-	5
H. franciscanus Lilljeborg[130]		5	-	-	-	5	5	-	-	-	-	-	-	-	-
H. hirsutus Wilson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
H. kenai Wilson[131]		5	-	-	-	5	-	-	-	-	-	-	-	-	-

118 Synonyms are *Calanus arietis,C. borealis, C. elegans, C. mundus, C. perspicax, C. quinqueannulatus, C. recticornis, C. sanguineus, C. septentrionalis, C. spitzbergensis, Cetochilus finmarchicus, C. septentrionalis,* and *Monoculus finmarchicus*.
119 Synonyms are *Calanus magnus* and *C. plumosus*.
120 Synonym is *Candacia pacifica*.
121 Synonym is *Centropages mcmurrichi*.
122 Synonym is *Diaptomus gracilis*.
123 Synonym is *Diaptomus intermedius*.
124 Synonym is *Gaidius columbiae*.
125 Synonym is *Gaidius pungens*.
126 Synonym is *Gaidius tenuispinus*.
127 Synonym is *Gaussia scotti*.
128 Synonyms are *Diaptomus arcticus, Hesperodiaptomus judayi, H. koolensis, H. kurenkovi* and *H. occidentalis*.
129 Synonym is *Diaptomus breweri*.
130 Synonym is *Diaptomus franciscanus*.
131 Synonym is *Diaptomus kenai*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
H. kiseri Kincaid[132]		5	-	-	-	5	5	5	-	-	-	-	-	-	-
H. nevadensis Light[133]		5	-	-	-	5	5	5	-	-	-	-	-	-	-
H. novemdecimus Wilson[134]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
H. shoshone Forbes[135]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
H. victoriaensis Reed[136]		5	-	-	5	-	-	-	-	-	-	-	-	-	-
H. wilsonae Reed[137]		5	-	-	-	-	-	-	-	5	5	-	-	-	-
Heterocope septentrionalis Juday & Muttkowski		5	5	5	5	5	-	5	5	-	-	-	-	-	-
Heterorhabdus papilliger Claus		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Labidocera detruncata Dana		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Leptodiaptomus angustilobus Sars[138]		5	5	5	5	5	-	5	5	-	-	-	-	-	-
L. ashlandi Marsh[139]		5	-	-	-	5	5	5	5	5	5	-	-	-	-
L. connexus Light[140]		5	-	-	-	5	5	5	-	-	-	-	-	-	-
L. minutus Lilljeborg[141]		5	-	5	5	5	-	5	5	5	5	5	5	-	5
L. moorei Wilson[142]		5	-	-	-	-	5	-	-	-	-	-	-	-	-
L. nudus Marsh[143]		5	-	-	-	5	5	5	5	-	-	-	-	-	-
L. sicilis Forbes[144]		5	5	5	5	5	5	5	5	5	5	-	-	-	-
L. siciloides Lilljeborg[145]		5	-	5	-	5	5	5	5	5	5	-	-	-	-
L. tenuicaudatus Marsh[146]		5	-	-	-	-	-	5	-	5	-	-	-	-	-
L. tyrelli Poppe[147]		5	5	5	-	5	5	-	5	-	5	-	-	-	5
Limnocalanus grimaldi De Guerne		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Li. johanseni Marsh		5	-	5	-	-	-	-	-	-	-	-	-	-	-
Li. macrurus Sars		5	-	5	5	-	-	5	5	5	5	5	-	-	-
Mecynocera clausi Thompson		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Metridia longa Lubbock		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. lucens Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Nannocalanus minor Claus[148]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Neocalanus cristatus Krøyer[149]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
N. flemingeri Miller		5	-	-	-	?[150]	-	-	-	-	-	-	-	-	-

[132] Synonym is *Diaptomus kiseri*.
[133] Synonym is *Diaptomus nevadensis*.
[134] Synonym is *Diaptomus novemdecimus*.
[135] Synonym is *Diaptomus Shoshone*.
[136] Synonym is *Diaptomus victoriaensis*.
[137] Synonym is *Diaptomus wilsonae*.
[138] Synonym is *Diaptomus pribilofensis*.
[139] Synonyms are *Diaptomus ashlandi* and *Eutrichodiaptomus ashlandi*.
[140] Synonym is *Diaptomus connexus*.
[141] Synonym is *Diaptomus minutus*.
[142] Synonym is *Diaptomus moorei*.
[143] Synonym is *Diaptomus nudus*.
[144] Synonym is *Diaptomus sicilis*.
[145] Synonym is *Diaptomus siciloides*.
[146] Synonym is *Diaptomus tenuicaudatus*.
[147] Synonym is *Diaptomus tyrelli*.
[148] Synonyms are *Calanus minor* and *Cetochilus minor*.
[149] Synonym is *Calanus cristatus*.
[150] Reported 1500 km offshore of BC coast (Goldblatt et al. 1999).

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
N. plumchrus Marukawa[151]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Onychodiaptomus sanguineus Forbes[152]		5	-	-	-	-	5	5	-	5	5	5	5	-	-
Paracalanus parvus Claus[153]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Paraeuchaeta norvegica Boeck[154]		5	-	-	-	5	-	-	-	-	-	-	5	-	-
P. tonsa Giesbrecht[155]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Pleuromamma robusta Dahl		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Pontella tenuiremis Giesbrecht		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Pseudocalanus elongatas Boeck		5	-	-	5	-	-	-	-	-	-	-	5	-	-
Rhincalanus nasutus Giesbrecht		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Senecella calanoides Juday		5	5	5	-	-	5	5	5	5	5	-	-	-	-
Skistodiaptomus oregonensis Lilljeborg[156]		5	-	5	-	5	5	5	5	5	5	-	5	-	-
S. pygmaeus Pearse[157]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
S. reighardi Marsh[158]		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Spinocalanus longicornis Sars		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Temora longicornis Müller		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Tharybis fultoni Park		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Tortanus discaudatus Thompson & Scott		5	-	-	-	5	-	-	-	-	-	-	5	-	-
Cyclopoida															
Acanthocyclops capillatus Sars		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. carolinianus Yeatman		5	-	-	-	-	-	-	-	5	-	-	-	-	-
A. robustus Sars[159]		5	-	-	-	5	5	5	-	5	-	-	-	-	-
A. venustoides Coker		5	-	-	-	-	-	-	-	5	-	-	5	-	-
A. venustoides bispinosus Yeatman		5	-	-	-	-	-	-	-	5	-	-	-	-	-
A. vernalis Fischer		5	5	5	5	5	5	5	5	5	5	5	5	-	5
Ascidicola rosea Thorell[160]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Botryllophilus bamfieldensis Ooishi		3?	-	-	-	3?	-	-	-	-	-	-	-	-	-
Cyclops abyssorum Sars		5	-	5	5	-	-	-	-	-	-	-	-	-	-
C. capillatus Sars		5	5	5	5	5	-	-	5	-	5	-	-	-	5
C. magnus Marsh		5	5	-	5	-	-	-	-	-	-	-	-	-	-
C. nanus Sars		5	-	5	-	-	-	-	-	-	-	-	-	-	-
C. scutifer Sars		5	5	5	5	5	-	5	5	5	5	5	5	-	5
C. serrulatus Fischer		5	-	-	-	-	-	-	-	-	-	5	-	-	-
C. signatus Koch		5	-	-	-	-	-	-	-	-	-	5	-	-	-

151 Synonym is *Calanus plumchrus*.
152 Synonym is *Diaptomus sanguineus*.
153 Synonym is *Calanus parvus*.
154 Synonym is *Euchaeta norvegica*.
155 Synonym is *Euchaeta tonsa*.
156 Synonym is *Diaptomus oregonensis*.
157 Synonym is *Diaptomus pygmaeus*.
158 Synonym is *Diaptomus reighardi*.
159 Synonyms are *Acanthocyclops* amercanus, *Cyclops robustus* and *Megacyclops robustus*.
160 Synonyms are *Ascidicola aculeoretusa*, *A. setigera*, and *Coilacola setigera*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
C. strenuous Fischer		5	5	-	-	-	-	5	-	-	-	-	-	-	-
C. tenuicornis Claus		5	-	-	-	-	-	-	-	-	-	5	-	-	-
C. varicans Sars		5	-	-	-	-	-	-	-	5	-	-	-	-	-
C. vicinus vicinus Uljanin[161]		5	-	5	-	-	-	-	-	-	-	-	-	-	-
Diacyclops albus Reid		5	-	-	-	-	-	-	-	5	-	-	-	-	-
D. bicuspidatus Claus		5	5	5	-	5	5	5	5	5	5	-	-	-	-
D. chrisae Reid		5	-	-	-	-	-	-	-	5	-	-	-	-	-
D. crassicaudis Sars		5	-	-	-	-	-	5	-	-	-	-	-	-	-
D. languidoides Lilljeborg		5	-	-	-	-	-	5	-	-	-	-	-	-	-
D. navus Herrick		5	-	-	-	5	-	5	5	5	-	-	-	-	-
D. thomasi Forbes		5	-	-	-	-	5	5	-	-	5	-	-	-	-
Doropygopsis longicauda Aurivillius		5	-	-	-	-	-	-	-	-	-	5	5	-	5
Doropygus demissus Aurivillius		5	-	-	-	-	-	-	-	-	5[162]	-	-	-	-
Ectocyclops polyspinosus Harada[163]		5	-	-	-	5	5	-	-	5	-	-	-	-	-
Eucyclops agilis Koch[164]		5	5	-	5	5	5	5	5	5	5	5	-	-	5
E. macruroides denticulatus Graeter[165]		5	-	-	-	-	-	-	-	5	-	-	-	-	-
E. neomacruroides Dussart & Fernando[166]		5	5	5	-	5	5	5	5	5	5	-	-	-	-
E. prionophorus Kiefer		5	-	-	-	-	-	-	-	5	-	-	-	-	-
E. serrulatus Fischer[167]		5	5	-	5	5	5	5	5	5	5	5	-	-	5
Lernaea catostomi Krøyer		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Macrocyclops albidus Jurine		5	5	5	-	5	5	5	5	5	5	-	5	-	5
M. ater Herrick[168]		5	-	-	-	5	-	-	-	5	5	5	-	-	5
M. fuscus Jurine		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Megacyclops latipes Lowndes		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Mg. magnus Marsh		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Mesocyclops americanus Dussart[169]		5	-	-	-	5	5	5	5	5	5	5	-	-	-
Ms. edax Forbes		2?	-	5	-	-	5	5	5	2?	5	5	5	-	5
Microcyclops rubellus Lilljeborg		5	-	-	-	5	5	5	-	-	-	-	-	-	-
Mi. varicans Lilljeborg		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Notodelphys allmani Thorell[170]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Oithona sp. Baird		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Orthocyclops modestus Herrick		5	-	-	-	5	5	5	-	5	5	5	5	-	-
Paracyclops affinis Sars		5	-	-	-	-	-	-	-	5	-	-	-	-	-

161 Synonym is *Cyclops vicinus*.
162 Reported in the St. Lawrence estuary (GBIF 2010), interpreted here as in Quebec.
163 Synonyms are *Ectocyclops phaleratus* and *Platycyclops phaleratus*.
164 Synonym is *Leptocyclops agilis*.
165 Synonym is *Eucyclops lilljeborgi*.
166 Synonym is *Eucyclops speratus*.
167 Synonym is *Eucyclops agilis*.
168 Synonym is *Homocyclops ater*.
169 Synonym is *Mesocyclops leuckarti*.
170 Synonyms are *Notodelphys ascidicola* and *N. mediterranea*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
P. canadensis Willey		5	-	-	-	-	-	-	-	5	-	-	5	-	-
P. fimbriatus Fischer		5	-	-	-	5	5	-	-	-	-	-	-	-	-
P. poppei Rehberg		5	-	-	-	-	5	5	-	-	-	-	-	-	-
P. yeatmani Dagget & Davis		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Pygodelphys aquilonaris Illg		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Schizoproctus inflatus Aurivillius		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Tropocyclops extensus Kiefer*		2?	-	-	-	-	-	-	-	2?	-	-	-	-	-
T. prasinus prasinus Fischer		5	-	-	-	-	-	-	-	5	-	-	-	-	-
T. prasinus mexicanus Kiefer*		2?	-	-	-	-	5	5	5	2?	-	5	5	-	5
Mormonilloida															
Neomormonilla polaris Sars[171]		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Harpacticoida															
Attheyella illinoisensis Forbes		5	5	-	-	-	-	-	-	5	-	-	-	-	-
A. nordenskioldi Lilljeborg		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Bryocamptus hutchinsoni Kiefer		5	-	-	-	5	5	5	-	-	-	-	-	-	-
B. tikchikensis Wilson		5	-	-	5	-	-	-	-	-	-	-	-	-	-
B. vejdovskyi Mrázek		5	-	-	-	-	-	5	-	-	-	-	-	-	-
B. zschokkei Schmeil		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Canthocamptus staphylinoides Pearse		5	-	-	-	5	5	5	-	-	-	-	-	-	-
C. vagus Coker & Morgan		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Cletocamptus albuquerquensis Herrick[172]		5	-	-	-	-	-	5	-	-	-	-	-	-	-
Diosaccus spinatus Campbell		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Elaphoidella subgracilis Willey[173]		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Gorgonophilus canadensis Buhl-Mortensen and Mortensen	Canadian sea fan lover	3?	-	-	3?	-	-	-	-	-	-	-	3?	-	3?
Gulcamptus laurentiacus Flössner[174]		3?	3?	-	-	-	-	-	-	-	-	-	-	-	-
Halectinosoma kliei Clement & Moore[175]		5	-	-	5	-	-	-	-	-	-	-	-	-	-
H. paragothiceps Clement & Moore[176]		5	-	-	-	-	-	-	-	-	5	-	-	-	-
Harpacticus chelifer Müller		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Itunella muelleri Gagern[177]		5	-	-	-	-	-	-	-	-	-	-	5	-	-

* Dussart and Fernando (1990) considered that Ontario records of *T. prasinus mexicanus* had been misidentified in the past and that they actually represented *T. extensus*. However it is unclear whether all other Canadian records of *T. prasinus mexicanus* should be similarly reclassified.

171 Synonym is *Mormonilla polaris*.
172 Synonym is *Marshia albuquerquensis*.
173 Synonym is *Canthocamptus subgracilis*.
174 Synonym is *Neomaraenobiotus laurentiacus*.
175 Synonym is *Ectinosoma finmarchicum*.
176 Synonym is *Ectinosoma gothiceps*.
177 Synonym is *Paramoraria muelleri*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Maraenobiotus canadensis Flössner		3?	3?	-	-	-	-	-	-	-	-	-	-	-	-
Moraria cristata Chappuis		5	-	-	-	-	-	-	-	5	-	-	-	-	-
M. duthiei Scott		5	5	-	-	-	-	-	-	-	-	-	-	-	-
M. laurentica Willey		5	5	-	-	-	-	-	-	5	5	-	-	-	-
M. mrazeki Scott		5	-	5	-	-	-	-	-	5	-	-	-	-	-
Nitokra spinipes Boeck		5	-	5	-	-	-	-	-	-	-	-	-	-	-
Onychocamptus mohammed Blanchard & Richard[178]		5	-	5	-	-	-	-	-	-	-	-	-	-	-
Parathalestris croni Krøyer[179]		5	-	-	5	-	-	-	-	-	-	-	-	-	-
P. jacksoni Scott		5	-	-	5	-	-	-	-	-	-	-	-	-	-
P. lacustris Chappuis															
Porcellidium fimbriatum Claus		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Sacodiscus ovalis Wilson[180]		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Tachidius discipes Giesbrecht		5	-	5	5	-	-	-	-	-	-	-	-	-	-
Tigriopus brevicornis Müller[181]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
T. triangulus Campbell		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Tisbe celata Humes		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Poecilostomatoida															
Acanthochondria rectangularis Fraser[182]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Bomolochus cuneatus Fraser		5	-	-	-	5	-	-	-	-	-	-	-	-	-
B. longisetosus Bere[183]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
B. varians Bere[184]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Chondracanthus deltoideus Fraser[185]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. gracilis Fraser		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. palpifer Wilson[186]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. pinguis Wilson[187]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Clausidium vancouverensis Haddon[188]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Ergasilus auritus Markevich		5	-	-	-	5	-	-	-	-	-	-	-	-	-
E. caeruleus Wilson		5	-	-	-	-	5	-	-	-	-	-	-	-	-
E. celestis Mueller[189]		5	-	-	-	-	-	-	-	5	-	-	-	-	-
E. centrarchidarum Wilson		5	-	-	-	-	-	-	-	-	-	5	-	-	-
E. manicatus Wilson		5	-	-	-	-	-	-	-	-	-	5	-	-	-
E. megaceros Wilson		5	-	-	-	-	-	-	-	-	5	-	-	-	-
E. nerkae Roberts		5	-	-	-	5	-	-	-	-	-	-	-	-	-

[178] Synonym is *Laophonte mohammed*.
[179] Synonym is *Halithalestris croni*.
[180] Synonym is *Unicalteutha ovalis*.
[181] Synonynm is *Cyclops brevicornis*.
[182] Synonym is *Chondracanthus rectangularis*.
[183] Unconfirmed name.
[184] Unconfirmed name.
[185] Synonym is *Acanthochondria deltoidea*.
[186] Synonym is *Acanthochondria palpifer*.
[187] Synonym is *Chondracanthus slastnicovi*.
[188] Synonym is *Hersilia vancouverensis*.
[189] Synonym is *Ergasilus osburni*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
E. turgidus Fraser		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Herpyllobius polynoes Krøyer[190]		5	-	-	-	-	-	-	-	-	-	5	-	-	5
Leptinogaster major Williams		5	-	-	-	-	-	-	-	-	-	-	-	5	-
Myicola metisiensis Wright		5	-	-	-	-	-	-	-	-	5	5	-	-	-
Oncaea sp. Philippi		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Zygomolgus tenuifurcatus Sars[191]		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Siphonostomatoida															
Actheres pimelodi Kroyer		5	-	-	-	-	-	-	-	5	-	-	-	-	-
Anthosoma crassum Abildgaard[192]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Brachiella dentata Wilson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Caligus clemensi Parker & Margolis		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. curtus Müller[193]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
C. rapax Milne Edwards		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Charopinus parkeri Thomson[194]		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Clavella adunca Strøm[195]		5	-	-	-	5	-	-	-	-	-	5	-	-	-
Cl. parva Wilson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Eudactylina acanthi Scott		5	-	-	-	-	-	-	-	-	-	5	-	-	-
E. corrugata Bere		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Gloiopotes hygomianus Steenstrup & Lütken		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Haemobaphes cyclopterina Müller[196]	Roe-bandit gill worm	5	-	-	-	5	-	-	-	-	-	-	-	-	-
Lepeophtheirus bifudus Fraser		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. breviventris Fraser		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. hippoglossi Krøyer		5	-	-	-	-	-	-	-	-	-	-	5	-	-
L. hospitalis Fraser		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. nanaimoensis Wilson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. nordmanni Milne Edwards[197]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. oblitus Kabata		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. parviventris Wilson[198]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. pravipes Wilson[199]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
L. salmonis Krøyer[200]	Salmon louse	5	-	-	-	5	-	-	-	-	5	-	-	-	5
Lernaeocera branchialis Linneaus[201]	Throat-ogre	5	-	-	-	-	-	-	-	-	-	-	5	-	5

[190] Synonyms are *Herpyllobius affinis* and *Silenium polynoes*.
[191] Synonym is *Lichomolgus tenuifurcatus*.
[192] Synonyms are *Anthosoma imbricata*, *A. smithi*, *Caligus crassus*, *C. imbricatus*, *C. smithii* and *Otrophesia imbricate*.
[193] Synonyms are *Caligus aeglefinae*, *C. americanus*, *C. bicuspidatus*, *C. elegans*, *C. fallax* and *C.muelleri*.
[194] Synonym is *Thomsonella parkeri*.
[195] Synonym is *Clavella uncinata*.
[196] Synonyms are *Lernaeocera cyclopterina* and *Schisturus cyclopterinus*.
[197] Synonyms are *Caligus nordmannii*, *C. ornatus*, *Lepeophtheirus insignis*, *L. nordmanni* and *L. ornatus*.
[198] Synonym is *Lepeophtheirus septentrionalis*.
[199] Synonym is *Lepeophtheirus trifudus*.
[200] Synonyms are *Caligus pacificus*, *C. salmonis*, *C. stroemii*, *C. vespa*, *Lepeophtheirus stroemii* and *L. uenoi*.
[201] Synonym is *Lernaea branchialis*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Lernaeopodina longimana Olsson[202]		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Nectobrachia indivisa Fraser		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Parabrachiella robusta Wilson[203]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Penella balaenoptera Koren & Danielssen[204]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
P. filosa Linnaeus[205]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Phrixocephalus cincinnatus Wilson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Pseudocharopinus dentatus Wilson[206]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Salmincola californiensis Dana[207]		5	-	-	-	5	-	-	-	5	-	-	-	-	-
S. edwardsii Olsson[208]		5	-	-	-	5	-	-	-	5	-	-	-	-	-
S. extumescens Gadd[209]		5	-	-	5	-	-	-	-	-	5	-	-	-	-
S. siscowet Smith[210]		5	-	-	-	-	-	-	-	5	-	-	-	-	-
S. thymalli Kessler[211]		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Monstrilloida															
Cymbasoma rigidum Thompson		5	-	-	-	-	-	-	-	-	5	5	5	-	-
Monstrilla anglica Lubbock		5	-	-	-	-	-	-	-	-	-	5	-	5	-
M. arctica Davis & Green		5	-	-	5	-	-	-	-	-	-	-	-	-	-
M. bernardensis Willey		5	-	-	5	-	-	-	-	-	-	-	-	-	-
M. canadensis McMurrich		5	-	-	5	-	-	-	-	-	5	5	-	-	-
M. gigas Scott[212]		5	-	-	-	-	-	-	-	-	-	5	-	-	-
M. helgolandica Claus		5	-	-	-	-	-	-	-	-	5	5	-	-	-
M. longicornis Thompson		5	-	-	5	-	-	-	-	-	-	-	-	-	-
M. nasuta Davis & Green		5	-	-	5	-	-	-	-	-	-	-	-	-	-
M. spinosa Park		5	-	-	-	5	-	-	-	-	-	-	-	-	-

References

Abele, L. G., T. spears, W. Kim and M. Applegate. 1992. Phylogeny of selected Maxillopodan and other crustacean taxa based on 18S ribosomal nucleotide sequences: A preliminary analysis. Acta. Zool. 73(5): 373-382.

[202] Synonyms are *Lernaeopoda cluthae*, *L. longimana* and *L. similis*.
[203] Synonyms are *Brachiella robusta*, *Clavella robusta*, *Clavellopsis robustus* and *Neobrachiella robusta*.
[204] Synonym is *Penella balaenopterae*.
[205] Synonyms are *Lernaea cirrhosa*, *Pennatula filosa*, *P. germonia*, *P. orthagorisci* and *P. rubra.*
[206] Synonym is *Charopinus dentatus*.
[207] Synonyms are *Actheres carpenteri*, *Lernaeopoda beani*, *l. californiensis*, *L. falculata*, *Salmincola beani*, *S. carpenteri*, *S. falculata* and *S. yaname*.
[208] Synonyms are *Lernaeopoda alpine*, *L. arcturi*, *L. bicauliculata*, *L. edwardsii*, *L, fontinalis*, *Salmincola bicaulicata*, *S. edwardsi*, *S. exsanguinata*, *S. heintzi*, *S. mattheyi* and *S. oquassa.*
[209] Synonyms are *Lernaeopoda extumescens*, *L. inermis*, *Salmincola inermis* and *S. omuli*.
[210] Synonym is *Lernaeopoda siscowet*.
[211] Synonyms are *Lernaeopoda clavigera*, *L. thymalli* and *Salmincola baikalensis*.
[212] Synonym is *Thaumaleus gigas*.

Alonso Rodriguez, C., H. J. Browman, J. A. Runge and J-F. St.-Pierre. 2000. Impact of solar ultraviolet radiation on hatching of a marine copepod, *Calanus finmarchicus*. Mar. Ecol. Prog. Ser. 193: 85-93.

Appeltans, W., P. Bouchet, G. A. Boxshall, K. Fauchald, D. P. Gordon, B. W. Hoeksma, G. C. B. Poore, R. W. M. van Soest, S. Stöhr, T. C. Walter and M. J. Costello (eds.). 2010. World Register of Marine Species. World wide web electronic publication http://www.marinespecies.org. [Accessed Dec. 2010].

Archambault, P., P. V. R. Snelgrove, J. A. D. Fisher, J-M. Gagnon, D. J. Garbary, M. Harvey, E. L. Kenchington, V. Lesage, M. Levesque, C. Lovejoy, D. L. Mackas, C. W. McKindsey, J. R. Nelson, P. Pepin, L. Piché and M. Poulin. 2010. From sea to sea: Canada's three oceans of biodiversity. PLoS ONE 5(8): e12182 doi: 10.1371/journal.pone.0012182.

Armstrong, M. (ed.). 2004. Encyclopedia of the Aquatic World, vol. 1. Algae, bacteria, and protists- Barnacle. Marshall Cavendish, New York, NY: 144 pp.

Beamish, R., J. Wade, W. Pennell, E. Gordon, S. Jones, C. Neville, K. Lange and R. Sweeting. 2009. A large, natural infection of sea lice on juvenile Pacific salmon in the Gulf Islands area of British Columbia, Canada. Aquaculture 297: 31-37.

Bernier, R., G. Klassen and A. Locke. 2002. Occurrence of *Cymbasoma rigida* Thompson, 1888 (Copepoda, Monstrilloida) in estuaries of the southern Gulf of St. Lawrence, Canada. Crustaceana 75(5): 649-661.

Bertness, M. D., G. H. Leonard, J. M. Levine and J. F. Bruno. 1999. Climate-driven interactions among rocky intertidal organisms caught between a rock and a hot place. Oecologia 120: 446-450.

Bower, S. M and G. R. Meyer. 1999. Synopsis of infectious diseases and parasites of commercially exploited shellfish: Rhizocephalan parasites of crabs. Worldwide web publication http://www.pac.dfo-mpo.gc.ca/science/species-especes/shellfish-coquillages/diseases/maladies/pages/rhizocb-eng.htm [Accessed on Dec. 1, 2010].

Boxshall, G. A. and D. Defaye. 2008. Global diversity of copepods (Crustacea: Copepoda) in freshwater. Hydrobiologia 595: 195-207.

Bresciani, J. and P. J. López-González. 2001. *Arthurhemesia canadiensis*, new genus and species of a highly transformed parasitic copepod (Crustacea) associated with an ascidian from British Columbia. J. Crust. Biol. 21(1): 90-95.

Buhl-Mortensen, L. and P. B. Mortensen. 2004. *Gorgonophilus canadensis n. gen., n. sp.* (Copepoda: Lamippidae), a gall forming endoparasite in the octocoral *Paragorgia arborea* (L., 1758) from the Northwest Atlantic. Symbiosis 37(1-3); 155-168.

Buhl-Mortensen, L. and P. B. Mortensen. 2005. Distribution and diversity of species associated with deep-sea gorgonian corals off Atlantic Canada. *In* A. Freiwald and J. M. Roberts (eds.), Cold-water Corals and Ecosystems. Springer-Verlag Berlin Heidelberg, pp. 849-879.

Carter, J. C. H., M. J. Dadswell, J. C. Roff and W. G. Sprules. 1980. Distribution and zoogeography of planktonic crustaceans and dipterans in glaciated eastern North America. Can. J. Zool. 58: 1355-1387.

Clément, M. and C. G. Moore. 2007. Towards a revision of the genus *Halectinosoma* (Copepoda, Harpacticoida, Ectinosomatidae): new species from the North Atlantic and Arctic regions. Zool. J. Linn. Soc. 149: 453-475.

Cordell, J. R., L. M. Tear and S. M. Bollens. 2010. Modelling physico-chemical factors affecting occurrences of a non-indigenous planktonic copepod in northeast Pacific estuaries. Biol. Inv. 12: 1427-1445.

Covich, A. P. and J. P. Thorp. 2001. Introduction to the Subphylum Crustacea. *In* Ecology and Classification of North American Freshwater Invertebrates. 2nd Edition. Academic Press: San Diego, CA., pp. 777-800.

Derry, A. M. and S. E. Arnott. 2007. Adaptive reversals in acid tolerance in copepods from lakes recovering from historical stress. Ecol. App. 17(4): 1116-1126.

Dumitru, C., W. G. Sprules and N. D. Yan. 2001. Impact of *Bythotrephes longimanus* on zooplankton assemblages of Harp Lake, Canada: an assessment based on predator consumption and prey production. Fresh. Biol. 46: 241-251.

Dussart, B. H. and C. H. Fernando. 1990. A review of the taxonomy of five Ontario genera of freshwater cyclopoid copepoda (Crustacea). Can. J. Zool. 68: 2594-2604.

Findlay, H. S., M. A. Kendall, J. I. Spicer and S. Widdicombe. 2010. Relative influences of ocean acidification and temperature on intertidal barnacle post-larvae at the northern edge of their geographic distribution. Estu. Coast. Shel. Sci. 86: 675-682.

Flössner, D. 1992. A new genus and a new species of freshwater Canthocamptidae (Copepoda: Harpacticoida) from wet mosses of Canada. Hydrobiologia 234: 7-14.

GBIF 2010. Data portal of the Global Biodiversity Information Facility. Biodiversity occurrence data provided by the Museum of Evolution-Uppsala , the National Museum of Natural History, NatureServe Network Species Occurrence Data, Ocean Biogeographic Information System (OBIS Canada), the University of Alberta Museums, and Yale University's Peabody Museum. World wide web electronic publication http://data.gbif.org [Accessed Oct-Dec. 2010].

Goldblatt, R. H., D. L. Mackas, A. G. Lewis 1999. Mesozooplankton community characteristics in the NE subarctic Pacific. Deep Sea Research II 46: 2619-2644.

Gosselin, L. A. and L. A. Jones. 2010. Effects of solar radiation on barnacle settlement, early post-settlement mortality and community development in the intertidal zone. Mar. Ecol. Prog. Ser. 407: 149-158.

Gray, D. K. and S. E. Arnott. 2009. Recovery of acid damaged zooplankton communities: measurement, extent, and limiting factors. Environ. Rev. 17: 81-99.

Havens, K. E., N. D. Yan and W. Keller. 1993. Lake acidification: effects on crustacean zooplankton populations. Environ. Sci. Technol. 27: 1621-1624.

Ingólfsson, A. and M. B. Steinarsdóttir. 2007. First records of two remarkable copepods (Copepoda, Harpacticoida) in the Upper Littoral fringe of eastern North America. Crustaceana 79(3): 257-261.

ITIS 2010. Integrated Taxonomic Information System. World wide web electronic publication http://www.itis.gov. [Accessed December 2010].

IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1 http://www.iucnredlist.org [Accessed on Nov. 10, 2010].

Kreutzweiser, D. P., R. C. Back, T. M. Sutton, D. G. Thompson and T.A. Scarr. 2002. Community-level disruptions among zooplankton of pond mesocosms treated with a neem (azadirachtin) insecticide. Aquat. Tox. 56: 257-273.

Krkošek, M. 2010. Sea lice and salmon in Pacific Canada: ecology and policy. Front. Ecol. Envir. 8(4): 201-209.

Lecointre, G. and H. LeGuyader. 2006. Maxillopoda. *In* The Tree of Life: A Phylogenetic Classification, pp. 316-317. President and Fellows of Harvard College: U. S. A.

Levings, C. D., J. R. Cordell, S. Ong and G. E. Piercey. 2004. The origin and identity of invertebrate organisms being transported to Canada's Pacific coast by ballast water. Can. J. Fish. Aquat. Sci. 61: 1-11.

Mackas, D. L., R. E. Thomson and M. Galbraith. 2001. Changes in the zooplankton community of the British Columbia continental margin, 1985-1999, and their covariation with oceanographic conditions. Can. J. Fish. Aquat. Sci. 58: 685-702.

Marcogliese, D. J., A. D. Gendron and P. Dumont. 2009. Parasites of illegally introduced tench (*Tinca tinca*) in the Richelieu River, Quebec, Canada. Comp. Parasitol. 76(2): 222-228.

Martin, J. W. and G. E. Davis. 2001. An updated classification of the recent crustacean. Natural History Museum of Los Angeles County No. 39 Science Series.

Mosquin, T., P. G. Whiting and D. E. McAllister. 1995. Canada's biodiversity: the variety of life, its status, economic benefits, conservation costs and unmet needs. Canadian Museum of Nature: Ottawa. Xxiv, 293 pp.

Ooishi, S. 2000. *Botryllophilus bamfieldensis*, new species (Copepoda: Cyclopoida: Ascidicolidae), living in a compound ascidian from the west coast of Vancouver Island, Canada. J. Crust. Biol. 20(3): 571-588.

Patalas, K. 1990. Diversity of the zooplankton communities in Canadian lakes as a function of climate. Verh. Internat. Verhein. Limnol. 24: 360-368.

Patalas, K., J. Patalas and A. Salki. 1994. Planktonic crustaceans in lakes of Canada (Distribution of species, bibliography). Can. Tech. Rep. Fish. Aquat. Sci. 1954: v+ 218 p.

Poloczanska, E. S., S. J. Hawkins, A. J. Southward and M. T. Burrows. 2008. Modeling the response of populations of competing species to climate change. Ecology 89(11): 3138-3149.

Poly, W. J. 2008. Global diversity of fish lice (Crustacea: Branchuiua: Argulidae) in freshwater. Hydrobiologia 595: 209-212.

Reed, E. B. 1991. *Eudiaptomus yukonensis*, new species (Copepoda: Calanoida) from northwestern Canada. J. Crust. Biol. 11(4): 647-652.

Regier, J. C., J. W. Shultz and R. E. Kambic. 2005. Pancrustacean phylogeny: hexapods are terrestrial crustaceans and maxillopods are not monophyletic. Proc. R. Soc. B. 272: 395-401.

Reid, J. W. 1986. Some usually overlooked cryptic copepod habitats. Syllogeus 58: 594-598.

Richter, S., O. S. Møller and C. S. Wirkner. 2009. Advances in crustacean phylogenetics. Arth. Syst. Phyl. 67(2): 275-286.

Samchyshyna, L., L-A. Hansson and K. Christoffersen. 2008. Patterns in the distribution of Arctic freshwater zooplankton related to glaciation history. Polar Biology 31: 1427-1435.

Seuront, L. 2010. Zooplankton avoidance behaviour as a response to point sources of hydrocarbon-contaminated water. Mar. Fresh. Res. 61(3): 263-270.

Shih, C-t. and R. Chengalath. 1994. Freshwater littoral copepods of British Columbia and Alberta (Canada). Hydrobiologia 292/293: 379-388.

Shukalyuk, A. I., V.V. Isaeva, I. I. Pushchin and S. M. Dolganov. 2005. Effects of the *Briarosaccus callosus* infestation on the commercial golden king crab *Lithodes aequispina*. J. Parasitol. 91(6): 1502-1504.

Sloan, N. A. 1984. Incidence and effects of parasitism by the Rhizocephalan barnacle, *Briarosaccus callosus* Boschma, in the golden king crab, *Lithodes aequispina* Benedict, from deep fjords in Northern British Columbia. Can. J. Exp. Mar. Biol. Ecol. 84: 111-131.

Smith, K. E. and C. H. Fernando. 1977. New records and little known freshwater copepods (Crustacea, Copepoda) from Ontario. Can. J. Zool. 55: 1874-1884.

Strecker, A. L., T. P. Cobbs and R. D. Vinebrooke. 2004. Effects of experimental greenhouse warming on phytoplankton and zooplankton communities in fishless alpine ponds. Limnol. Oceanogr. 49(4): 1182-1190.

Strecker, A. L., R. Milne and S. E. Arnott. 2008. Dispersal limitation and climate-related environmental gradients structure microcrustacean composition in freshwater lakes, Ellesmere Island, Canada. Can. J. Fish. Aquat. Sci. 65: 1905-1918.

Swadling, K. M., R. Pienitz and T. Nogrady. 2000. Zooplankton community composition of lakes in the Yukon and Northwest Territories (Canada): relationship to physical and chemical limnology. Hydrobiologia 431: 211-224.

Swadling, K. M., J. A. E. Gibson, R. Pienitz and W. F. Vincent. 2001. Biogeography of copepods in lakes and ponds of subarctic Québec, Canada. Hydrobiologia 453/454: 341-350.

Walseng, B., N. D. Yan and A. K. Schartau. 2003. Littoral microcrustacean (Cladocera and Copepoda) indicators of acidification in Canadian Shield Lakes. Ambio 32 (3): 208-213.

Walter, T. C. and G. A. Boxshall. 2008. World of Copepods database. World wide web electronic publication http://www.marinespecies.org/copepoda. [Accessed Nov-Dec. 2010].

Williams, D. D. 2002. Temporary water crustaceans: biodiversity and habitat loss. Modern Approaches to the Study of Crustacea, pp. 223-233. E. Escobar-Briones and F. Alvarez (eds.) Conference Proceedings of the Summer Meeting of the Crustacea Society, Puerto Vallarta, Mexico, June 26-30.

Williamson, C. E. and J. W. Reid. 2001. Copepoda *In* Ecology and Classification of North American Freshwater Invertebrates. 2nd Edition. Academic Press: San Diego, CA., pp. 915-954.

Yamane, L. and S. E. Graham. 2009. Opposite responses by an intertidal predator to increasing aquatic and aerial temperatures. Mar. Ecol. Prog. Ser. 393: 27-36.

Yan, N. and T. Pawson. 1997. Changes in the crustacean zooplankton community of Harp Lake, Canada, following invasion by *Bythotrephes cederstrœmi*. Fresh. Biol. 37(2): 409-425.

Yan, N. D., A. Blukacz, W. G. Sprules, P. K. Kindy, D. Hackett, R. E. Girard and B. J. Clark. 2001. Changes in zooplankton and the phenology of the spiny water flea, *Bythotrephes*, following its invasion of Harp Lake, Ontario, Canada. Can. J. Fish. Aquat. Sci. 58: 2341-2350.

Yan, N. D., R. Girard, J. H. Heneberry, W. B. Keller, J. M. Gunn and P. J. Dillon. 2004. Recovery of copepod, but not cladoceran, zooplankton from severe and chronic effects of multiple stressors. Ecol. Lett. 7: 452-460.

Zrum, L., B. J. Hann, L. G. Goldsborough and G. A. Stern. 2000. Effects of organophosphorus insecticide and inorganic nutrients on the planktonic microinvertebrates and algae in a prairie wetland. Archi fur Hydro 147(3): 373-399.

10. Malacostraca

Phylum: Arthropoda

Subphylum: Crustacea

Class: Malacostraca

Subclasses: Phyllocarida, Hoplocarida, Eumalacostraca

Superorders: Synacarida, Peracarida, Eucarida (all in Eumalacostraca)

Orders: Leptostraca (Phyllocarida), Stomatopoda (Hoplacarida), Anaspidacea (Synacarida), Bathynellacea (Synacarida), Spelaeogriphacea (Peracarida), Thermosbaenacea (Peracarida), Lophogastrida (Peracarida), Mysida (Peracarida), Mictacea (Peracarida), Amphipoda (Peracarida), Isopoda (Peracarida), Tanaidacea (Peracarida), Cumacea (Peracarida), Euphausiacea (Eucarida), Amphionides (Eucarida), Decapoda (Eucarida)

Malacostraca is the largest class of crustaceans, comprising roughly 2/3 of all living species in the subphylum (Clifford 1991a). Over 25,000 species have been described worldwide, including crabs, lobsters, crayfish, shrimp, prawn, krill, woodlice, and other less familiar taxa. The class exhibits significant morphological diversity, but the general unifying feature is that members have 19-20 body segments divided amongst the head, thorax and abdominal sections (Atwater and Fautin 2001; Clifford 1991a). Malacostraca occur in a variety of marine, freshwater and terrestrial environments. The class appears to be monophyletic, although taxonomic relationships below class level are not well resolved (Martin and Davis 2001, Richter et al. 2009).

Most Malacostraca occur in the orders Amphipoda, Isopoda, and Decapoda. The following annotated list examines the Amphipoda of Canada.

Amphipoda (Peracarida, Eumalacostraca)

Amphipods are a diverse group of Malacostracan crustaceans, with approximately 9100 species in 155 families (Väïnölä et al. 2008). Taxonomy of the order is problematic, because of disparate classifications based on poorly defined characters (Martin and Davis 2001). Three to four suborders are generally recognized: Gammariidea (which contains most families, and is considered the most taxonomically confusing suborder), Caprellidea, Hyperiidea, and Ingolfiellidea (which is sometimes identified as a family of Gammaridea; Schaadt 2003).

Amphipods are small, shrimp-like animals that lack a carapace. They typically have laterally compressed bodies divided into head, thorax and abdomen, and sessile compound eyes. Seven thoracic appendages are divided into two pairs of gnathopods, for feeding, and five pairs used for crawling, jumping and digging. The abdomen has six pairs of appendages: three (pleopods) for swimming and sweeping water through a burrow, and three (uropods) for swimming, jumping and digging. Most species are 5-15 mm long, but some deep sea benthic taxa are 25 cm or more in length (Schaadt 2003).

Amphipods occur in a wide variety of habitats worldwide. Most species are marine, but over 1800 species and subspecies have been identified in freshwater environments, and almost 100 species are terrestrial (Schaadt 2003; Väïnölä et al. 2008). Amphipods also occur in brackish waters. The majority of amphipods are benthic or epibenthic, inhabiting burrows in the mud or sand, or buried in detritus on the surface of the substrate. Some marine taxa (i.e., hyperiids and caprellids) are pelagic, commonly associated as symbionts with other organisms, such as jellyfish, anemones, jellyfish, fish, marine mammals and kelp (Bousfield 1987; Schaadt 2003).

Amphipods are most abundant in cool, temperate environments and are relatively rare in the tropics (Väïnölä et al. 2008). All non-marine amphipods belong to the suborder Gammaridae. Almost half of freshwater taxa are subterranean, occurring in caves (troglobitic forms) and groundwater (stygobitic forms). These hypogean species typically lack eyes and pigmentation. Subterranean forms are particularly diverse in karst landscapes, where they are found in flooded fissures and caverns, and interstitially in groundwater. Amphipods are among the most diverse hypogean animal taxa (Väïnölä et al. 2008).

Freshwater amphipods also inhabit a wide variety of epigean aquatic habitats, including lakes, ponds, rivers, streams, and wetlands (Väïnölä et al. 2008). They occur both in shallow littoral and deeper limnetic and benthic zones of lakes (Hebert 2002). Terrestrial amphipods belong exclusively to the family Talitridae and are found in moist habitats, like forest leaf litter and beaches (Serejo 2009).

The feeding habits of amphipods are extremely varied, with herbivores, carnivores, omnivores and detritivores represented in the order. As scavengers, amphipods play an important role in aquatic food webs, making nutrients and energy from decaying plants and animals available to higher trophic levels (Väïnölä et al. 2008). Carnivorous taxa appear to exert significant pressure on zooplankton communities, similar to that of planktivorous fish (Wilhelm and Schindler 2001; Marion et al. 2008). Ectoparasites attach to marine mammals (e.g., whales, dolphins, porpoises) and marine fishes (e.g., benthic sharks, rockfish, sculpins), feeding on surface mucus, skin tissues, body wastes and discarded food items (Bousfield 1987; Schaadt 2003).

Amphipods are an important food source for numerous animals. In the mudflats of the upper Bay of Fundy, for example, the intertidal amphipod *Corophium volutator* Pallas, reaches densities of 60,000 individuals/m² in summer, supporting many migratory shorebirds (such as the endangered Piping Plover *Charadrius melodus*) and fish (Barbeau et al. 2009).

Amphipods exhibit direct development with no separate larval stage. Females brood their young in a marsupium (brood chamber) between the thoracic appendages. Juveniles go through several molts before maturity (Väïnölä et al. 2008). Amphipods usually live one year, although some species may live for more than two years (Hebert 2002).

Amphipods are widely used as bioindicators of the impact of chemical contaminants such as pesticides, heavy metals, and hydrocarbons on aquatic ecosystems, and in ecotoxicological testing (e.g., Gómez Gesteira and Dauvin 2000; Rinderhagen et al. 2000; Blais et al. 2003; Pastorinho et al. 2009; Adam et al. 2010).

Amphipod Conservation Issues

Seventy-one amphipod species are currently listed on the IUCN Red List, including 51 North American amphipods listed as extinct (one species), endangered (six species) and vulnerable (44 species; IUCN 2010). The majority of North American species listed are freshwater taxa that inhabit caves or underground springs. None are known to occur in Canada.

As a group, amphipods face a number of conservation threats worldwide, including habitat destruction and degradation, pollution, invasive alien species, and climate change. Parasitic species whose hosts are species at risk (like the amphipod *Neocyamus physeteris* Pouchet, which occurs on the vulnerable Sperm whale, *Physeter macrocephalus*) are probably threatened as well, since they occur exclusively on one host species (Schaadt 2003). Cave-dwelling amphipods may be among the most sensitive of all invertebrates to disturbance because of their extremely specific habitat requirements and limited physiological tolerances (NatureServe 2010). Human activities, such as timber harvesting, road construction, and agriculture, can adversely affect these species by altering water infiltration rates, sediment production and debris transport, and by introducing pollutants or organic materials into subterranean aquatic environments. In karst areas, changes to water temperature from human activities can also be a major concern. Furthermore, species accidentally introduced to caves as a result of human activity (e.g., ants) can pose a threat to subterranean invertebrate communities (NatureServe 2010). Recent studies of a marine/estuarine gammarid in Scotland have shown high levels of intersexuality in both males and females at sites of industrial discharge, suggesting that pollution may be disrupting amphipod development (Ford et al. 2004, 2006).

Climate change will likely impact amphipod species in multiple ways, depending on their habitat and life history characteristics. For example, Mouritsen et al. (2005) predicted a parasite-induced collapse of *C. volutator* populations in coastal habitats of temperate North America with a rise of 3.8ºC in ambient temperature. Populations of *Hyalella azteca* Saussure, a common freshwater amphipod in North America, responded to experimental increases of 2-3.5ºC in water temperature with elevated growth rates, precocious breeding and smaller size at maturity (Hogg and Williams 1996). Amphipod biomass declined in boreal wetlands from 1985-1989 to 2001-2003 as a result of drying associated with climate change (Corcoran et al. 2009). Marine amphipod species with symbiotic relationships may be indirectly threatened if their host species are negatively affected by climate change. Cave-dwelling amphipods will likely be vulnerable to increasing demand for groundwater as the frequency and duration of droughts increases worldwide (Väïnölä et al. 2008).

Amphipoda in Canada

The State of Our Knowledge

No systematic inventory of Canadian amphipods has been conducted to date, although smaller scale studies of specific amphipod groups or individual species, or geographic regions, have been carried out (e.g., Holsinger 1980; Bousfield and Holsinger 1981; Bousfield 1987; France 1992; Brunel et al. 1998; Van Overdijk et al. 2003; Barbeau et al. 2009). Significant gaps exist in our knowledge of the basic biology and life history of taxa such as fish parasites (mostly in the genus *Ophisa*) and subterranean species (especially belonging to the rare genus *Stygobromus*; Bousfield 1987; Clifford 1991b). Many undescribed species likely remain to be discovered in poorly studied environments, such as interstitial cave habitats (Holsinger 1976).

Freshwater amphipods exhibit a latitudinal gradient in species diversity, declining in number from 35º to 70ºN (roughly the central United States to the arctic coast of Canada; France 1992). A total of 236 freshwater species occur in North America, representing 12 families and 23 genera. Only 10% of these taxa are found in previously glaciated parts of the continent, likely because insufficient time has passed for recolonization (Väïnölä et al. 2008). Non-glaciated regions are dominated by narrowly endemic species, frequently known only from a single locality. The majority of North American freshwater amphipods (70%) are subterranean. Species diversity is highest in karst landscapes of eastern North America (Väïnölä et al. 2008). Some of the most common amphipod species found in Canada include *Gammarus lacustris* Sars, *G. tigrinus* Sars, and *H*. *azteca*.

The tally of total number of described amphipod species in Canada (Table 10) was derived from a combination of published studies (Holsinger 1980; Bousfield and Holsinger 1981; Schaadt 2003) and online databases (the Global Biodiversity Information Facility Data Portal, GBIF 2010; NatureServe Explorer, NatureServe 2010; the World Register of Marine Species, Appeltans et al. 2010).

A total of at least 270 species of amphipods have been described to date in Canada, comprising 48 families. This tally is likely to be an underestimate since the country's amphipod diversity has not yet been systematically inventoried. One species, *Echinogammarus ischnus* Stebbing, is considered an invasive alien species (Vanderploeg et al. 2002). At least one species, *Paramphithoe hystrix* Ross, may represent several cryptic species (Schnabel and Hebert 2003). The *Diporeia* species complex identified in the Great Lakes is believed to comprise at least two, and possibly eight, species (Cavaletto et al. 1996). Two species, *Stygobromus canadensis* Holsinger, and *S. secundus* Bousfield and Holsinger, are recognized as critically imperiled according to NatureServe, meaning that they are at very high risk of extinction due to extreme rarity, very steep declines or other factors (NatureServe 2010). Two species, *S. borealis* Holsinger, and *S. quatsinensis* Holsinger and Shaw, are recognized as imperiled, meaning that they are at high risk of extinction due to very restricted range, very few populations, steep declines, or other factors (NatureServe 2010). Although no other amphipods are formally recognized as species at risk in Canada, one additional species, *Neocyamus physeteris* Pouchet, is considered potentially at risk in this report because its host species is listed as vulnerable by some jurisdictions.

Potential Species at Risk

Benthic *Diporeia* spp. that occur in the Great Lakes have experienced dramatic declines in population densities since the introduction of dreissenid mussels (i.e., *Dreissena polymorpha* Pallas*, D. bugensis* Andrusov; Barbiero et al. 2011). Although the exact causal mechanisms remain unclear, it is hypothesized that the intensive filtering of water by dreissenids deprives *Diporeia* of food that would normally occur in the water column. The United States Environmental Protection Agency began annual monitoring of benthic macroinvertebrates in the Great Lakes in 1997. While historically *Diporeia* was the dominant benthic invertebrate in all five Great Lakes, it is now declining or absent in many areas. For example, no specimens were found in Lake Erie from 1997-2000. *Diporeia* is almost completely absent from shallow (<90 m) sites in Lakes Huron, Ontario and Michigan, although it is still present in some deep (>90 m) sites in each of these lakes. There is no evidence of a decline in Lake Superior (Barbiero et al. 2011).

Neocyamus physeteris is found only on Sperm whales and occurs throughout its host's range. Sperm whales are currently listed as vulnerable by the IUCN and as endangered under the U. S. Endangered Species Act, although they are not listed as a species at risk in Canada (IUCN 2010; USFWS 2011).

Stygobromus borealis is a rare subterranean amphipod that has been reported in Quebec, as well as New York, Vermont and Massachusetts (where it is listed as endangered). The species is believed to be threatened by groundwater pollution and depletion (MA 2008).

Stygobromus canadensis was the first subterranean amphipod discovered in Canada (Holsinger 1980). It is currently known only from its type locality in Castleguard Cave, situated within Banff National Park in the Alberta Rockies. This cave is the longest and among the deepest in Canada. *Stygobromus canadensis* was found in pools in the cave, but Holsinger (1980) suspected the species might also occur in karst groundwaters. Nothing else is known about the biology of this cave amphipod (Clifford 1991b).

Stygobromus secundus was the second subterranean amphipod discovered in Canada (Bousfield and Holsinger 1981). It is known only from a spring in Alberta. Nothing else is known about its biology (Clifford 1991b).

Stygobromus quatsinensis is a subterranean amphipod known only from caves on Vancouver Island, British Columbia and karst groundwater habitats in the Alexander Archipelago of southeast Alaska (Holsinger and Shaw 1987; NatureServe 2010). It is considered to face substantial imminent indirect threats from timber harvesting (NatureServe 2010).

Threats

Amphipods in Canada face a number of conservation threats, including pollution, invasive alien species and climate change.

Pollution of ground and surface waters can have both sub-lethal and lethal effects on amphipod populations. For example, sediment and stream water near an abandoned copper mine in British Columbia were highly toxic to the amphipod *Eohaustorius washingtonianus* Thorsteinson, because of high levels of the metal and low pH (Levings et al. 2004). Sediment samples collected from seafood-processing plants in New Brunswick caused a greater than 30% reduction in the survival of *Eohaustorius estuarius* Bosworth, due to high levels of sulfide and ammonia and decreased redox reactions (Lalonde et al. 2009). However, it appears that amphipods may be capable of detecting and avoiding areas with high concentrations of sulfide in the sediment, potentially lowering their risk of exposure to this pollutant at least at a small scale (Lalonde et al. 2009). Populations of *Hyalella azteca* exposed to concentrations of seven pharmaceuticals commonly found in Canadian freshwater showed no significant changes in survival, reproduction, or body size. However, the sex ratio became male biased (Borgmann et al. 2007). Amphipods may also be able to detoxify trace metals accumulated through diet and in solution, although the protective mechanisms are not well understood. Pastorinho et al. (2009) found that neonates accumulated cadmium and zinc to a greater extent than juveniles or adults, indicating that this ability likely varies depending on developmental stage.

Amphipods are sensitive to acidification, which has caused drastic changes to zooplankton communities across eastern North America over the last 50 years (Havens et al. 1993). *Hyalella azteca*, the most common and widely distributed freshwater amphipod in North America, disappeared from acidified lakes in Ontario (Stephenson and Mackie 1986). Its recolonization of recovering lakes has gradually occurred four to eight years after a pH threshold of 5.6 had been reached (Snucins 2003).

The non-native amphipod *Echinogammarus ischnus* has rapidly replaced the native *Gammarus fasciatus* Say throughout much of the lower Great Lakes (Kestrup and Ricciardi 2009). Originally from the Ponto-Caspian region, the species was likely transported to North America in ballast water. It was first detected in the Great Lakes in the early 1990s and has since spread to the St. Lawrence, where it also competes with *G. fasciatus*. The invasion of *E. ischnus* has been facilitated by zebra mussels (*D. polymorpha*) and quagga mussels (*D. bugensis*), two other Ponto-Caspian invaders with which the amphipod is closely associated in its native range (Vanderploeg et al. 2002). However, complete replacement of the native *G. fasciatus* has not occurred in all parts of the invaded range. Instead, *E. ischnus* appears to be kept in check in some regions by its intolerance of low conductivity levels, and by its higher susceptibility to infections by a native parasitic water mold (Kestrup and Ricciardi 2010; Kestrup et al. 2011a; Kestrup et al. 2011b). Dreissenid mussels seem to be driving dramatic declines of benthic amphipods belonging to the genus *Diporeia* in the Great Lakes (Barbiero et al. 2011).

As mentioned previously, amphipods may also be adversely affected by climate change. Some species may become more vulnerable to parasitic infections with warming temperatures (Mourtisen et al. 2005), while others may suffer from droughts destroying surface water or groundwater habitat (Corcoran et al. 2009).

<u>Next Steps</u>

Information on the remaining 15 orders of Malacostraca needs to be compiled for Canada. At least one order (Anaspidacea) does not have any representatives in North America (Lowry and Yerman 2002).

Table 10. Distribution and Status of Canadian Amphipoda (Malacostraca) 0.1 = extirpated, 0.2 = extinct, 1 = at risk, 2 = may be at risk, 3 = sensitive, 4 = secure, 5 = undetermined, 6 = not assessed, 7 = exotic, 8 = accidental; ? = status needs further clarification.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Acanthonotozomatidae															
Acanthonotozoma rusanovae Bryazgin		5	-	-	-	-	-	-	-	-	-	5	5	-	5
A. serratum Fabricius		5	-	-	-	-	-	-	-	-	5	5	5	-	-
Ampeliscidae															
Ampelisca abdita Mills		5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. aequicornis Bruzelius		5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. agassizi Judd		5	-	-	-	5	-	-	-	-	-	-	5	-	-

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
A. declivitatis Mills		5	-	-	-	-	-	-	-	-	-	5	-	-	-
A. eschrictii Krøyer[213]		5	-	-	-	-	-	-	-	-	5	-	5	-	5
A. fageri Dickinson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. hancocki Barnard		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. lobata Holmes		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. macrocephala Lilljeborg		5	-	-	-	-	-	-	-	-	5	5	5	-	5
A. vadorum Mills		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Byblis gaimardi Krøyer		5	-	-	-	-	-	-	-	-	5	-	5	-	5
B. serrata Smith		5	-	-	-	-	-	-	-	-	5	-	-	-	-
Haploops fundiensis Wildish & Dickinson		5	-	-	-	-	-	-	-	-	-	5	5	-	-
H. setosa Boeck		5	-	-	-	-	-	-	-	-	5	5	5	-	5
H. tubicola Lilljeborg[214]		5	-	-	-	-	-	-	-	-	5	5	5	-	5
Amphilochidae															
Amphilochus manudens Bate		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Gitanopsis arctica Sars		5	-	-	-	-	-	-	-	-	-	5	5	-	-
G. bispinosa Boeck		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Ampithoidae															
Ampithoe longimana Smith		5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. rubricata Montagu		5	-	-	-	-	-	-	-	-	-	5	5	-	-
A. virescens Stimpson		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Peramphithoe humeralis Stimpson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
P. lindbergi Gurjanova		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Anisogammaridae															
Eogammarus conferricolus Stimpson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Ramellogammarus ramellus Weckel[215]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Aoridae															
Aoroides inermis Conlan & Bousfield[216]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. intermedius Conlan & Bousfield[217]		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Leptocheirus pinguis Stimpson		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Microdeutopus gryllotalpa Costa		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Neohela monstrosa Boeck		5	-	-	-	-	-	-	-	-	5	-	5	-	-
Pseudunciola obliquua Shoemaker		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Unciola inermis Shoemaker		5	-	-	-	-	-	-	-	-	-	5	5	-	-
U. irrorata Say		5	-	-	-	-	-	-	-	-	-	5	5	-	-
U. leucopis Krøyer		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Argissidae															

213 Synonyms are *Ampelisca pelagicus* and *Pseudopthalmus pelagicus*.
214 Synonym is *Haploops spinosa*.
215 Synonym is *Gammarus ramellus*.
216 Synonym is *Aora inermis*.
217 Synonym is *Aora intermedius*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Argissa hamatipes Norman		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Calliopiidae															
Amphithopsis longicaudata Boeck		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Apherusa glacialis Hansen		5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. megalops Buchholz		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Calliopius laeviusculus Krøyer		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Haliragoides inermis Sars		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Laothoes meinerti Boeck		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Weyprechtia pinguis Krøyer		5	-	-	-	-	-	-	-	-	5	-	-	-	-
Caprellidae															
Aeginella spinosa Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Aeginina longicornis Krøyer		5	-	-	-	-	-	-	-	-	5	5	5	-	-
Caprella laeviuscula Mayer		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. linearis Linnaeus		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. pustulata Laubitz		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. rinki Stephenson		5	-	-	-	-	-	-	-	-	-	5	-	-	-
C. septentrionalis Krøyer		5	-	-	-	-	-	-	-	-	5	5	5	-	-
C. ungulina Mayer		5	-	-	-	5	-	-	-	-	-	-	-	-	-
C. unica Mayer		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Cyamus scammoni Dall	Gray whale louse; Whale flea	5	-	-	-	5	-	-	-	-	-	-	-	-	-
Neocyamus physeteris Pouchet	Sperm whale louse; Whale flea	2	-	-	-	2	-	-	-	-	-	2	2	-	-
Tritella laevis Mayer		5	-	-	-	5	-	-	-	-	-	-	-	-	-
T. pilimana Mayer		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Corophiidae															
Apocorophium acutum Chevreux		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Corophium acherusicum Costa		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. bonelli Milne-Edwards		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. crassicorne Bruzelius		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. insidiosum Crawford		5	-	-	-	-	-	-	-	-	-	5	5	-	-
C. lacustre Vanhoffen		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. tuberculatum Shoemaker		5	-	-	-	-	-	-	-	-	-	-	5	-	-
C. volutator Pallas		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Crassicorophium crassicorne Bruzelius		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Monocorophium acherusicum Costa		5	-	-	-	-	-	-	-	-	-	5	-	-	-
M. tuberculatum Shoemaker		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Crangonyctidae															
Crangonyx gracilis Smith	Northern lake crangonyctid	5	-	-	-	-	-	-	-	5	-	-	-	-	-

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
C. minor Bousfield	Small stream crangonyctid	5	-	-	-	-	-	-	-	5	-	-	-	-	-
C. pseudogracilis Bousfield		5	-	-	-	-	-	-	-	5	5	-	-	-	-
C. richmondensis Bousfield		5	-	-	-	-	-	-	-	-	5	-	-	-	-
Stygobromus borealis Holsinger	Taconic cave amphipod; New England cave amphipod; New England stygobromid	1	-	-	-	-	-	-	-	-	1	-	-	-	-
S. canadensis Holsinger	Castleguard cave amphipod; Castleguard cave stygobromid	1	-	-	-	-	1	-	-	-	-	-	-	-	-
S. secundus Bousfield & Holsinger	Alberta spring amphipod; Cordilleran stygobromid	1	-	-	-	-	1	-	-	-	-	-	-	-	-
S. quatsinensis Holsinger & Shaw	Vancouver Island cave amphipod; Vancouver stygobromid	1	-	-	-	1	-	-	-	-	-	-	-	-	-
Dexaminidae															
Atylus carinatus Fabricius		5	-	-	5	-	-	-	-	-	-	-	-	-	-
A. swammerdami Milne-Edwards		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Dexamine thea Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Nototropis smitti Goës		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Dulichiidae															
Dulichia tuberculata Boeck[218]		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Dyopedos arcticus Murdoch[219]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
D. monocantha Metzger[220]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
D. porrectus Bate[221]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Paradulichia typica Boeck[222]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Epimeriidae															
Epimeria loricata Sars		5	-	-	-	-	-	-	-	-	5	5	5	-	-
Paramphithoe hystrix Ross		5	-	-	5	-	-	-	-	-	5	5	5	-	5
Eusiridae															
Eusirus cuspidatus Krøyer		5	-	-	-	-	-	-	-	-	5	-	5	-	-

[218] Synonyms are *Dulichia curticauda* and *D. septentrionalis*.
[219] Synonym is *Dulichia arctica*.
[220] Synonyms are *Dulichia monocantha* and *Dyopedos monocanthus*.
[221] Synonyms are *Dulichia porrecta* and *D. porrectus*.
[222] Synonym is *Paradulichia spinifera*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
E. propinquus Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Halirages fulvocinctus Sars		5	-	-	-	-	-	-	-	-	5	5	5	-	5
Pontogeneia inermis Krøyer		5	-	-	-	-	-	-	-	-	-	5	5	-	5
Rhachotropis aculeata Lepechin		5	-	5	-	-	-	-	-	-	5	-	5	-	-
R. oculata Hansen		5	-	-	-	-	-	-	-	-	5	-	5	-	-
Gammaracanthidae															
Gammaracanthus loricatus Sabine		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Gammarellidae															
Gammarellus angulosus Rathke		5	-	-	-	-	-	-	-	-	-	-	5	-	-
G. homari Fabricius		5	-	-	5	-	-	-	-	-	-	-	5	-	-
Gammaridae															
Echinogammarus ischnus Stebbing		7	-	-	-	-	-	-	-	7	7	-	-	-	-
Gammarus annulatus Smith		5	-	-	-	-	-	-	-	-	-	-	5	-	-
G. duebeni Lilljeborg		5	-	-	-	-	-	-	-	-	-	5	5	-	-
G. fasciatus Say		5	-	-	-	-	-	-	-	5	5	5	-	-	-
G. lacustris Sars		5	-	-	-	5	5	-	-	5	5	-	-	-	-
G. lawrencianus Bousfield		5	-	-	-	-	-	-	-	-	-	5	5	-	5
G. limnaeus Smith		5	-	-	-	-	-	-	-	5	-	-	-	-	-
G. locusta Linnaeus		5	-	-	-	-	-	-	-	-	5	-	5	5	-
G. mucronatus Say[223]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
G. oceanicus Segerstråle		5	-	-	5	-	-	-	-	-	-	5	5	-	5
G. pseudolimnaeus Bousfield		5	-	-	-	-	-	-	-	5	-	-	-	-	-
G. setosus Dementieva		5	-	-	-	-	-	-	-	-	-	-	5	-	-
G. tigrinus Sexton		5	-	-	-	-	-	-	-	-	-	5	5	-	-
G. wilkitzkii Birula		5	-	-	5	-	-	-	-	-	-	-	-	-	-
Marinogammarus finmarchicus Dahl		5	-	-	-	-	-	-	-	-	-	5	5	-	-
M. obtusatus Dahl		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. stoerensis Reid		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Haustoriidae															
Acanthohaustorius millsi Bousfield		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Eohaustorius estuarius Bosworth		5	-	-	-	5	-	-	-	-	-	-	-	-	-
E. washingtonianus Thorsteinson		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Haustorius canadensis Bousfield		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Hyalellidae															
Hyalella azteca Saussure[224]		5	-	-	-	-	5	-	-	5	5	5	5	-	5
Hyalidae															
Apohyale prevostii Milne-Edwards[225]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Hyperiidae															
Cytisoma fabricii Stebbing		5	-	-	-	5	-	-	-	-	5	5	5	5	5
Hyperia galba Montagu		5	-	-	-	5	-	-	-	-	5	5	5	5	5

[223] Synonym is *Carinogammarus mucronatus*.
[224] Synonyms are *Hyalella dentate*, *H. fluvialis*, *H. inermis*, *H. knickerbockeri* and *H. ornata*.
[225] Synonyms are *Hyale danai*, *H. major*, *H. nidrosiensis*, *H. nilssoni*, and *H. prevosti*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
H. medusarum Müller		5	-	-	-	5	-	-	-	-	-	-	5	-	-
Hyperoche medusarum Krøyer		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Scina borealis Sars		5	-	-	-	5	-	-	-	-	-	5	5	-	-
Themisto abyssorum Boeck[226]		5	-	-	-	-	-	-	-	-	5	-	5	-	-
T. compressa Goës[227]		5	-	-	-	-	-	-	-	-	5	-	5	-	-
T. libellula Lichtenstein[228]		5	-	5	5	5	-	-	-	-	5	-	-	-	5
Isaeidae															
Eurystheus melanops Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Gammaropsis melanops Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	-
G. thompsoni Walker		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Protomedeia fasciata Krøyer		5	-	-	-	-	-	-	-	-	-	-	5	-	-
P. grandimana Brüggen		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Ischyroceridae															
Ericthonius difformis Milne-Edwards[229]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
E. fasciatus Stimpson[230]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Ischyrocerus anguipes Krøyer		5	-	-	-	-	-	-	-	-	-	5	5	-	-
I. megacheir Boeck		5	-	-	-	-	-	-	-	-	-	5	5	-	-
I. megalops Sars		5	-	-	-	-	-	-	-	-	-	-	-	-	5
I. parvus Stout		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Jassa falcata Montagu		5	-	-	-	-	-	-	-	-	-	5	-	-	5
J. slatteryi Conlan		5	-	-	-	5	-	-	-	-	-	-	-	-	-
J. staudei Conlan		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Lafystiidae															
Lafystius morhuanus Bousfield		5	-	-	-	-	-	-	-	-	5	5	-	-	-
L. sturionis Krøyer		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Protolafystius madillae Bousfield		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Laphystiopsidae															
Laphystiopsis planifrons Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Leucothoidae															
Leucothoe spinicarpa Abildgaard		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Lycaeidae															
Lycaea pulex Marion		5	-	-	-	-	-	-	-	-	-	-	5		
Lysianassidae															
Centromedon pumilus Lilljeborg		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Hippomedon abyssi Goës		5	-	-	-	-	-	-	-	-	5	-	-	-	-
H. propinquus Sars		5	-	-	-	-	-	-	-	-	-	5	5	-	-
H. serratus Holmes		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Menigrates obtusifrons Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-

[226] Synonym is *Parathemisto abyssorum*.
[227] Synonyms are *Euthemisto compressa* and *Parathemisto compressa*.
[228] Synonym is *Parathemisto libellula*.
[229] Synonyms are *Ericthonius hunteri*, *E. leachii*, *E. longimanus*, *E. ponticus*, and *E. whitei*.
[230] Synonym is *Ericthonius rubricornis*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Opisa odontochela Bousfield		5	-	-	-	5	-	-	-	-	-	-	-	-	-
O. tridentata Hurley[231]		5	-	-	-	5	-	-	-	-	5	-	-	-	-
Orchomene depressa Shoemaker		5	-	-	-	-	-	-	-	-	-	-	5	-	-
O. laevipes Stephenson		5	-	-	5	-	-	-	-	-	-	-	-	-	-
O. macroserratus Shoemaker[232]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Orchomenella affinis Holmes		5	-	-	-	5	-	-	-	-	-	-	-	-	-
O. groenlandica Hansen		5	-	-	-	-	-	-	-	-	-	5	-	-	-
O. minuta Krøyer		5	-	5	5	-	-	-	-	-	-	5	5	-	5
O. pinguis Boeck		5	-	-	-	-	-	-	-	-	5	5	5	-	-
Psammonyx nobilis Stimpson		5	-	-	-	-	-	-	-	-	-	5	5	-	-
P. terranovae Steele		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Socarnes bidenticulatus Bate[233]		5	-	-	-	-	-	-	-	-	-	-	-	-	5
S. vahli Krøyer		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Tryphosella compressa Sars[234]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
T. nanoides Lilljeborg		5	-	-	-	-	-	-	-	-	-	5	-	-	-
T. spitzbergensis Chevreux		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Melitidae															
Maera danae Stimpson		5	-	-	-	-	-	-	-	-	-	5	5	-	-
M. fusca Bate		5	-	-	-	5	-	-	-	-	-	-	-	-	-
M. loveni Bruzelius		5	-	-	-	-	-	-	-	-	-	-	5	5	-
Melita dentata Krøyer		5	-	-	-	-	-	-	-	-	-	5	5	-	5
M. formosa Murdoch		5	-	-	-	-	-	-	-	-	-	-	5	-	5
Melphidippidae															
Casco bigelowi Blake		5	-	-	-	-	-	-	-	-	5	5	5	-	-
Melphidippa borealis Boeck		5	-	-	-	-	-	-	-	-	-	5	-	-	-
M. goësi Stebbing		5	-	-	-	-	-	-	-	-	5	5	5	-	-
M. macrura Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Odiidae															
Odius carinatus Bate		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Oedicerotidae															
Acanthostepheia malmgreni Goës		5	-	-	-	-	-	-	-	-	5	-	-	-	-
Aceroides latipes Sars[235]		5	-	-	-	-	-	-	-	-	5	-	5	-	-
Arrhis phyllonyx Sars		5	-	-	-	-	-	-	-	-	5	-	5	-	-
Bathymedon obtusifrons Hansen		5	-	-	-	-	-	-	-	-	-	5	5	-	-
B. saussurei Boeck		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Deflexilodes intermedius Shoemaker		5	-	-	-	-	-	-	-	-	-	5	-	-	-

[231] Synonym is *Opisa eschrictii*.
[232] Synonym is *Orchomene macroserrata*.
[233] Synonym is *Socarnes ovalis*.
[234] Synonym is *Tryphosa compressa*.
[235] Synonym is *Halicreion latipes*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Monoculodes borealis Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. edwardsi Holmes		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. intermedius Shoemaker		5	-	-	-	-	-	-	-	-	-	5	5	-	-
M. latimanus Goës		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. norvegicus Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. packardi Boeck		5	-	-	-	-	-	-	-	-	-	5	5	-	-
M. tesselatus Schneider		5	-	-	-	-	-	-	-	-	-	5	5	-	-
M. tuberculatus Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Paroediceros lynceus Sars		5	-	-	-	-	-	-	-	-	5	5	5	-	5
Synchelidium tenuimanum Norman		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Westwoodilla brevicalcar Goës		5	-	-	-	-	-	-	-	-	-	-	5	5	-
W. caecula Bate		5	-	-	-	-	-	-	-	-	-	5	5	-	-
W. helle Jansen		5	-	-	-	-	-	-	-	-	-	-	5	-	-
W. megalops Sars		5	-	-	-	-	-	-	-	-	5	-	5	-	-
Oxycephalidae															
Streetsia challengeri Stebbing		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Pardaliscidae															
Halice abyssi Boeck		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Pardalisca cuspidata Krøyer		5	-	-	-	-	-	-	-	-	5	-	5	-	-
Rhynohalicella halona Barnard		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Photidae															
Photis pollex Walker[236]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Podoceropsis inaequistylis Shoemaker		5	-	-	-	-	-	-	-	-	-	-	5	-	-
P. nitida Myers & Mcgrath		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Phoxocephalidae															
Harpinia cabotensis Shoemaker		5	-	-	-	-	-	-	-	-	-	-	5	-	5
H. crenulata Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	-
H. plumosa Krøyer		5	-	-	-	-	-	-	-	-	-	-	5	-	-
H. propinqua Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	-
H. truncata Sars		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Phoxocephalus holbolli Krøyer[237]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Phronimidae															
Phronima sedentaria Forskål		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Phrosinidae															
Primno brevidens Bowman		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Pleustidae															
Neopleustes boecki Hansen		5	-	-	-	-	-	-	-	-	-	-	-	-	5
N. pulchellus Krøyer[238]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Pleustes panoplus Krøyer[239]		5	-	-	-	-	-	-	-	-	-	5	5	-	-

[236] Synonyms are *Photis macrocoxa* and *P. reinhardi*.
[237] Synonyms are *Phoxocephalus kroyeri* and *Phoxus holbolli*.
[238] Synonym is *Paramphithoe pulchella*.
[239] Synonyms are *Ampithoe panopla* and *Pleustes panopla*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
Pleusymtes glaber Boeck[240]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Stenopleustes gracilis Holmes		5	-	-	-	-	-	-	-	-	-	-	5	-	-
S. inermis Shoemaker		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Pontoporeiidae															
Amphiporeia lawrenciana Shoemaker		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Bathyporeia quoddyensis Shoemaker		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Diporeia hoyi Smith		5	-	-	-	-	5	-	-	-	-	-	-	-	-
Diporeia spp.[241]		2	-	-	-	-	-	-	-	2	-	-	-	-	-
Pontoporeia femorata Krøyer		5	-	-	-	-	-	-	-	-	5	-	5	-	5
Priscillina armata Boeck		5	-	-	-	-	-	-	-	-	5	-	5	5	-
Protellidae															
Mayerella banksia Laubitz		5	-	-	-	5	-	-	-	-	-	-	-	-	-
M. limicola Huntsman		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Stegocephalidae															
Andaniopsis nordlandica Boeck		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Phippsiella similis Sars		5	-	-	-	-	-	-	-	-	-	-	-	-	5
Stegocephalus inflatus Krøyer		5	-	-	-	-	-	-	-	-	5	5	5	-	-
Stenothoidae															
Hardametopa carinata Hansen[242]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Metopa alderi Bate		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. boeckii Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. borealis Sars		5	-	-	-	-	-	-	-	-	-	5	5	-	-
M. glacialis Krøyer		5	-	-	-	-	-	-	-	-	5	5	-	-	-
M. groenlandica Hansen		5	-	-	-	-	-	-	-	-	-	-	5	-	-
M. latimana Hansen		5	-	-	-	-	-	-	-	-	-	-	-	-	5
M. longicornis Boeck		5	-	-	-	-	-	-	-	-	-	-	5	-	5
M. norvegica Lilljeborg		5	-	-	-	-	-	-	-	-	-	-	-	-	5
M. propinqua Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	5
M. pusilla Sars		5	-	-	-	-	-	-	-	-	-	5	-	-	5
M. robusta Sars		5	-	-	-	-	-	-	-	-	-	-	5	-	5
M. solsbergi Schneider		5	-	-	-	-	-	-	-	-	-	5	-	-	-
M. tenuimana Sars		5	-	-	-	-	-	-	-	-	5	5	5	-	5
Metopella angusta Shoemaker		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Metopelloides micropalpa Shoemaker[243]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Parametopella cypris Holmes[244]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Stenothoe brevicornis Sars		5	-	-	-	-	-	-	-	-	-	5	5	-	-

[240] Synonyms are *Amphithopsis glaber* and *Sympleustes glaber*.
[241] All *Diporeia spp*. in the Great Lakes were previously classified as *Pontoporeia hoyi*.
[242] Synonym is *Metopella carinata*.
[243] Synonym is *Metopella micropalpa*.
[244] Synonym is *Stenothoe cypris*.

Scientific Name	Common Name	Ca	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL
S. minuta Holmes		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Stenula peltata Smith		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Stilipedidae															
Astyra abyssi Boeck		5	-	-	-	-	-	-	-	-	-	5	-	-	-
Synopiidae															
Syrrhoe crenulata Goës		5	-	-	-	-	-	-	-	-	5	5	5	-	-
S. longifrons Shoemaker		5	-	-	-	5	-	-	-	-	-	-	-	-	-
Tiron spiniferus Stimpson[245]		5	-	-	-	-	-	-	-	-	-	5	5	-	-
Talitridae															
Americorchestia longicornis Say[246]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Orchestia gammarellus Pallas[247]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
O. grillus Bosc		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Megalorchestia californiana Brandt[248]	Beach hopper; beach flea; sand hopper; sand flea; long-horned beach hopper	5	-	-	-	5	-	-	-	-	-	-	-	-	-
Platorchestia platensis Krøyer[249]		5	-	-	-	-	-	-	-	-	-	-	5	-	-
Uristidae															
Anonyx anivae Gurjanova		5	-	-	-	5	-	-	-	-	-	-	-	-	-
A. compactus Gurjanova		5	-	-	-	-	-	-	-	-	-	-	5	-	-
A. debruynii Hoek		5	-	-	-	-	-	-	-	-	-	5	5	-	-
A. laticoxae Gurjanova		5	-	-	5	-	-	-	-	-	-	-	-	-	-
A.lilljeborgi Boeck[250]		5	-	-	-	-	-	-	-	-	5	5	5	-	5
A. makarovi Gurjanova		5	-	-	5	-	-	-	-	-	-	-	5	-	5
A. nugax Phipps		5	-	-	5	-	-	-	-	-	-	-	5	-	-
A. ochoticus Gurjanova		5	-	-	5	-	-	-	-	-	-	-	5	-	5
A. sarsi Steele & Brunel[251]		5	-	-	-	-	-	-	-	-	5	-	5	-	5
Onisimus plautus Krøyer		5	-	5	5	-	-	-	-	-	-	-	-	-	-
Tmetonyx cicada Fabricius		5	-	-	-	-	-	-	-	-	-	5	5	-	-
T. gulosa Krøyer		5	-	-	5	-	-	-	-	-	-	-	-	-	5

245 Synonyms are *Tiron acanthurus*, *T. bicuspis*, *T. hastata*, and *T. spiniferum*.
246 Synonyms are *Talitrus longicornis* and *Talorchestia longicornis*.
247 Synonyms are *Orchestia gammarella* and *O. littorea*.
248 Synonym is *Orchestoidea californiana*.
249 Synonym is *Orchestia platensis*.
250 Synonym is *Anonyx carinatus*.
251 Synonym is *Anonyx lagena*.

References

Adam, O., F. Degiorgi, G. Crini and P-M Badot. 2010. High sensitivity of *Gammarus sp.* juveniles to deltamethrin: outcomes for risk assessment. Ecotoxicology and Environmental Safety 73: 1402-1407.

Appeltans, W., P. Bouchet, G. A. Boxshall, K. Fauchald, D. P. Gordon, B. W. Hoeksma, G. C. B. Poore, R. W. M. van Soest, S. Stöhr, T. C. Walter and M. J. Costello (eds.). 2010. World Register of Marine Species. Worldwide web electronic publication http://www.marinespecies.org. [Accessed Jan.-Mar. 2011].

Atwater, D. and D. G. Fautin. 2001. Malacostraca, Animal Diversity Web. Worldwide web electronic publication http://animaldiversity.ummz.umich.edu/site/accounts/information/Malacostraca.html [Accessed March 2011].

Barbeau, M. A., L. A. Grecian, E. E. Arnold, D. C. Sheahan and D. J. Hamilton. 2009. Spatial and temporal variation in the population dynamics of the intertidal amphipod *Corphium volutator* in the Upper Bay of Fundy, Canada. Journal of Crustacean Biology 29(4): 491-506.

Barbiero, R. P., K., Schmude, B. M. Lesht, C. M. Riseng, G. J. Warren, and M. L. Tuchma. 2011. Trends in Diporeia populations across the Laurentian Great Lakes, 1997–2009. J. Great Lakes. Res. 37: 9-17.

Blais, J. M., F. Wilhelm, K. A. Kidd, D. C. G. Muir, D. B. Donald and D. W. Schindler. 2003. Concentrations of organochlorine pesticides and polycholorinated biphenyls in amphipods (*Gammarus lacustris*) along an elevational gradient in mountain lakes of western Canada. Env. Toxicology and Chemistry 22 (11): 2605-2613.

Borgmann, U., D. T. Bennie, A. L. Ball and V. Palabrica. 2007. Effect of a mixture of seven pharmaceuticals on *Hyalella azteca* over multiple generations. Chemosphere 66: 1278-1283.

Bousfield, E. L. 1987. Amphipod parasites of fishes of Canada. Can. Bull. Fish. Aquat. Sci. 217: 37 pp.

Bousfield, E. L. and J. R. Holsinger. 1981. A second new subterranean amphipod crustacean of the genus *Stygobromus* (Crangonyctidae) from Alberta. Can. J. Zool. 59: 1827-1830

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the marine invertebrates of the Estuary and Gulf of Saint Lawrence. Can. Special Publ. Fish. Aquat. Sci. No. 126, p. i-xi, 1-405. National Research Council Research Press, National Research Council of Canada, Ottawa.

Cavaletto, J., T. Nalepa, R. Dermott, W. Gardner, M. Quigley and G. Lang. 1996. Seasonal variation of lipid composition, weight, and length in juvenile *Diporeia* spp. (Amphipoda) from lakes Michigan and Ontario. Can. J. Fish. Aquat. Sci. 53: 2044-2051.

Clifford, H. F. 1991a. Introduction to the Malacostraca. *In* Aquatic Invertebrates of Alberta: an illustrated guide. University of Alberta Press: Edmonton, Alberta, pp. 173-175.

Clifford, H. F. 1991b. Amphipoda. *In* Aquatic Invertebrates of Alberta: an illustrated guide. University of Alberta Press: Edmonton, Alberta, pp. 176-178.

Corcoran, R. M., J. R. Lovvorn and P. J. Heglund. 2009. Long-term change in limnology and invertebrates in Alaskan boreal wetlands. Hydrobiologia 620: 77-89.

Ford, A. T., T. F. Fernandes, S. A. Rider, P. A. Read, C. D. Robinson and I. M. Davies. 2004. Endocrine disruption in a marine amphipod? Field observations of intersexuality and de-masculinasation. Marine Environmental Research 58(2-5): 169-173.

Ford, A. T., T. F. Fernandes, C. D. Robinson, I. M. Davies and P. A. Read. 2006. Can industrial pollution cause intersexuality in the amphipod, *Echinogammarus marinus*? Marine Pollution Bulletin 53(1-4): 100-106.

France, R. 1992. The North American latitudinal gradient in species richness and geographical range of freshwater crayfish and amphipods. The American Naturalist 139(2): 342-354.

GBIF 2010. Data portal of the Global Biodiversity Information Facility. Biodiversity occurrence data provided by the Biologiezentrum Linz Oberoesterreich, Austria, Alaska Ocean Observing System, National Museum of Natural History, Ocean Biogeographic Information System (OBIS Canada), and Yale University's Peabody Museum. Worldwide web electronic publication http://data.gbif.org [Accessed Jan.-Mar. 2011].

Gómez Gesteira and Dauvin. 2000. Amphipods are good bioindicators of the impact of oil spills on soft-bottom macrobenthic communities. Marine Pollution Bulletin 40(11): 1017-1027.

Havens, K. E., N. D. Yan and W. Keller. 1993. Lake acidification: effects on crustacean zooplankton populations. Environ. Sci. Technol. 27: 1621-1624.

Hebert, P. D. N. 2002. Canada's Aquatic Environment, CyberNatural Software, University of Guelph. Worldwide web electronic publication http://www.aquatic.uoguelph.ca [Accessed March 2011].

Hogg, I. D. and D. D. Williams. 1996. Response of stream invertebrates to a global-warming thermal regime: an ecosystem-level manipulation. Ecology 77(2): 395-407.

Holsinger, J. R. 1976. The freshwater amphipod crustaceans (Gammaridae) of North America. Water Pollution Control Research Series 18050 ELD04/72, U. S. Environmental Protection Agency, Cincinnati, Ohio.

Holsinger, J.R. 1980. *Stygobromus canadensis*, a new subterranean amphipod crustacean (Crangonyctidae) from Canada, with remarks on Wisconsin refugia. Can. J. Zool. 58: 290-297.

Holsinger, J. R. and D. P. Shaw. 1987. *Stygobromus quatsinensis*, a new amphipod crustacean (Crangonyctidae) from caves on Vancouver Island, British Columbia, with remarks on zoogeographic relationships. Can. J. Zool. 65: 2202-2209.

IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1 Worldwide web electronic publication http://www.iucnredlist.org [Accessed on Jan. 19, 2011].

Kestrup, Å. And A. Ricciardi. 2009. Are interactions among Ponto-Caspian invaders driving amphipod species replacement in the St. Lawrence River? J. Great Lakes Research 35: 392-298.

Kestrup, Å. And A. Ricciardi. 2010. Influence of conductivity on life history traits of exotic and native amphipods in the St. Lawrence River. Fundamental and Applied Limnology 176(3): 249-262.

Kestrup, Å. M., J. T. A. Dick and A. Ricciardi. 2011a. Interactions between invasive and native crustaceans: differential functional responses of intraguild predators towards juvenile heterospecifics. Biological Invasions 13: 731-737.

Kestrup, Å. M., S. H. Thomas, K. van Rensburg, A. Ricciardi and M. A. Duffy. 2011b. Differential infection of exotic and native freshwater amphipods by a parasitic water mold in the St. Lawrence River. Biological Invasions 13: 769-779.

Lalonde, B. A., P. Jackman, K. Doe, C. Garron and J. Aubé. 2009. Toxicity testing of sediment collected in the vicinity of effluent discharges from seafood processing plants in the Maritimes. Arch. Environ. Contam. Toxicol. 56: 389-396.

Levings, C. D., K. L. Barry, J. A. Grout, G. E. Piercey, A. D. Marsden, A. P. Coombs and B. Mossop. 2004. Effects of acid mine drainage on the estuarine food web, Britannia Beach, Howe Sound, British Columbia, Canada. Hydrobiologia 525: 185-202.

Lowry, J. K. and M. Yerman. 2002. Anaspidacea: families. Version 2. Worldwide web electronic publication http: //crustacean.net/crustace/anaspidacea/www/anaspid.htm [Accessed March 2011].

Marion, A., M. Harvey, D. Chabot and J. C. Brethes. 2008. Feeding ecology and predation impact of the recently established amphipod, *Themisto libellula*, in the St. Lawrence marine system, Canada. Marine Ecology Progress Series 373: 53-70.

Martin, J. W. and G. E. Davis. 2001. An updated classification of the recent crustacean. Natural History Museum of Los Angeles County. Science Series 39, 132 pp.

Massachusetts Division of Fish and Wildlife (MA). 2008. Taconic cave amphipod *Stygobromus borealis*. Natural Heritage & Endangered Species Program. Worldwide web electronic publication http://www.mass.gov/dfwele/dfw/nhesp/species_info/nhfacts/stygobromus_borealis.pdf [Accessed March 2011].

Mouritsen, K. N., D. M. Tompkins and R. Poulin. 2005. Climate warming may cause a parasite-induced collapse in coastal amphipod populations. Oecologia 146(3): 476-483.

NatureServe. 2010. NatureServe Explorer: an online encyclopedia of life. Version 7.1 Worldwide web electronic publication http://www.natureserve.org/explorer [Accessed March 2011].

Pastorinho, M. R., T. C. Telfer and A. M. V. M. Soares. 2009. Amphipod susceptibility to metals: cautionary tales. Chemosphere 75: 1423-1428.

Richter, S., O. S. Møller and C. S. Wirkner. 2009. Advances in crustacean phylogenetics. Arth. Syst. Phyl. 67(2): 275-286.

Rinderhagen, M., J. Ritterhoff and G-P. Zauke. 2000. Crustaceans as bioindicators. *In* Biomonitoring of Polluted Water- Reviews on Actual Topics. A. Gerhardt (ed.). Trans Tech Publications- Sci Tech Publications, Environmental Research Forum 9: 161-194.

Schaadt, M. S. 2003. Amphipoda (Amphipods) *in* Grzimek's Animal Life Encyclopedia, 2nd Edition. Volume 2, Protosomes. M. Hutchins, S. F. Craig, D. A. Thoney and N. Schlager (eds.). Farmington Hills, MI: Gale Group. Pp. 261-272.

Schnabel, K. E. and P. D. N. Hebert. 2003. Resource-associated divergence in the arctic marine amphipod *Paramphithoe hystrix*. Marine Biology 143: 851-857.

Serejo, C. S. 2009. Talitridae. Zootaxa 2260: 892-903.

Snucins, E. 2003. Recolonization of acid-damaged lakes by the benthic invertebrates *Stenacron interpunctatum*, *Stenonema femoratum* and *Hyalella azteca*. Ambio 32(3): 225-229.

Stephenson, M. G. L. Mackie. 1986. Lake acidification as a limiting factor in the distribution of the freshwater amphipod *Hyalella azteca*. Can. J. Fish. Aquat. Sci. 43: 288-292.

U. S. Fish and Wildlife Service. 2011. Species Profile: Sperm Whale (*Physeter macrocephalus*). Environmental Conservation Online System. Worldwide web electronic publication http://ecos.fws.gov/speciesProfile/profile/speciesprofile.action?spcode=A02T [Accessed March 2011].

Väinölä, R., J. D. S. Witt M. Grabowski, J. H. Bradbury, K. Jazdzewski and B. Sket. 2008. Global diversity of amphipods (Amphipoda; Crustacea) in freshwater. Hydrobiologia 595: 241-255.

Van Overdijk, C. D., I. A. Grigorovich, T. Mabee, W. J. Ray, J. J. H. Ciborowski and H. J. MacIsaac. 2003. Microhabitat selection by the invasive amphipod *Echinogammarus ischnus* and native *Gammarus fasciatus* in laboratory experiments and in Lake Erie. Freshwater Biology 48: 567-578.

Vanderploeg, H. A., T. F. Nalepa, D. J. Jude, E. L. Mills, K. T. Holeck, J. R. Liebig, I. A. Girgorovich and H. Ojaveer. 2002. Dispersal and emerging ecological impacts of Ponto-Caspian species in the Laurentian Great Lakes. Can. J. Fish. Aquat. Sci. 59: 1209-1228.

Wilhelm, F. M. and D. W. Schindler. 2001. *Gammarus lacustris* (Crustacea: Amphipoda) zooplankton predation in a Canadian Rocky Mountain lake. Proceedings of the International Association of Theoretical and Applied Limnology 27: 783-784.

PART 2: CANDIDATE SPECIES LIST

Austrotyla borealis Shear

Canadian range: Alberta

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Myriapoda – myriapods

Class: Diplopoda – gongolo, millipedes, millipedes, piolho de cobra

Subclass: Helminthomorpha

Order: Chordeumatida Koch, 1847

Suborder: Chordeumatidea Koch, 1847

Superfamily: Heterochordeumatoidea Pocock, 1894

Family: Conotylidae Cook, 1896

Subfamily: Austrotylinae Shear, 1976

Genus: *Austrotyla* Causey, 1961

Species: *Austrotyla borealis* Shear, 1971

Austrotyla borealis is one of only two millipede species known to be endemic to Canada, and appears to have a restricted range. To date it has only been described from its type locality on the northwestern slope of Mt. Edith Cavell (at 1615 m) in Jasper National Park, Alberta, although it may occur throughout the Alberta and BC Rockies (Shear 1971; Shelley 2002; W. Shear pers. comm.). Based on its endemicity, Shelley (2002) considered the species “a significant component of the Canadian biota and a worthy candidate for consideration as a rare and endangered species” (p. 1867).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – 100%
iii. Existing global conservation status – None

iv. Canadian population size and trends – Unknown
v. Threats – Unknown
vi. Small extent of occurrence (EO) or area of occupancy (AO) – Restricted to Canadian Rockies
vii. Limiting biological factors – Unknown

References

Shear, W. A. 1971. The millipede family Contylidae in North America, with a description of the new family Adritylidae (Diplopoda: Chordeumida). *Bull. Mus. Comp. Zool.* 141: 55-97.

Shelley, R. M. 2002. The millipeds of central Canada (Arthropoda: Diplopoda), with reviews of the Canadian fauna and diplopod faunistic studies. *Can. J. Zool*. 80: 1863-1875.

Personal Communication

Dr. William Shear, Professor, Biology Department, Hampden-Sydney College, Hampden-Sydney, VA. April 20, 2011.

Branchinecta campestris Lynch

Canadian range: British Columbia, Alberta, Saskatchewan

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Branchiopoda Latreille, 1817 – branchiopodes, branchiopods

Subclass: Sarsostraca Tasch, 1969

Order: Anostraca Sars, 1867 – brine shrimp, fairy shrimp

Suborder: Anostracina

Family: Banchinectidae Daday de Dées, 1910

Genus:*Branchinecta* Verrill, 1869

Species: *Branchinecta campestris* Lynch, 1960 – Pocket-pouch Fairy shrimp

The Pocket-pouch Fairy Shrimp, *Branchinecta campestris*, is known from only seven localities in western North America, many of which have been destroyed. In Washington State the species has been extirpated from much of its former range because its habitat has been inundated by the Grand Coulee Reservoir (Rogers 2006). It is also reported from one locality in California, one locality in Oregon, and one locality in southern British Columbia (C. Rogers pers. comm.). The Pocket-pouch Fairy Shrimp is typically found within a freshwater layer on hypersaline lakes, which forms due to snowmelt or rain runoff. Adults die once this freshwater layer mixes with the underlying salt water. The fairy shrimp is rarely found in hyposaline pools (Lynch 1960; Rogers 2006). Fairy shrimp eggs can remain in a resting stage if environmental conditions are unfavourable (e.g., ponds dry up) for 6-10 months (NatureServe 2010). The species is listed by NatureServe as globally imperiled (G2) because it is experiencing a rapid short term decline and moderate long term decline (NatureServe 2010). It is not ranked in Washington, Oregon or British Columbia, but is considered critically imperiled in California (S1).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – ~14%
iii. Existing global conservation status – Globally imperiled (G2)
iv. Canadian population size and trends – Inferred decline since global short term trend estimated to be a 10-50% decline and global long term trend estimated to be stable to 50% decline (NatureServe 2012)
v. Threats – Loss of habitat due to reservoirs
vi. Small extent of occurrence (EO) or area of occupancy (AO) – EO approximately 5000-20,000 km²; AO probably less than 100 km²
vii. Limiting biological factors – Fairy shrimp are not usually found in waterbodies that have fish and they have restricted habitat requirements with respect to salinity, temperature and pH.

References

Lynch, J. E. 1960. The fairy shrimp *Branchinecta campestris* from northwestern United States (Crustacea: Phyllopoda). *Proc. U. S. Nat. Mus.* 84: 555-566.

NatureServe. 2010. NatureServe Explorer: an online encyclopedia of life. Version 7.1 Worldwide web electronic publication http://www.natureserve.org/explorer [Accessed April 2011].

NatureServe. 2012. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. [Accessed: July 9, 2012].

Rogers, D. C. 2006. Three new species of *Branchinecta* (Crustacea: Branchiopoda: Anostraca) from the Nearctic. *Zootaxa* 1126: 35-51.

Personal Communication

Christopher Rogers, Crustacean Taxonomist and Ecologist, Kansas Biological Survey Kansas University, Lawrence, Kansas. August 25, 2010.

Ornate Fairy Shrimp, *Eubranchipus ornatus* Holmes

Canadian range: Alberta, Manitoba

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Branchiopoda Latreille, 1817 – branchiopodes, branchiopods

Subclass: Sarsostraca Tasch, 1969

Order: Anostraca Sars, 1867 – brine shrimp, fairy shrimp

Suborder: Anostracina

Family: Chirocephalidae Daday de Dées, 1910

Genus: *Eubranchipus* Verrill, 1870

Species: *Eubranchipus ornatus*, Holmes 1910 – Ornate Fairy Shrimp

The Ornate Fairy Shrimp, *Eubranchipus ornatus*, is considered rare in the Central Great Plains of the northern U. S. and southern Canada (southern Alberta and Manitoba), where it is known from less than 25 localities (NatureServe 2010; C. Rogers pers. comm.). The branchiopod occurs in well-vegetated, ephemeral pools with clear cool to cold water, and neutral to low pH (NatureServe 2010). Fairy shrimp eggs can remain in a resting stage if environmental conditions are unfavourable (e.g., ponds dry up) for 6-10 months (NatureServe 2010). The Ornate Fairy Shrimp is listed as globally vulnerable (G3) and imperiled to vulnerable nationally (N2N3) by NatureServe because its low number of populations puts it at moderate risk of extinction (NatureServe 2010).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – Unknown
iii. Existing global conservation status – Globally vulnerable (G3)
iv. Canadian population size and trends – Unknown
v. Threats – Unknown

vi. Small extent of occurrence (EO) or area of occupancy (AO) – EO approximately 5000-20,000 km^2

vii. Limiting biological factors – Fairy shrimp are not usually found in waterbodies that have fish.

References

NatureServe. 2010. NatureServe Explorer: an online encyclopedia of life. Version 7.1 Worldwide web electronic publication http://www.natureserve.org/explorer [Accessed April 2011].

Personal Communication

Christopher Rogers, Crustacean Taxonomist and Ecologist, Kansas Biological Survey Kansas University, Lawrence, Kansas. August 25, 2010.

Leptodora kindtii Focke

Canadian range: Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland and Labrador

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Branchiopoda Latreille, 1817 – branchiopodes, branchiopods

Subclass: Phyllopoda Preuss, 1951

Order: Diplostraca Gerstaecker, 1866

Suborder: Cladocera Latreille, 1829 – cladocères, puces d'eau, water fleas

Infraorder: Haplopoda Sars, 1865

Family: Leptodoridae Lilljebor, 1861

Genus: *Leptodora* Lilljeborg, 1861

Species: *Leptodora kindtii* Focke, 1844

Leptodora kindtii is among the largest of planktonic cladocerans. It is widespread in North American temperate lakes, and is also found throughout Europe and in parts of northern Africa and northern Asia (Abrusan 2003). *Leptodora kindtii* is a voracious predator, mainly feeding on other cladocerans, such as *Bosmina*, *Ceriodaphnia*, and *Diaphanosoma* and regulates densities of its preferred prey (Browman et al. 1989). Abundances of this native predator are negatively correlated with the abundance of the introduced predatory cladoceran *Bythotrephes longimanus* Leydig in the Laurentian Great Lakes, as well as within inland lakes in Ontario (Foster and Sprules 2009; Weisz and Yan 2010). For example, *Leptodora* populations have declined significantly in Lakes Erie and Huron since the *Bythotrephes* invasion (Barbiero and Tuchman 2004). Similarly, Weisz and Yan (2010) documented a widespread replacement of *Leptodora* by *Bythotrephes* in lakes in the Muskoka region of Ontario. It is unclear whether competition or predation is responsible for these observed declines in *Leptodora* populations, since *Bythotrephes* both outcompetes and preys on *Leptodora kindtii* (Branstrator 1995). If this trend continues, the disappearance of a common native Cladoceran species could have drastic repercussions for inland lake food webs in Canada. In particular, Weisz and Yan (2010) predicted that *Leptodora* will experience drastic losses if *Bythotrephes* continues its spread across the Canadian Shield.

i. Taxonomic level – Species
ii. Proportion of global range in Canada – ~20%?
iii. Existing global conservation status – None
iv. Canadian population size and trends – Inferred decline in Ontario due to reduction and disappearance in lakes where invasive non-native *Bythotrephes* present; declines predicted to continue with spread of *Bythotrephes*
v. Threats – invasive alien species *Bythotrephes longimanus*
vi. Small extent of occurrence (EO) or area of occupancy (AO) – Widespread in Canadian temperate lakes
vii. Limiting biological factors – Unknown

References

Abrusan, G. 2003. Morphological variation of the predatory cladoceran *Leptodora kindtii* in relation to prey characteristics. *Oecologia* 134(4): 278-283.

Barbiero, R. P. and M. L. Tuchman. 2004. Changes in the crustacean communities of Lakes Michigan, Huron, and Erie following the invasion of the predatory cladoceran *Bythothrephes longimanus*. *Can. J. Fish. Aquat. Sci.* 61: 2111-2125.

Branstrator, D. K. 1995. Ecological interactions between *Bythotrephes cederstroemii* and *Leptodora kindtii* and the implications for species replacement in Lake Michigan. *J. Great Lakes Res.* 21: 670-679.

Browman, H. I., S. Kruse and W. J. O'Brien. 1989. Foraging behaviour of the predaceous cladoceran, *Leptodora kindtii*, and escape responses of their prey. *J. Plankton Res.* 11(5): 1075-1088.

Foster, S. E. and W. G. Sprules. 2009. Effects of the *Bythotrephes* invasion on native predatory invertebrates. *Limnol. Oceanogr.* 54(3): 757-769.

Weisz, E. J. and N. D. Yan. 2010. Shifting invertebrate zooplanktivores: watershed-level replacement of the native *Leptodora* by the non-indigenous *Bythotrephes* in Canadian Shield lakes. *Biological Invasions* DOI 10.1007/s10530-010-9794-8.

Limnocythere liporeticulata Delorme

Canadian range: Yukon, Northwest Territories

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Ostracoda Latreille, 1802 – ostracodes, ostracods

Subclass: Podocopa

Order: Podocopida Sars, 1866

Suborder: Cytherocopina Baird, 1850

Superfamily: Cytheroidea Baird, 1850

Family: Limnocytheridae Klie, 1938

Genus: *Limnocythere* Brady, 1868

Species: *Limnocythere liporeticulata* Delorme, 1968

The ostracod *Limnocythere liporeticulata* is endemic to the Canadian arctic. The species is widespread and abundant throughout the region, occurring in lakes with a wide range of alkalinity levels, and those having high concentrations of sodium and chloride (Bunbury and Gajewski 2009). It can withstand low water temperatures (e.g., 0-10º C; Bunbury and Gajewski 2009). Because *Limnocythere liporeticulata* is restricted to arctic freshwater environments its populations may be threatened by climate change in the future (J. Bunbury pers. comm.).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – 100%
iii. Existing global conservation status – None
iv. Canadian population size and trends – Widespread and abundant in arctic lakes

v. Threats – Climate change
vi. Small extent of occurrence (EO) or area of occupancy (AO) – Widespread in the Yukon and Northwest Territories
vii. Limiting biological factors – Requires cold water temperatures

References

Bunbury, J. and K. Gajewski. 2009. Biogeography of freshwater ostracodes in the Canadian arctic archipelago. *Arctic* 62(3): 324-332.

Personal Communication

Dr. Joan Bunbury, Department of Geography, University of Toronto, Toronto, ON. April 28, 2011.

Pollicipes polymerus Sowerby

Canadian range: British Columbia

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Maxillopoda

Subclass: Thecostraca Gruvel, 1905

Infraclass: Cirripedia Burmeister, 1834 – barnacles, bernacles

Superorder: Thoracica Darwin, 1854 -- barnacles

Order: Pedunculata Lamarck, 1818 – stalked barnacles

Suborder: Scalpellomorpha Newman, 1987

Family: Pollicipedidae Leach, 1817

Genus: *Pollicipes* Leach, 1817

Species: *Pollicipes polymerus* Sowerby, 1833 – Leaf Barnacle, Goose Neck Barnacle, Goose Barnacle

The Leaf Barnacle, *Pollicipes polymerus*, is a stalked or pedunculate barnacle native to the west coast of North America, where it ranges from southern Alaska to Baja California (DFO 1998). Populations also occur in southern Europe (Garand 2001). Leaf Barnacles are abundant in the high to mid intertidal zone on rocky wave-exposed coasts, often associated with Acorn Barnacles (*Balanus cariosus* Pallas) and California Mussels (*Mytilus californianus* Conrad; Lessard et al. 2003). They are a major prey item of Glaucous-winged Gulls (*Larus glaucescens* Naumann; Vermeer 1982). Leaf Barnacles have been harvested as a traditional food of B. C. First Nations for thousands of years, and an active native fishery still occurs today. The species is considered a delicacy in France, Spain and Portugal, where local populations have been depleted (Garand 2001). A commercial fishery was established in B. C. in the late 1970s to supply European markets, but subsequently shut down in 1999 because of concerns over regulation, ecological damage and overexploitation (Lessard et al. 2003; C. Harley pers. comm.).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – ?
iii. Existing global conservation status – None
iv. Canadian population size and trends – Overall status unknown but vulnerable to localized depletions
v. Threats – Overexploitation by humans
vi. Small extent of occurrence (EO) or area of occupancy (AO) – Widespread along B. C. west coast
vii. Limiting biological factors – Resettlement of rocky substrate may depend on presence of other barnacles (Bernard 1988)

References

Bernard, F. R. 1988. Potential fishery for the gooseneck barnacle *Pollicipes polymerus* (Sowerby, 1833) in British Columbia. *Fish. Res.* 6(3): 287-298.

DFO. 1998. Goose barnacle. Department of Fisheries and Oceans Science Stock Status Report C6-06.

Garand, C. 2001. “Pollicipes polymerus”, Animal Diversity Web, World Wide Web publication, http://animaldiversity.ummz.umich.edu/site/accounts/information/Pollicipes_polymerus.html [Accessed April 2011].

Lessard, J., J. Osborne, R. Lauzier, G. Jamieson and R. Harbo. 2003. Applying local and scientific knowledge to the establishment of a sustainable fishery: the West Coast Vancouver Island goose barnacle fishery experience. Putting Fishers’ Knowledge to Work Conference Proceedings Aug. 27-30, 2001, *Fisheries Centre Research Reports* 11(1): 36-43.

Vermeer, K. 1982. Comparison of the diet of the Glaucous-winged Gull on the east and west coasts of Vancouver Island. *The Murrelet* 63: 80-85.

Personal Communication

Dr. Chris Harley, Associate Professor, Department of Zoology, University of British Columbia,Vancouver, BC. April 28, 2011.

Stygobromus canadensis Holsinger

Canadian range: Alberta

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Malacostraca

Subclass: Eumalacostraca Grobben, 1892

Superorder: Peracarida Calman, 1904 – barata da praia, pulga da praia, tatuzinho de jardim

Order: Amphipoda Latreille, 1816 – amphipodes, amphipods

Suborder: Gammaridea Latreille, 1802 – gammarid amphipods

Family: Crangonyctidae Bousfield, 1973

Genus: *Stygobromus* Cope, 1872

Species: *Stygobromus canadensis* Holsinger, 1980 – Castleguard Cave Stygobromid, Castleguard Cave Amphipod

The Castleguard Cave Stygobromid, *Stygobromus canadensis*, was the first subterranean amphipod discovered in Canada (Holsinger 1980). It is currently known only from its type locality in Castleguard Cave, situated within Banff National Park in the Alberta Rockies (Wang and Holsinger 2001). This cave is the longest and among the deepest in Canada. The Castleguard Cave Stygobromid was found in pools in the cave, but Holsinger (1980) suspected the species might also occur in karst groundwaters. Nothing else is known about the biology of this cave amphipod (Clifford 1991). The species is listed as critically imperiled (G1) both globally and within Alberta (S1) because its extreme rarity puts it at high risk of extinction (NatureServe 2010).

i. Taxonomic level – Species

ii. Proportion of global range in Canada – 100%
iii. Existing global conservation status – Globally critically imperiled (G1)
iv. Canadian population size and trends – Population inferred to be extremely small due to single record in subterranean pools
v. Threats – Habitat loss or disturbance
vi. Small extent of occurrence (EO) or area of occupancy (AO) – <100 km²
vii. Limiting biological factors – Unknown

References

Holsinger, J.R. 1980. *Stygobromus canadensis*, a new subterranean amphipod crustacean (Crangonyctidae) from Canada, with remarks on Wisconsin refugia. *Can. J. Zool.* 58: 290-297.

NatureServe. 2010. NatureServe Explorer: an online encyclopedia of life. Version 7.1 Worldwide web electronic publication http://www.natureserve.org/explorer [Accessed March 2011].

Wang, D. and J. R. Holsinger. 2001. Systematics of the subterranean amphipod genus *Stygobromus* (Crangonyctidae) in western North America, with emphasis on species of the hubbsi group. *Amphipacifica* 3(2): 39-147.

Stygobromus quatsinensis Holsinger & Shaw

Canadian range: British Columbia

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Malacostraca

Subclass: Eumalacostraca Grobben, 1892

Superorder: Peracarida Calman, 1904 – barata da praia, pulga da praia, tatuzinho de jardim

Order: Amphipoda Latreille, 1816 – amphipodes, amphipods

Suborder: Gammaridea Latreille, 1802 – gammarid amphipods

Family: Crangonyctidae Bousfield, 1973

Genus: *Stygobromus* Cope, 1872

Species: *Stygobroumus quatsinensis* Holsinger & Shaw, 1987 – Vancouver Island Cave Amphipod, Vancouver Stygobromid

The Vancouver Island Cave Amphipod, *Stygobromus quatsinensis*, is a subterranean amphipod known only from caves on Vancouver Island, British Columbia and karst groundwater habitats in the Alexander Archipelago of southeast Alaska (Holsinger and Shaw 1987; NatureServe 2010). It is a blind, unpigmented amphipod that occurs in cave streams, springs and pools with mud, pebble, cobble or bare rock substrate. The amphipod is believed to feed on organic matter entering its subterranean habitat through runoff, seeps and streams. It is considered to face substantial imminent threats from timber harvesting, which could alter or destroy its specialized habitat (e.g., by affecting water infiltration, sediment production and debris transport, and by introducing pollutants or organic materials that alter water chemistry; NatureServe 2010). The Vancouver Island Cave Amphipod is considered globally imperiled (G2) and vulnerable to imperiled nationally (N2N3) and within British Columbia (S2S3) because of its restricted range and relatively few populations (NatureServe 2010).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – 50%?
iii. Existing global conservation status – Globally imperiled (G2), S2S3 in British Columbia and Alaska
iv. Canadian population size and trends – Between 6-20 populations estimated globally
v. Threats – Habitat loss or disturbance due to logging and road construction, temperature changes, introduced non-native species. Threats are considered to be very high to high.
vi. Small extent of occurrence (EO) or area of occupancy (AO) – 250-1000 km²
vii. Limiting biological factors – Restricted to subterranean freshwater environments with low temperatures (~3-8.5ºC) and pH between 7.5-8.0, and having small amounts of organic matter

<u>References</u>

Holsinger, J. R. and D. P. Shaw. 1987. *Stygobromus quatsinensis*, a new amphipod crustacean (Crangonyctidae) from caves on Vancouver Island, British Columbia, with remarks on zoogeographic relationships. *Can. J. Zool.* 65: 2202-2209.

NatureServe. 2010. NatureServe Explorer: an online encyclopedia of life. Version 7.1 Worldwide web electronic publication http://www.natureserve.org/explorer [Accessed March 2011].

Tropocyclops extensus Kiefer

Canadian range: Ontario (perhaps elsewhere in Canada also)

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode
Subphylum: Crustacea Brünnich, 1772 – crustaceans, crustáceo, crustacés

Class: Maxillopoda

Subclass: Copepoda Milne-Edwards, 1840 – copépodes, copepods

Infraclass: Neocopepoda Huys & Boxshall, 1991

Superorder: Podoplea Giesbrecht, 1882

Order: Cyclopoida Burmeister, 1834

Family: Cyclopidae Dana, 1846

Genus: *Tropocyclops* Kiefer, 1927

Species: *Tropocyclops extensus* Kiefer, 1931

Tropocyclops extensus is a small, primarily herbivorous copepod that occurs across North America. Studies in Harp Lake, Ontario have shown that this copepod species experiences precipitous declines in the presence of the introduced predatory cladoceran *Bythotrephes longimanus* Leydig (Yan and Pawson 1997; Dumitru et al. 2001). *Tropocyclops extensus* formed a major component of the diet of *Bythotrephes* and was the most vulnerable of all small zooplankton species to the invasive predator (Dumitru et al. 2001). In fact, consumption of this copepod species by the non-native cladoceran was found to greatly exceed its production. If *Bythotrephes* continues its spread through Canadian Shield lakes and into other areas of North America it could lead to similar declines in populations of *Tropocyclops extensus* in other lakes (N.Yan pers. comm.).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – ?
iii. Existing global conservation status – None
iv. Canadian population size and trends – Inferred decline in Ontario due to reduction in lakes where invasive non-native *Bythotrephes* present; declines predicted to continue with spread of *Bythotrephes*
v. Threats – invasive alien species *Bythotrephes longimanus*

vi. Small extent of occurrence (EO) or area of occupancy (AO) – Widespread in Canadian lakes

vii. Limiting biological factors – Unknown

References

Dumitru, C., W. G. Sprules and N. D. Yan. 2001. Impact of *Bythotrephes longimanus* on zooplankton assemblages of Harp Lake, Canada: an assessment based on predator consumption and prey production. *Fresh. Biol.* 46: 241-251.

Yan, N. and T. Pawson. 1997. Changes in the crustacean zooplankton community of Harp Lake, Canada, following invasion by *Bythotrephes cederstrœmi*. *Fresh. Biol.* 37(2): 409-425.

Personal Communication

Dr. Norman Yan, Professor, Department of Biology, York University, Toronto, ON. January 7, 2011.

Tubaphe levii Causey

Canadian range: British Columbia

Kingdom: Animalia –Animal, animals, animaux

Phylum: Arthropoda – arthropods, arthropods, Artrópode

Subphylum: Myriapoda – myriapods

Class: Diplopoda – gongolo, millipedes, millipedes, piolho de cobra

Subclass: Helminthomorpha

Order: Polydesmida

Suborder: Chelodesmidea Cook, 1895

Family: Xystodesmidae Cook, 1895

Tribe: Chonaphini Verhoeff, 1941

Genus: *Tubaphe* Causey, 1954

Species: *Tubaphe levii* Causey, 1954 (also known by junior synonym *Metaxycheir pacifica*)

Tubaphe levii is restricted to rainforest habitat on the west coast of Vancouver Island and on the Olympic Peninsula, Washington State. In the Olympic Mountains it is typically associated with decaying deciduous logs, usually under bark. On Vancouver Island it has only been found in deciduous leaf litter, and seems to be limited to deciduous patches within dense, primarily coniferous forests, where little light filters down to the forest floor (Shelley 1994). In Canada, this millipede species has so far been documented within a narrow coastal strip along the western edge of Vancouver Island, extending only 5-10 km inland from Bamfield to China Beach Provincial Park (Shelley 1990). However, its range may also stretch further north along the Pacific coast of Vancouver Island. Much of the millipede's forest habitat has been heavily logged in British Columbia, and it is unlikely to occur in monoculture conifer plantations that typically replace the clearcut native forests (Shelley 1990).

i. Taxonomic level – Species
ii. Proportion of global range in Canada – ~50-75%
iii. Existing global conservation status – None
iv. Canadian population size and trends – Inferred decline due to decline in its forest habitat on Vancouver Island
v. Threats – clearcut logging
vi. Small extent of occurrence (EO) or area of occupancy (AO) – EO ~300-600 km
vii. Limiting biological factors – appears to require mainly coniferous forest with deciduous patches and dense overstory

References

Shelley, R. M. 1990. A new millipede of the genus *Metaxycheir* from the Pacific coast of Canada (Polydesmida: Xystodesmidae), with remarks on the tribe Chonaphini and the western Canadian and Alaskan diplopod fauna. *Can. J. Zool*. 68: 2310-2322.

Shelley, R. M. 1994. The Chonaphini, a biogeographically significant Milliped tribe in Eastern and Western North America (Polydesmida: Xystodesmidae). *Brimleyana* 20: 111-200.

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PART 4: REFERENCES FOR CRUSTACEANS AND RELATED TAXA

Phoronida

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the Marine Invertebrates of the Estuary and Gulf of Saint Lawrence. Canadian Special Publication of Fisheries and Aquatic Sciences 126. 405 p.

Burd, B. J. and R. O. Brinkhurst. 1987. Macrobenthic infauna from Hecate Strait, British Columbia. Can. Tech. Report of Hydrography and Ocean Sciences. No. 88. Institute of Ocean Sciences, Department of Fisheries and Oceans, Sidney, BC.

Cohen, B. L. 2000. Monophyly of brachiopods and phoronids: reconciliation of molecular evidence with Linnean classification (the subphylum Phoroniformea nov.). *Proc. R. Soc. Lond.* B. 267: 225-231.

Duméril, A. M. 1806. Zoologie analytique au méthode naturelle de classification des animaux. Paris: Allais.

Emig, C. C. 1977. Un nouvel embranchement: les Lophophorates. *Bull. Soc. Zool. France* 102: 341-344.

Emig, C. C. 1985. Phylogenetic systematics in Phoronida (Lophophorata). *Z. Zool. System. Evolut.-forsch.* 23: 184-193.

Emig, C. C. 2003 Phoronida. *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 491-497.

Gilchrist, J. D. 1907. New forms of the Hemichordata from South Africa. *Trans. S. Afr. Phil. Soc.* 17: 151-176.

Johnson, A. S. 1988. Hydrodynamic study of the functional morphology of the benthic suspension feeder *Phoronpsis viridis* (Phoronida). *Mar. Biol.* 100: 117-126.

Santagata, S. 2004. A waterborne behavioral cue for the actinotroch larva of *Phoronis pallida* (Phoronida) produced by *Upogebia pugettensis* (Decapoda: Thalassinidea). *Biol. Bull.* 207: 103-115.

Wright, T. S. 1856. Description of two tubicolar animals. *Proc. R. Soc. Edinb.* 1: 165-167.

Pentastomida

Abele, L. G., W. Kim, and B. E. Felgenhauer. 1989. Molecular evidence for the inclusion of the Phylum Pentastomida in the crustacean. *Mol. Biol. Evol.* 6: 685-691.

Gyorkos, T. W. and D. K. McE. Kevan. 1979. Pentastomida. *Mem. Ent. Soc. Canada* 108: 290-291.

Lavrov, D. V., W. M. Brown, J. L. Boore. 2004. Phylogenetic position of the Pentastomida and (pan) crustacean relationships. *Proc. R. Soc. Lond.* 271: 537-544.

Riley, J. 1986. The biology of pentastomids. *Adv. Parasitol.* 25: 45-128.

Tappe, D. and D. W. Büttner. 2009. Diagnosis of human visceral pentastomiasis. PLOS. Negl. Trop. Dis. 3: e320.3oi:10.1371/journal.pntd.0000320.

Pauropoda

Scheller, U. 1979. Pauropoda. *Mem. Ent. Soc. Can.* 108: 294.

Scheller, U. 1983. Pauropoda (Myriapoda) from Canada. *Can. J. Zool.* 62: 2074-2091.

Scheller, U. 2003 Pauropoda (Pauropods). *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 375-377.

Tomlin, A. D. 1982. Pauropoda (Arthropoda: Myriapoda) do occur in Canada. *Can. Entomol.* 114: 655-657.

Symphyla

Behan-Pelletier, V. M. 1993. Diversity of soil arthropods in Canada: systematic and ecological problems. *Mem. Ent. Soc. Can.* 165: 11-50.

Peachey, R. E., A. Moldenke, R. D. William, R. Berry, E. Ingham and E. Groth. 2002. Effect of cover crops and tillage system on symphylan (Symphyla: *Scutigerella immaculata,* Newport) and *Pergamasus quisquiliarum* Canestrini (Acari: Mesostigmata) populations, and other soil organisms in agricultural soils. *App. Soil Ecol.* 21: 59-70.

Scheller, U. 1979. Symphyla. *Mem. Ent. Soc. Can.* 108: 299.

Scheller, U. 2003. Symphyla (Symphylans). *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 371-373.

Shanks, C. H. Jr. 1966. Factors that affect reproduction of the garden symphylan, *Scutigerella immaculata*. *J. Econ. Ent.* 59: 1403-1406.

Waterhouse, J. S. 1967. Population studies of the garden symphylan *Scutigerella immaculata* (Symphyla: Scutigerellidae). *Can. Ent.* 99: 696-702.

Waterhouse, J. S. 1968. Studies on the garden symphylan, *Scutigerella immaculata* (Symphyla: Scutigerellidae). *Can. Ent.* 100: 172-178.

Diplopoda

Adamski, Z., J. Błoszyk, K. Piosik and K. Tomczak. 2009. Effects of diflubensuron and mancozeb on soil microarthropods: a long-term study. *Bio. Lett.* 46(1): 3-13.

Behan-Pelletier, V. M. 1993. Diversity of soil arthropods in Canada: systematic and ecological problems. *Mem. Ent. Soc. Can.* 165: 11-50.

Brunke, A. J., C. A. Bahlai, M. K. Sears and R. H. Hallett. 2009. Generalist predators (Coleoptera: Carabidae, Staphylinidae) associated with millipede populations in sweet potato and carrot fields and implications for millipede management. *Env. Ent.*. 38(4): 1106-1116.

Cárcamo, H. A., T. A. Abe, C. E. Prescott, F. B. Holl, and C. P. Chanway. 2000. Influence of millipedes on litter decomposition, N mineralization, and microbial communities in a coastal forest in British Columbia, Canada. *Can. J. For. Res.* 30: 817-826.

Davis, D. S., and B. Wright. 2002. Further studies of the leaf litter fauna in Kejimkujik National Park, Biodiversity Monitoring Plots 1 & 2. Final Report, April 2002.

Grelle, C., M. C. Fabre, A. Leprete and M. Descamps. 2000. Myriapod and isopod communities in soils contaminated by heavy metals in northern France. *Eur. J. Soil Sci.* 51(3): 425-433.

Hoffman, R. L. 1979. Diplopoda. *Mem. Ent. Soc. Canada* 108: 294-296.

Kevan, D. K. McE. 1983. A preliminary survey of known and potentially Canadian millipedes (Diplopoda). *Can. J. Zool*. 61: 2956-2975.

Kevan, D. K. McE., and G. G. E. Scudder. 1989. Illustrated keys to the families of terrestrial arthropods of Canada. I Myriapods (Millipedes, Centipedes, etc.). Biological Survey of Canada Taxomonic Series No. 1.

McAllister, C. T., R. M. Shelley, and S. E. Trauth. 2009. *Aniulus garius* (Chamberlin, 1912), a widespread millipede in Central and Eastern North America (Julida: Parajulidae: Aniulini). Pp. 223-231 *in* S. M. Roble and J. C. Mitchell (eds.) A Lifetime of Contributions to Myriapodology and the Natural History of Virginia: A Festschrift in Honor of Richard L. Hoffman's 80th Birthday. Virginia Museum of Natural History Special Publication No. 16, Martinsville, VA.

Shear, W. A. 1971. The millipede family Contylidae in North America, with a description of the new family Adritylidae (Diplopoda: Chordeumida). *Bull. Mus. Comp. Zool.* 141: 55-97.

Shear, W. A. 2004. Two new species in the millipede genus *Taiyutla* from British Columbia, Canada, and Washington, USA (Diplopoda, Chordeumatida, Conotylidae). *Myriapodologica* 8(2): 13-20.

Shelley, R. M. 1988. The millipeds of eastern Canada (Arthropoda: Diplopoda). *Can. J. Zool*. 66: 1638-1663.

Shelley, R. M. 1990. A new millipede of the genus *Metaxycheir* from the Pacific coast of Canada (Polydesmida: Xystodesmidae), with remarks on the tribe Chonaphini and the western Canadian and Alaskan diplopod fauna. *Can. J. Zool*. 68: 2310-2322.

Shelley, R. M. 1993. The millipede genus *Underwoodia* (Chordeumatida: Caseyidae). *Can. J. Zool*. 71: 168-176.

Shelley, R. M. 1994. The Chonaphini, a biogeographically significant Milliped tribe in Eastern and Western North America (Polydesmida: Xystodesmidae). *Brimleyana* 20: 111-200.

Shelley, R. M. 1996. The millipede family Hirudisomatidae in the New World (Polyzoniida) *Brimleyana* 23: 103-143.

Shelley, R. M. 1999. Centipedes and millipedes with emphasis on North American fauna. *The Kansas School Naturalist* 45(3): 1-15.

Shelley, R. M. 2002a. The millipeds of central Canada (Arthropoda: Diplopoda), with reviews of the Canadian fauna and diplopod faunistic studies. *Can. J. Zool*. 80: 1863-1875.

Shelley, R. M. 2002b. The millipede genus *Oriulus* Chamberlin (Julida: Parajulidae). *Can. J. Zool*. 80: 100-109.

Shelley, R. M. 2007. Occurrence of the millipede genus *Scytonotus* C. L. Koch, 1847 (Polydesmida: Polydesmidae) in Alberta Canada. *Ent. News* 118 (3): 319-320.

Shelley, R. M., W. A. Shear, W. P. Leonard and K. Ovaska. 2007. Diplopoda, Chordeumatida, Caseyidae, *Opiona columbiana* Chamberlin, 1951: Distribution extensions into the Alexander Archipelago, Alaska, USA, Queen Charlotte Islands, British Columbia, Canada, and eastern & southern Washington State, USA; additional new records from British Columbia and Washington. *Check List* 3(1): 14-17.

Shelley, R., M. Medrano, W. Shear, K. Ovaska, K. J. White, E. Havard. 2009. Distribution extensions of the millipede families Conotylidae and Rhiscosomididae (Diplopoda: Chordeumatida) into northern coastal British Columbia and Southern Alaska. *Insecta Mundi* 0071: 1-6.

Sierwald, P. and J. E. Bond. 2007. Current status of the myriapod class diplopoda (millipedes): taxonomic diversity and phylogeny. *Ann. Rev. Ent.* 52: 401-420.

Snyder, B. A., B. Boots, and P. F. Hendrix. 2009. Competition between invasive earthworms (*Amynthas cortices,* Megascolecidae) and native North American millipedes (*Pseudopolydesmus erasus*, Polydesmidae): Effects on carbon cycling and soil structure. *Soil Biol.Biochem*. 41: 1442-1449.

Whitney, C. L. and R. M. Shelley. 1995. Occurrence of the millipede *Ergodesmus compactus* Chamberlin in Canada (Polydesmida: Nearctodesmidae*). Insecta Mundi* 9(3-4): 277-278.

Chilopoda

Behan-Pelletier, V. M. 1993. Diversity of soil arthropods in Canada: systematic and ecological problems. *Mem. Ent. Soc. Can.* 165: 11-50.

Edgecombe, G. D. 2003. Chilopoda (Centipedes). *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI., Pp. 353-362.

Kevan, D. K. McE. 1979. Chilopoda. *Mem. Ent. Soc. Canada* 108: 296-298.

Kevan, D. K. McE. 1983. A preliminary survey of known and potentially Canadian and Alaskan centipedes (Chilopoda). *Can. J. Zool*. 61: 2938-2955.

Mercurio, R. J. 2010. An Annotated Catalog of Centipedes (Chilopoda) from the United States of America, Canada and Greenland (1758-2008). Xlibris Corp. USA.

Shelley, R. M. 1992. Distribution of the centipede *Scolopocryptops sexspinosus* (Say) in Alaska and Canada (Scolopendromorpha: Cryptopidae). *Insecta Mundi* 6(1): 23-27.

Shelley, R. M. 1999. Centipedes and millipedes with emphasis on North American fauna. *The Kansas School Naturalist* 45(3): 1-15.

Branchiopoda

Abrusan, G. 2003. Morphological variation of the predatory cladoceran *Leptodora kindtii* in relation to prey characteristics. *Oecologia* 134(4): 278-283.

Adamowicz, S. J. and A. Purvis. 2005. How many branchiopod crustacean species are there? Quantifying the components of underestimation. *Global Ecol. Biogeo*. 14(5): 455-468.

Angeler, D. G., O. Viedma, S. Sànchez-Carrillo and M. Alvarez-Cobelas. 2008. Conservation issues of temporary wetland Branchiopoda (Anostra, Notostraca: Crustacea) in a semiarid agricultural landscape: what spatial scales are relevant? *Biol. Cons.* 141: 1224-1234.

Barbiero, R. P. and M. L. Tuchman. 2004. Changes in the crustacean communities of Lakes Michigan, Huron, and Erie following the invasion of the predatory cladoceran *Bythothrephes longimanus*. *Can. J. Fish. Aquat. Sci.* 61: 2111-2125.

Belk, D. and J. Brtek. 1995. Checklist of the Anostraca. *Hydrobiologia* 298: 315-353.

Bernier, R. and A. Locke. 2006. New record of *Penila avirostris* Dana, 1849 (Cladocera) in the Gulf of St. Lawrence. *Crustaceana* 79(8): 949-959.

Billington, N., M. G. Boileau and P. D. N. Hebert. 1989. Range extension of the fairy shrimp *Polyartemiella hazeni* (Murdoch 1884) (Crustacea: Anostraca) to the eastern Canadian arctic, with notes on the distribution of other eastern arctic Anostraca. *Can. Field-Nat.* 103(3): 404-405.

Boudreau, S. A. and N. D. Yan. 2003. The differing crustacean zooplankton communities of Canadian Shield lakes with and without the nonindigenous zooplanktivore *Bythotrephes longimanus*. *Can. J. Fish. Aquat. Sci.* 60: 1307-1313.

Brandlova, J., Z. Brandl, and C. H. Fernando. 1972. The Cladocera of Ontario with remarks on some species and distribution. *Can. J. Zool.* 50: 1373-1403.

Branstrator, D. K. 1995. Ecological interactions between *Bythotrephes cederstroemii* and *Leptodora kindtii* and the implications for species replacement in Lake Michigan. *J. Great Lakes Res.* 21: 670-679.

Brendonck, L., D. C. Rogers, J. Olesen, S. Weeks, W. R. Hoeh. 2008. Global diversity of large branchiopods (Crustacea: Branchiopoda) in freshwater. *Hydrobiologia* 595: 167-176.

Browman, H. I., S. Kruse and W. J. O'Brien. 1989. Foraging behaviour of the predaceous cladoceran, *Leptodora kindtii*, and escape responses of their prey. *J. Plankton Res.* 11(5): 1075-1088.

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the marine invertebrates of the Estuary and Gulf of Saint Lawrence. Can. Special Publ. Fish. Aquat. Sci. No. 126, p. i-xi, 1-405. National Research Council Research Press, National Research Council of Canada, Ottawa.

Carter, J. C. H., M. J. Dadswell, J. C. Roff, and W. G. Sprules 1980. Distribution and zoogeography of planktonic crustaceans and dipterans in glaciated eastern North America. *Can. J. Zool.* 58: 1355-1387.

Chengalath, R. 1982. A faunistic and ecological survey of the littoral Cladocera of Canada. *Can. J. Zool.* 60: 2668-2682.

Chengalath, R. 1987. The distribution of chydorid Cladocera in Canada. *Hydrobiologia* 145: 151-157.

Chengalath, R. and B. J. Hann. 1981a. Two new species of *Alona* (Chydoridae, Cladocera) from western Canada. *Can. J. Zool.* 59: 377-389.

Chengalath, R. and B. J. Hann. 1981b. A new species of *Chydorus* (Cladocera: Chydoridae) from Ontario, Canada. *Trans. Am. Microsc. Soc.* 100(3): 229-238.

deWaard, J. R., V. Sacherova, M. E. A. Cristescu, E. A. Remigio, T. J. Crease and P. D. N. Hebert. 2006. Probing the relationships of the branchiopod crustaceans. *Mol. Phyl. Evol.* 39: 491-502.

Donald, D. B. 1989. First Canadian record for the clam shrimp *Caenestheriella belfragei* (Crustacea: Conchostraca). *Can. Field. Nat.* 103(4): 593-594.

Dumont, H. J. 2003. Anostraca. *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 135-140

Foster, S. E. and W. G. Sprules. 2009. Effects of the *Bythotrephes* invasion on native predatory invertebrates. *Limnol. Oceanogr.* 54(3): 757-769.

Gray, D. K. and S. E. Arnott. 2009. Recovery of acid damaged zooplankton communities: measurement, extent, and limiting factors. *Environ. Rev.* 17: 81-99.

Hann, B. J. 1981. Occurrence and distribution of littoral Chydoridae (Crustacean, Cladocera) in Ontario, Canada, and taxonomic notes on some species. *Can. J. Zool.* 59: 1465-1474.

Hann, B. J. 1990. Redescription of *Eurycercus (Teretifrons) glacialis* (Cladocera, Chydoridae) and description of a new species, *E. (T.) nigracanthus*, from Newfoundland, Canada. *Can. J. Zool.* 68: 2146-2157.

Havens, K. E., N. D. Yan and W. Keller. 1993. Lake acidification: effects on crustacean zooplankton populations. *Environ. Sci. Technol.* 27: 1621-1624.

Jeziorski, A., N. D. Yan, A. M. Paterson, A. M. DeSellas, M. A. Turner, D. S. Jeffries, B. Keller, R. C. Weeber, D. K. McNicol, M. E. Palmer, K. McIver, K. Arseneau, B. K. Ginn, B. F. Cumming and J. P. Smol. 2008. The widespread threat of calcium decline in fresh waters. *Science* 322: 1374-1377.

Korovchinsky, N. M. 2002. Description of two new species of *Diaphanosoma* Fischer, 1850 (Crustacea, Branchiopoda, Sididae) from the United States and Canada and species richness of the genus in North America. *Hydrobiologia* 489: 45-54.

Lui, K., M. Butler, M. Allen, J. da Silva and B. Brownson. 2008. Field Guide to Aquatic Invasive Species: Identification, collection and reporting of aquatic invasive species in Ontario waters. Ontario Ministry of Natural Resources, Queen's Printer for Ontario, ON.

Lynch, J. E. 1960. The fairy shrimp *Branchinecta campestris* from northwestern United States (Crustacea: Phyllopoda). *Proc. U. S. Nat. Mus.* 84: 555-566.

McLaughlin, P. A., D. K. Camp, M. V. Angel, E. L. Bousfield, P. Brunel, R. C. Brusca, D. Cadien, A. C. Cohen, K. Conlan, L. G. Eldgredge, D. L. Felder, J. W. Goy, T. Haney, B. Hann, R. W. Heard, E. A. Hendryks, H. H. Hobbs III, J. R. Holsinger, B. Kensley, D.R. Laubitz, S. E. LeCroy, R. Lemaitre, R. F. Maddocks, J. W. Martin, P. Mikkelsen, E. Nelson, W. A. Newman, R. M. Overstreet, W. J. Poly, W. W. Price, J. W. Reid, A. Robertson, D. C. Rogers, A. Ross, M. Schotte, F. R. Schram, C-T. Shih, L. Watling, G. D. G. Wilson and D. D. Turgeon. 2005. Common and scientific names of aquatic invertebrates from the United States and Canada: crustaceans. Amer. Fish. Soc. Spec. Publ. 31, Bethesda, MD.

Mills, K. E. 2003. Cladocera. *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 153-159

Patalas, K., J. Patalas and A. Salki. 1994. Planktonic crustaceans in lakes of Canada (Distribution of species, bibliography). Can. Tech. Rep. Fish. Aquat. Sci. 1954: v+ 218 p.

Rautio, M., S. Bonilla and W. F. Vincent. 2009. UV photoprotectants in arctic zooplankton. *Aquat. Biol.* 7: 93-105.

Rincones, J. and A. Arab. 2003a. Conchostraca. *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 147-151.

Rincones, J. and A. Arab. 2003b. Notostraca. *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 141-146.

Rogers, D. C. 2006. Three new species of *Branchinecta* (Crustacea: Branchiopoda: Anostraca) from the Nearctic. *Zootaxa* 1126: 35-51.

Samchyshyna, L., L-A. Hansson and K. Christoffersen. 2008. Patterns in the distribution of Arctic freshwater zooplankton related to glaciation history. *Polar Biol.* 31: 1427-1435.

Strecker, A. L., S. E. Arnott, N. D. Yan and R. Girard. 2006. Variation in the response of crustacean zooplankton species richness and composition to the invasive predator *Bythotrephes longimanus*. *Can. J. Fish. Aquat. Sci.* 63: 2126-2136.

Strecker, A. L., R. Milne and S. E. Arnott. 2008. Dispersal limitation and climate-related environmental gradients structure microcrustacean composition in freshwater lakes, Ellesmere Island, Canada. *Can. J. Fish. Aquat. Sci.* 65: 1905-1918.

Suchy, K. D. and B. J. Hann. 2007. Using microfossil remains in lake sediments to examine the invasion of *Eubosmina coregoni* (Cladocera, Bosminidae) in Lake of the Woods, Ontario, Canada. *J. Great Lakes Res*. 33: 867-874.

Swadling, K. M., R. Pienitz and T. Nogrady. 2000. Zooplankton community composition of lakes in the Yukon and Northwest Territories (Canada): relationship to physical and chemical limnology. *Hydrobiologia* 431: 211-224.

Sweetman, J. N., E. LaFace, K. M. Rühland and J. P. Smol. 2008. Evaluating the response of cladocera to recent environmental changes in lakes from the Central Canadian Arctic treeline region. *Arct. Antarct. Alp. Res.* 40(3): 584-591.

Taylor, D. J. and P. D. N. Hebert. 1993. Cryptic intercontinental hybridization in *Daphnia* (Crustacea): the ghost of introductions past. *Proc. Roy. Soc. Lond. Ser. B.* 254: 163-168.

Walossek, D. 1993. The Upper Cambrian *Rehbachiella* and the phylogeny of Branchiopoda and Crustacea. *Fossils and Strata* 32: 1-202.

Walseng, B., N. D. Yan and A. K. Schartau. 2003. Littoral microcrustacean (Cladocera and Copepoda) indicators of acidification in Canadian Shield Lakes. *Ambio* 32(3): 208-213.

Weisz, E. J. and N. D. Yan. 2010. Shifting invertebrate zooplanktivores: watershed-level replacement of the native *Leptodora* by the non-indigenous *Bythotrephes* in Canadian Shield lakes. *Biol. Inv.* DOI 10.1007/s10530-010-9794-8.

Williams, D. D. 2002. Temporary water crustaceans: biodiversity and habitat loss. Modern Approaches to the Study of Crustacea, pp. 223-233. E. Escobar-Briones and F. Alvarez (eds.) Conference Proceedings of the Summer Meeting of the Crustacea Society, Puerto Vallarta, Mexico, June 26-30.

Yan, N. D., A. Blukacz, W. G. Sprules, P. K. Kindy, D. Hackett, R. E. Girard and B. J. Clark. 2001. Changes in zooplankton and the phenology of the spiny water flea, *Bythotrephes*, following its invasion of Harp Lake, Ontario, Canada. *Can. J. Fish. Aquat. Sci.* 58: 2341-2350.

Yan, N. D., R. Girard and S. Boudreau. 2002. An introduced invertebrate predator (*Bythotrephes*) reduces zooplankton species richness. *Ecol. Lett.* 5: 481-485.

Yan, N. D., B. Leung, W. Keller, S. E. Arnott, J. M. Gunn and G. G. Raddum. 2003. Developing conceptual frameworks for the recovery of aquatic biota from acidification. *Ambio* 32(3): 165-169.

Ostracoda

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the marine invertebrates of the Estuary and Gulf of Saint Lawrence. Can. Special Publ. Fish. Aquat. Sci. No. 126, p. i-xi, 1-405. National Research Council Research Press, National Research Council of Canada, Ottawa.

Bunbury, J. and K. Gajewski. 2009. Biogeography of freshwater ostracodes in the Canadian arctic archipelago. *Arctic* 62(3): 324-332.

Delorme, L. D. 1969. On the identity of the ostracode genera *Cypriconcha* and *Megalocypris*. *Can. J. Zool.* 47: 271-281.

Delorme, L. D. 1970a. Freshwater ostracodes of Canada. Part I. Subfamily Cypridinae. *Can. J. Zool.* 48: 153-168.

Delorme, L. D. 1970b. Freshwater ostracodes of Canada. Part II. Subfamilies Cyrpidospinae and Herpetocypridinae, and family Cyclocyprididae. *Can. J. Zool.* 48: 253-266.

Delorme, L. D.1970c. Freshwater ostracodes of Canada. Part III. Family Candonidae. *Can. J. Zool.* 48: 1099-1127.

Delorme, L. D. 1970d. Freshwater ostracodes of Canada. Part IV. Families Ilyocyprididae, Notodromadidae, Darwinulidae, Cytherideidae, and Entocytheridae. *Can. J. Zool.* 48: 1251-1259.

Delorme, L. D. 1971. Freshwater ostracodes of Canada. Part V. Families Limnocytheridae, Loxoconchidae. Can. J. Zool. 49: 43-64. *Can. J. Zool.* 49: 43-64.

Delorme, L. D. 1978. Distribution of freshwater ostracodes in Lake Erie. *J. Great Lakes Res.* 4(2): 216-220.

Delorme, L. D. 1989. Methods in Quaternary ecology. No. 7: Freshwater Ostracoda. *Geosciences Canada* 16: 85-90.

Delorme, L. D. 2001. Ostracoda. *In* Ecology and Classification of North American Freshwater Invertebrates, second edition,. J. H. Thorp and A. P. Covich (eds.). Academic Press, New York, NY. Pp. 811-848.

Dermott. R. and D. Kerec. 1997. Changes to the deepwater benthos of eastern Lake Erie since the invasion of *Dreissena*: 1979-1993. *Can. J. Fish. Aquat. Sci.* 54: 922-930.

Dezfuli, B. S. 1996. *Cypria reptans* (Crustacea: Ostracoda) as an intermediate host of *Neoechinorhynchus rutili* (Acanthocephla: Eoacanthocephala) in Italy. *J. Parasitol.* 82(3): 503-505.

Fleeger, J. W., D. S. Johnson, K. A. Galván and L. A. Deegan. 2008. Top-down and bottom-up control of infauna varies across the saltmarsh landscape. *J. Expt. Mar. Biol. Ecol.* 357: 20-34.

Jeziorski, A., N. D. Yan, A. M. Paterson, A. M. DeSellas, M. A. Turner, D. S. Jeffries, B. Keller, R. C. Weeber, D. K. McNicol, M. E. Palmer, K. McIver, K. Arseneau, B. K. Ginn, B. F. Cumming and J. P. Smol. 2008. The widespread threat of calcium decline in fresh waters. *Science* 322: 1374-1377.

Martens, K., I. Schön, C. Meisch and D. J. Horne. 2008. Global diversity of ostracods (Ostracoda, Crustacea) in freshwater. *Hydrobiologia* 595: 185-193.

Takamura, K. and M. Yasuno. 1986. Effects of pesticide application on chironomid larvae and ostracods in rice fields. *Appl. Entomol.Zool.* 21(3): 370-376.

Walsh, M. G., D. E. Dittman and R. O'Gorman. 2007. Occurrence and food habits of the round goby in the profundal zone of southwestern Lake Ontario. *J. Great Lakes Res.* 33: 83-92.

Watling, L. 2003. Ostracoda (Mussel shrimps). *In* Protosomes. Grzimek's Animal Life Encyclopedia, ed. 2, vol. 2, M. Hutchins, S. F. Craig, D. A Thoney and N. Schlager (eds.). Gale Group, Farmington Hills, MI. Pp. 311-315

Williams, D. D. 2002. Temporary water crustaceans: biodiversity and habitat loss. Modern Approaches to the Study of Crustacea, pp. 223-233. E. Escobar-Briones and F. Alvarez (eds.) Conference Proceedings of the Summer Meeting of the Crustacea Society, Puerto Vallarta, Mexico, June 26-30.

Maxillopoda

Abele, L. G., T. Spears, W. Kim and M. Applegate. 1992. Phylogeny of selected Maxillopodan and other crustacean taxa based on 18S ribosomal nucleotide sequences: A preliminary analysis. *Acta. Zool*. 73(5): 373-382.

Alonso Rodriguez, C., H. J. Browman, J. A. Runge and J-F. St.-Pierre. 2000. Impact of solar ultraviolet radiation on hatching of a marine copepod, *Calanus finmarchicus*. *Mar. Ecol. Prog. Ser.* 193: 85-93.

Archambault, P., P. V. R. Snelgrove, J. A. D. Fisher, J-M. Gagnon, D. J. Garbary, M. Harvey, E. L. Kenchington, V. Lesage, M. Levesque, C. Lovejoy, D. L. Mackas, C. W. McKindsey, J. R. Nelson, P. Pepin, L. Piché and M. Poulin. 2010. From sea to sea: Canada's three oceans of biodiversity. *PLoS ONE* 5(8): e12182 doi: 10.1371/journal.pone.0012182.

Armstrong, M. (ed.). 2004. Encyclopedia of the Aquatic World, vol. 1. Algae, bacteria, and protists- Barnacle. Marshall Cavendish, New York, NY: 144 pp.

Beamish, R., J. Wade, W. Pennell, E. Gordon, S. Jones, C. Neville, K. Lange and R. Sweeting. 2009. A large, natural infection of sea lice on juvenile Pacific salmon in the Gulf Islands area of British Columbia, Canada. *Aquaculture* 297: 31-37.

Bernard, F. R. 1988. Potential fishery for the gooseneck barnacle *Pollicipes polymerus* (Sowerby, 1833) in British Columbia. *Fish. Res.* 6(3): 287-298.

Bernier, R., G. Klassen and A. Locke. 2002. Occurrence of *Cymbasoma rigida* Thompson, 1888 (Copepoda, Monstrilloida) in estuaries of the southern Gulf of St. Lawrence, Canada. *Crustaceana* 75(5): 649-661.

Bertness, M. D., G. H. Leonard, J. M. Levine and J. F. Bruno. 1999. Climate-driven interactions among rocky intertidal organisms caught between a rock and a hot place. *Oecologia* 120: 446-450.

Bower, S. M and G. R. Meyer. 1999. Synopsis of infectious diseases and parasites of commercially exploited shellfish: Rhizocephalan parasites of crabs. World Wide Web publication http://www.pac.dfo-mpo.gc.ca/science/species-especes/shellfish-coquillages/diseases/maladies/pages/rhizocb-eng.htm.

Boxshall, G. A. and D. Defaye. 2008. Global diversity of copepods (Crustacea: Copepoda) in freshwater. *Hydrobiologia* 595: 195-207.

Bresciani, J. and P. J. López-González. 2001. *Arthurhemesia canadiensis*, new genus and species of a highly transformed parasitic copepod (Crustacea) associated with an ascidian from British Columbia. *J. Crust. Biol.* 21(1): 90-95.

Buhl-Mortensen, L. and P. B. Mortensen. 2004. *Gorgonophilus canadensis n. gen., n. sp.* (Copepoda: Lamippidae), a gall forming endoparasite in the octocoral *Paragorgia arborea* (L., 1758) from the Northwest Atlantic. *Symbiosis* 37(1-3): 155-168.

Buhl-Mortensen, L. and P. B. Mortensen. 2005. Distribution and diversity of species associated with deep-sea gorgonian corals off Atlantic Canada. *In* A. Freiwald and J. M. Roberts (eds.), Cold-water Corals and Ecosystems. Springer-Verlag Berlin Heidelberg, pp. 849-879.

Carter, J. C. H., M. J. Dadswell, J. C. Roff and W. G. Sprules. 1980. Distribution and zoogeography of planktonic crustaceans and dipterans in glaciated eastern North America. *Can. J. Zool.* 58: 1355-1387.

Clément, M. and C. G. Moore. 2007. Towards a revision of the genus *Halectinosoma* (Copepoda, Harpacticoida, Ectinosomatidae): new species from the North Atlantic and Arctic regions. *Zool. J. Linn. Soc.* 149: 453-475.

Cordell, J. R., L. M. Tear and S. M. Bollens. 2010. Modelling physico-chemical factors affecting occurrences of a non-indigenous planktonic copepod in northeast Pacific estuaries. *Biol. Inv.* 12: 1427-1445.

Covich, A. P. and J. P. Thorp. 2001. Introduction to the Subphylum Crustacea. *In* Ecology and Classification of North American Freshwater Invertebrates. 2nd Edition. Academic Press: San Diego, CA., pp. 777-800.

DFO. 1998. Goose barnacle. Department of Fisheries and Oceans Science Stock Status Report C6-06.

Derry, A. M. and S. E. Arnott. 2007. Adaptive reversals in acid tolerance in copepods from lakes recovering from historical stress. *Ecol. App.* 17(4): 1116-1126.

Dumitru, C., W. G. Sprules and N. D. Yan. 2001. Impact of *Bythotrephes longimanus* on zooplankton assemblages of Harp Lake, Canada: an assessment based on predator consumption and prey production. *Fresh. Biol.* 46: 241-251.

Findlay, H. S., M. A. Kendall, J. I. Spicer and S. Widdicombe. 2010. Relative influences of ocean acidification and temperature on intertidal barnacle post-larvae at the northern edge of their geographic distribution. *Estu. Coast. Shel. Sci.* 86: 675-682.

Flössner, D. 1992. A new genus and a new species of freshwater Canthocamptidae (Copepoda: Harpacticoida) from wet mosses of Canada. *Hydrobiologia* 234: 7-14.

Goldblatt, R. H., D. L. Mackas, A. G. Lewis 1999. Mesozooplankton community characteristics in the NE subarctic Pacific. *Deep Sea Res. II* 46: 2619-2644.

Gosselin, L. A. and L. A. Jones. 2010. Effects of solar radiation on barnacle settlement, early post-settlement mortality and community development in the intertidal zone. *Mar. Ecol. Prog. Ser.* 407: 149-158.

Gray, D. K. and S. E. Arnott. 2009. Recovery of acid damaged zooplankton communities: measurement, extent, and limiting factors. *Environ. Rev.* 17: 81-99.

Havens, K. E., N. D. Yan and W. Keller. 1993. Lake acidification: effects on crustacean zooplankton populations. *Environ. Sci. Technol*. 27: 1621-1624.

Ingólfsson, A. and M. B. Steinarsdóttir. 2007. First records of two remarkable copepods (Copepoda, Harpacticoida) in the Upper Littoral fringe of eastern North America. *Crustaceana* 79(3): 257-261.

Kreutzweiser, D. P., R. C. Back, T. M. Sutton, D. G. Thompson and T.A. Scarr. 2002. Community-level disruptions among zooplankton of pond mesocosms treated with a neem (azadirachtin) insecticide. *Aquat. Tox*. 56: 257-273.

Krkošek, M. 2010. Sea lice and salmon in Pacific Canada: ecology and policy. *Front. Ecol. Envir.* 8(4): 201-209.

Lecointre, G. and H. LeGuyader. 2006. Maxillopoda. *In* The Tree of Life: A Phylogenetic Classification. President and Fellows of Harvard College: U. S. A. Pp. 316-317.

Lessard, J., J. Osborne, R. Lauzier, G. Jamieson and R. Harbo. 2003. Applying local and scientific knowledge to the establishment of a sustainable fishery: the West Coast Vancouver Island goose barnacle fishery experience. Putting Fishers' Knowledge to Work Conference Proceedings Aug. 27-30, 2001, Fisheries Centre Research Reports 11(1): 36-43.

Levings, C. D., J. R. Cordell, S. Ong and G. E. Piercey. 2004. The origin and identity of invertebrate organisms being transported to Canada's Pacific coast by ballast water. *Can. J. Fish. Aquat. Sci.* 61: 1-11.

Mackas, D. L., R. E. Thomson and M. Galbraith. 2001. Changes in the zooplankton community of the British Columbia continental margin, 1985-1999, and their covariation with oceanographic conditions. *Can. J. Fish. Aquat. Sci.* 58: 685-702.

Marcogliese, D. J., A. D. Gendron and P. Dumont. 2009. Parasites of illegally introduced tench (*Tinca tinca*) in the Richelieu River, Quebec, Canada. *Comp. Parasitol.* 76(2): 222-228.

Martin, J. W. and G. E. Davis. 2001. An updated classification of the recent crustacean. Natural History Museum of Los Angeles County No. 39 Science Series.

Mosquin, T., P. G. Whiting and D. E. McAllister. 1995. Canada's biodiversity: the variety of life, its status, economic benefits, conservation costs and unmet needs. Canadian Museum of Nature: Ottawa. Xxiv, 293 pp.

Ooishi, S. 2000. *Botryllophilus bamfieldensis*, new species (Copepoda: Cyclopoida: Ascidicolidae), living in a compound ascidian from the west coast of Vancouver Island, Canada. *J. Crust. Biol.* 20(3): 571-588.

Patalas, K. 1990. Diversity of the zooplankton communities in Canadian lakes as a function of climate. *Verh. Internat. Verhein. Limnol.* 24: 360-368.

Patalas, K., J. Patalas and A. Salki. 1994. Planktonic crustaceans in lakes of Canada (Distribution of species, bibliography). Can. Tech. Rep. Fish. Aquat. Sci. 1954: v+ 218 p.

Poloczanska, E. S., S. J. Hawkins, A. J. Southward and M. T. Burrows. 2008. Modeling the response of populations of competing species to climate change. *Ecology* 89(11): 3138-3149.

Poly, W. J. 2008. Global diversity of fish lice (Crustacea: Branchuiua: Argulidae) in freshwater. *Hydrobiologia* 595: 209-212.

Reed, E. B. 1991. *Eudiaptomus yukonensis*, new species (Copepoda: Calanoida) from northwestern Canada. *J. Crust. Biol.* 11(4): 647-652.

Regier, J. C., J. W. Shultz and R. E. Kambic. 2005. Pancrustacean phylogeny: hexapods are terrestrial crustaceans and maxillopods are not monophyletic. *Proc. Roy. Soc. B.* 272: 395-401.

Reid, J. W. 1986. Some usually overlooked cryptic copepod habitats. *Syllogeus* 58: 594-598.

Richter, S., O. S. Møller and C. S. Wirkner. 2009. Advances in crustacean phylogenetics. *Arth. Syst. Phyl.* 67(2): 275-286.

Samchyshyna, L., L-A. Hansson and K. Christoffersen. 2008. Patterns in the distribution of Arctic freshwater zooplankton related to glaciation history. *Polar Biol.* 31: 1427-1435.

Seuront, L. 2010. Zooplankton avoidance behaviour as a response to point sources of hydrocarbon-contaminated water. *Mar. Fresh. Res.* 61(3): 263-270.

Shih, C-T. and R. Chengalath. 1994. Freshwater littoral copepods of British Columbia and Alberta (Canada). *Hydrobiologia* 292/293: 379-388.

Shukalyuk, A. I., V.V. Isaeva, I. I. Pushchin and S. M. Dolganov. 2005. Effects of the *Briarosaccus callosus* infestation on the commercial golden king crab *Lithodes aequispina*. *J. Parasitol*. 91(6): 1502-1504.

Sloan, N. A. 1984. Incidence and effects of parasitism by the Rhizocephalan barnacle, *Briarosaccus callosus* Boschma, in the golden king crab, *Lithodes aequispina* Benedict, from deep fjords in Northern British Columbia. *Can. J. Exp. Mar. Biol. Ecol.* 84: 111-131.

Smith, K. E. and C. H. Fernando. 1977. New records and little known freshwater copepods (Crustacea, Copepoda) from Ontario. *Can. J. Zool.* 55: 1874-1884.

Strecker, A. L., T. P. Cobbs and R. D. Vinebrooke. 2004. Effects of experimental greenhouse warming on phytoplankton and zooplankton communities in fishless alpine ponds. *Limnol. Oceanogr.* 49(4): 1182-1190.

Strecker, A. L., R. Milne and S. E. Arnott. 2008. Dispersal limitation and climate-related environmental gradients structure microcrustacean composition in freshwater lakes, Ellesmere Island, Canada. *Can. J. Fish. Aquat. Sci.* 65: 1905-1918.

Swadling, K. M., R. Pienitz and T. Nogrady. 2000. Zooplankton community composition of lakes in the Yukon and Northwest Territories (Canada): relationship to physical and chemical limnology. *Hydrobiologia* 431: 211-224.

Swadling, K. M., J. A. E. Gibson, R. Pienitz and W. F. Vincent. 2001. Biogeography of copepods in lakes and ponds of subarctic Québec, Canada. *Hydrobiologia* 453/454: 341-350.

Walseng, B., N. D. Yan and A. K. Schartau. 2003. Littoral microcrustacean (Cladocera and Copepoda) indicators of acidification in Canadian Shield Lakes. *Ambio* 32(3): 208-213.

Williams, D. D. 2002. Temporary water crustaceans: biodiversity and habitat loss. Modern Approaches to the Study of Crustacea, pp. 223-233. E. Escobar-Briones and F. Alvarez (eds.) Conference Proceedings of the Summer Meeting of the Crustacea Society, Puerto Vallarta, Mexico, June 26-30.

Williamson, C. E. and J. W. Reid. 2001. Copepoda *In* Ecology and Classification of North American Freshwater Invertebrates. 2nd Edition. Academic Press: San Diego, CA., Pp. 915-954.

Yamane, L. and S. E. Graham. 2009. Opposite responses by an intertidal predator to increasing aquatic and aerial temperatures. *Mar. Ecol. Prog. Ser.* 393: 27-36.

Yan, N. and T. Pawson. 1997. Changes in the crustacean zooplankton community of Harp Lake, Canada, following invasion by *Bythotrephes cederstrœmi*. *Fresh. Biol.* 37(2): 409-425.

Yan, N. D., A. Blukacz, W. G. Sprules, P. K. Kindy, D. Hackett, R. E. Girard and B. J. Clark. 2001. Changes in zooplankton and the phenology of the spiny water flea, *Bythotrephes*, following its invasion of Harp Lake, Ontario, Canada. *Can. J. Fish. Aquat. Sci.* 58: 2341-2350.

Yan, N. D., R. Girard, J. H. Heneberry, W. B. Keller, J. M. Gunn and P. J. Dillon. 2004. Recovery of copepod, but not cladoceran, zooplankton from severe and chronic effects of multiple stressors. *Ecol. Lett.* 7: 452-460.

Zrum, L., B. J. Hann, L. G. Goldsborough and G. A. Stern. 2000. Effects of organophosphorus insecticide and inorganic nutrients on the planktonic microinvertebrates and algae in a prairie wetland. *Arch. Hydrobiol.* 147(3): 373-399.

Malacostraca

Adam, O., F. Degiorgi, G. Crini and P-M Badot. 2010. High sensitivity of *Gammarus sp.* juveniles to deltamethrin: outcomes for risk assessment. *Ecotox. Environ. Safe.* 73: 1402-1407.

Barbeau, M. A., L. A. Grecian, E. E. Arnold, D. C. Sheahan and D. J. Hamilton. 2009. Spatial and temporal variation in the population dynamics of the intertidal amphipod *Corphium volutator* in the Upper Bay of Fundy, Canada. *J. Crust. Biol.* 29(4): 491-506.

Blais, J. M., F. Wilhelm, K. A. Kidd, D. C. G. Muir, D. B. Donald and D. W. Schindler. 2003. Concentrations of organochlorine pesticides and polycholorinated biphenyls in amphipods (*Gammarus lacustris*) along an elevational gradient in mountain lakes of western Canada. *Environ. Toxicol. Chem.* 22(11): 2605-2613.

Borgmann, U., D. T. Bennie, A. L. Ball and V. Palabrica. 2007. Effect of a mixture of seven pharmaceuticals on *Hyalella azteca* over multiple generations. *Chemosphere* 66: 1278-1283.

Bousfield, E. L. 1987. Amphipod parasites of fishes of Canada. *Can. Bull. Fish. Aquat. Sci.* 217: 37 pp.

Bousfield, E. L. and J. R. Holsinger. 1981. A second new subterranean amphipod crustacean of the genus *Stygobromus* (Crangonyctidae) from Alberta. *Can. J. Zool.* 59: 1827-1830.

Brunel, P., L. Bossé and G. Lamarche. 1998. Catalogue of the marine invertebrates of the Estuary and Gulf of Saint Lawrence. Can. Special Publ. Fish. Aquat. Sci. No. 126, p. i-xi, 1-405. National Research Council Research Press, National Research Council of Canada, Ottawa.

Clifford, H. F. 1991a. Introduction to the Malacostraca. *In* Aquatic Invertebrates of Alberta: an illustrated guide. University of Alberta Press: Edmonton, Alberta. Pp. 173-175.

Clifford, H. F. 1991b. Amphipoda. *In* Aquatic Invertebrates of Alberta: an illustrated guide. University of Alberta Press: Edmonton, Alberta. Pp. 176-178.

Corcoran, R. M., J. R. Lovvorn and P. J. Heglund. 2009. Long-term change in limnology and invertebrates in Alaskan boreal wetlands. *Hydrobiologia* 620: 77-89.

Ford, A. T., T. F. Fernandes, S. A. Rider, P. A. Read, C. D. Robinson and I. M. Davies. 2004. Endocrine disruption in a marine amphipod? Field observations of intersexuality and de-masculinasation. *Mar. Environ. Res.* 58(2-5): 169-173.

Ford, A. T., T. F. Fernandes, C. D. Robinson, I. M. Davies and P. A. Read. 2006. Can industrial pollution cause intersexuality in the amphipod, *Echinogammarus marinus*? *Mar. Pollut. Bull.* 53(1-4): 100-106.

France, R. 1992. The North American latitudinal gradient in species richness and geographical range of freshwater crayfish and amphipods. *Am. Nat.* 139(2): 342-354.

Gómez Gesteira and Dauvin. 2000. Amphipods are good bioindicators of the impact of oil spills on soft-bottom macrobenthic communities. *Mar. Pollut. Bull.* 40(11): 1017-1027.

Havens, K. E., N. D. Yan and W. Keller. 1993. Lake acidification: effects on crustacean zooplankton populations. *Environ. Sci. Technol.* 27: 1621-1624.

Hogg, I. D. and D. D. Williams. 1996. Response of stream invertebrates to a global-warming thermal regime: an ecosystem-level manipulation. *Ecology* 77(2): 395-407.

Holsinger, J. R. 1976. The freshwater amphipod crustaceans (Gammaridae) of North America. Water Pollution Control Research Series 18050 ELD04/72, U. S. Environmental Protection Agency, Cincinnati, Ohio.

Holsinger, J.R. 1980. *Stygobromus canadensis*, a new subterranean amphipod crustacean (Crangonyctidae) from Canada, with remarks on Wisconsin refugia. *Can. J. Zool.* 58: 290-297.

Holsinger, J. R. and D. P. Shaw. 1987. *Stygobromus quatsinensis*, a new amphipod crustacean (Crangonyctidae) from caves on Vancouver Island, British Columbia, with remarks on zoogeographic relationships. *Can. J. Zool.* 65: 2202-2209.

Kestrup, Å. And A. Ricciardi. 2009. Are interactions among Ponto-Caspian invaders driving amphipod species replacement in the St. Lawrence River? *J. Great Lakes Res.* 35: 392-298.

Kestrup, Å. And A. Ricciardi. 2010. Influence of conductivity on life history traits of exotic and native amphipods in the St. Lawrence River. *Fund. Appl. Limnol.* 176(3): 249-262.

Kestrup, Å. M., J. T. A. Dick and A. Ricciardi. 2011a. Interactions between invasive and native crustaceans: differential functional responses of intraguild predators towards juvenile heterospecifics. *Biol. Inv.* 13: 731-737.

Kestrup, Å. M., S. H. Thomas, K. van Rensburg, A. Ricciardi and M. A. Duffy. 2011b. Differential infection of exotic and native freshwater amphipods by a parasitic water mold in the St. Lawrence River. *Biol. Inv.* 13: 769-779.

Lalonde, B. A., P. Jackman, K. Doe, C. Garron and J. Aubé. 2009. Toxicity testing of sediment collected in the vicinity of effluent discharges from seafood processing plants in the Maritimes. *Arch. Environ. Contam. Toxicol.* 56: 389-396.

Levings, C. D., K. L. Barry, J. A. Grout, G. E. Piercey, A. D. Marsden, A. P. Coombs and B. Mossop. 2004. Effects of acid mine drainage on the estuarine food web, Britannia Beach, Howe Sound, British Columbia, Canada. *Hydrobiologia* 525: 185-202.

Marion, A., M. Harvey, D. Chabot and J. C. Brethes. 2008. Feeding ecology and predation impact of the recently established amphipod, *Themisto libellula*, in the St. Lawrence marine system, Canada. *Mar. Ecol. Prog. Ser.* 373: 53-70.

Martin, J. W. and G. E. Davis. 2001. An updated classification of the recent crustacean. Natural History Museum of Los Angeles County. Science Series 39, 132 pp.

Mouritsen, K. N., D. M. Tompkins and R. Poulin. 2005. Climate warming may cause a parasite-induced collapse in coastal amphipod populations. *Oecologia* 146(3): 476-483.

Pastorinho, M. R., T. C. Telfer and A. M. V. M. Soares. 2009. Amphipod susceptibility to metals: cautionary tales. *Chemosphere* 75: 1423-1428.

Richter, S., O. S. Møller and C. S. Wirkner. 2009. Advances in crustacean phylogenetics. *Arth. Syst. Phyl.* 67(2): 275-286.

Rinderhagen, M., J. Ritterhoff and G-P. Zauke. 2000. Crustaceans as bioindicators. *In* Biomonitoring of Polluted Water- Reviews on Actual Topics. A. Gerhardt (ed.). Trans Tech Publications- Sci Tech Publications, Environmental Research Forum 9: 161-194.

Schaadt, M. S. 2003. Amphipoda (Amphipods) *in* Grzimek's Animal Life Encyclopedia, 2nd Edition. Volume 2, Protosomes. M. Hutchins, S. F. Craig, D. A. Thoney and N. Schlager (eds.). Farmington Hills, MI: Gale Group. Pp. 261-272.

Schnabel, K. E. and P. D. N. Hebert. 2003. Resource-associated divergence in the arctic marine amphipod *Paramphithoe hystrix*. *Mar. Biol.* 143: 851-857.

Serejo, C. S. 2009. Talitridae. *Zootaxa* 2260: 892-903.

Snucins, E. 2003. Recolonization of acid-damaged lakes by the benthic invertebrates *Stenacron interpunctatum*, *Stenonema femoratum* and *Hyalella azteca*. *Ambio* 32(3): 225-229.

Stephenson, M. G. L. Mackie. 1986. Lake acidification as a limiting factor in the distribution of the freshwater amphipod *Hyalella azteca*. *Can. J. Fish. Aquat. Sci.* 43: 288-292.

Väinölä, R., J. D. S. Witt M. Grabowski, J. H. Bradbury, K. Jazdzewski and B. Sket. 2008. Global diversity of amphipods (Amphipoda; Crustacea) in freshwater. *Hydrobiologia* 595: 241-255.

Van Overdijk, C. D., I. A. Grigorovich, T. Mabee, W. J. Ray, J. J. H. Ciborowski and H. J. MacIsaac. 2003. Microhabitat selection by the invasive amphipod *Echinogammarus ischnus* and native *Gammarus fasciatus* in laboratory experiments and in Lake Erie. *Freshwater Biol.* 48: 567-578.

Vanderploeg, H. A., T. F. Nalepa, D. J. Jude, E. L. Mills, K. T. Holeck, J. R. Liebig, I. A. Girgorovich and H. Ojaveer. 2002. Dispersal and emerging ecological impacts of Ponto-Caspian species in the Laurentian Great Lakes. *Can. J. Fish. Aquat. Sci.* 59: 1209-1228.

Wang, D. and J. R. Holsinger. 2001. Systematics of the subterranean amphipod genus *Stygobromus* (Crangonyctidae) in western North America, with emphasis on species of the hubbsi group. *Amphipacifica* 3(2): 39-147.

Wilhelm, F. M. and D. W. Schindler. 2001. *Gammarus lacustris* (Crustacea: Amphipoda) zooplankton predation in a Canadian Rocky Mountain lake. *Proc. Int. Assoc. Theor. Appl. Limnol.* 27: 783-784.

General Information Sources

Appeltans W., P. Bouchet, G. A. Boxshall, K. Fauchald, D. P. Gordon, B. W. Hoeksema, G. C. B. Poore, R. W. M. van Soest, S. Stöhr, T. C. Walter, M. J. Costello, (eds.) 2010. The World Register of Marine Species. World Wide Web publication http://www.marinespecies.org.

Atwater, D. and D. G. Fautin. 2001. Malacostraca, Animal Diversity Web. World Wide Web electronic publication http://animaldiversity.ummz.umich.edu/site/accounts/information/Malacostraca.html

Emig, C. C. 2007. Phoronida world database. World Wide Web electronic publication http://www.marinespecies.org/phoronida.

Garand, C. 2001. "Pollicipes polymerus", Animal Diversity Web, World Wide Web publication http://animaldiversity.ummz.umich.edu/site/accounts/information/Pollicipes_polymerus.html

GBIF 2009. Data portal of the Global Biodiversity Information Facility. World Wide Web electronic publication http://data.gbif.org.

Green, G. 2007a. Cladocerans of British Columbia. Royal British Columbia Museum. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia. World Wide Web electronic publication. http://www.efauna/bc/ca. Lab for Advanced Spatial Analysis, Dept. of Geography, University of British Columbia, Vancouver.

Green, G. 2007b. Freshwater Ostracods of British Columbia. Royal British Columbia Museum. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia. World Wide Web electronic publication. http://www.efauna/bc/ca. Lab for Advanced Spatial Analysis, Dept. of Geography, University of British Columbia, Vancouver.

Hebert, P. D. N. 2002. Canada's Aquatic Environment, CyberNatural Software, University of Guelph. World Wide Web electronic publication http://www.aquatic.uoguelph.ca.

ITIS 2010. Integrated Taxonomic Information System. World Wide Web electronic publication http://www.itis.gov.

IUCN 2010. IUCN Red List of Threatened Species. World Wide Web electronic publication version 2010.1. http://www.iucnredlist.org.

Kipp, R. M. 2010. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx.

Lowry, J. K. and M. Yerman. 2002. Anaspidacea: families. Version 2. World Wide Web electronic publication http://crustacean.net/crustace/anaspidacea/www/anaspid.htm.

Massachusetts Division of Fish and Wildlife (MA). 2008. Taconic cave amphipod *Stygobromus borealis*. Natural Heritage & Endangered Species Program. World Wide Web electronic publication http://www.mass.gov/dfwele/dfw/nhesp/species_info/nhfacts/stygobromus_borealis.pdf.

NatureServe. 2010. NatureServe Explorer: an online encyclopedia of life. Version 7.1 World Wide Web electronic publication http://www.natureserve.org/explorer.

U. S. Fish and Wildlife Service. 2011. Species Profile: Sperm Whale (*Physeter macrocephalus*). Environmental Conservation Online System. World Wide Web electronic publication http://ecos.fws.gov/speciesProfile/profile/speciesprofile.action?spcode=A02T.

Van Guelpen, L., G. Pohle, E. Vanden Berghe and M. J. Costello (eds.). 2005. Marine Species Registers for the Northwest North Atlantic Ocean. World Wide Web electronic publication version 1.0/2005. http://www.marinebiodiversity.ca/nonNARMS.

Walter, T. C. and G. A. Boxshall. 2008. World of Copepods database. World Wide Web electronic publication http://www.marinespecies.org/copepoda.

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