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A summary of reports of abyssal and hadal Monoplacophora and Polyplacophora (Mollusca)*

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Abstract

A summary of literature records of Polyplacophora and Monoplacophora from below 2000 m is presented. Reports have been published of 11 described species of monoplacophorans and twice as many polyplacophorans from abyssal and hadal depths. Additionally taken into account are several records of deep water species of uncertain taxonomic position in both classes. Occurrence and geographic distribution are briefly discussed.

Key words: Polyplacophora, Monoplacophora, distribution, deep-water

Introduction

One of the greatest sensations in the past century was the discovery of a living monoplacophoran representative by the Danish "*Galathea*"-Expedition in the eastern Pacific (Lemche 1957). Previously only known as Paleozoic fossils (Cambrian-Devonian, ca. 500–320 Ma), this and other living monoplacophorans that have since been collected are more precisely grouped in the Molluscan taxon Tryblidiida Lemche, 1957, because "Monoplacophora" is probably paraphyletic (Wingstrand 1985), but are here referred to by their better known common name. The remarkable living representatives of this class that was previously believed to be extinct have been accorded high importance for their potential role in providing new information on the course of molluscan evolution. Numerous attempts, some successful, were made in order to obtain more suitably preserved material, and with that more detailed information on the animals' morphology, anatomy, ecology and their phylogenetic position (e.g. Lemche & Wingstrand 1959, Schmidt 1959, Wolff 1961, Meenakshi *et al*. 1970, Wingstrand 1985, Haszprunar *et al*. 1995, Healy *et al*. 1995, Schaefer & Haszprunar 1997a, b, Haszprunar & Schaefer 1997, Giribet *et al*. 2006). These issues are hardly settled and good material for embryological and molecular studies has remained unavailable. During the last decades several new taxa were described and at present the class comprises of 31 extant species (Schrödl 2006, Marshall 2006, Ivanov & Moskalex 2007, Haszprunar 2008) that bathymetrically range from approx. 200 m to hadal depths (Counts 2006, Haszprunar 2008).

Another ancient group of exclusive marine molluscs—the Polyplacophora—are found from the intertidal splash zone down to hadal depths. A tally of recent species (Schwabe 2005 + unpublished data, closing date 14.07.2008) counts 922 recognized species and a few of these are reported to be eurybathic. Despite these reports, still only a small percentage of all living chiton are reported from below the continental edge.

The present compilation has been completed at the request of the administrators of the network OBIS (Ocean Biogeographic Information System, see: http://www.iobis.org), whose charge has been to collect all

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available information on deep sea benthos. This compilation attempts to comprehensively assemble all literature records referring to monoplacophorans and polyplacophorans from below the 2000 m depth mark (in a wider sense the somewhat arbitrary cut-off value separating the continental rise from the abyssal plain, see Gage & Taylor 1991). The aim of this paper is also to make these data available in a compact version. Georeferences for localities not available from original data sets were established from the Gazetteer Server Client (http://middleware.alexandria.ucsb.edu/client/gaz/adl/index.jsp) and are added in square brackets. Other secondary sources have been included with the relevant records.

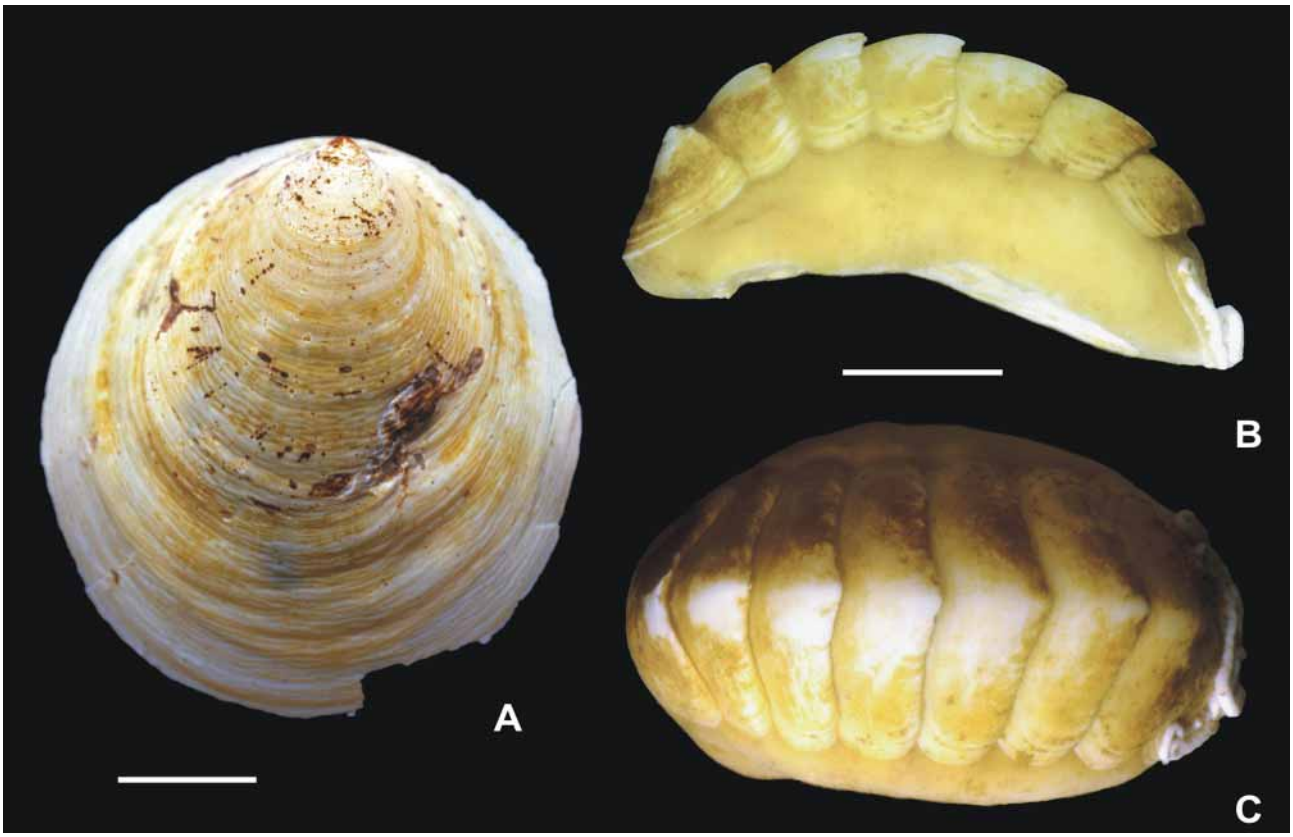

FIGURE 1. Representatives of monoplacophorans and polyplacophorans from below 2000 m. **A**, dorsal view of the holotype of *Neopilina galatheae* Lemche, 1957 from the East Pacific, off Costa Rica (09°23'N, 89°32'W), 3590 m (photo by G. Brovad, Zoological Museum, University of Copenhagen). **B, C**, Left lateral (B) and dorsal view (C) of the holotype of *Ferreiraella tsuchidai* Saito, 2006 (National Science Museum Tokyo Mo 73601) from the Philippine Basin between Mindanao Island and Palau Islands (05°30.8'-05°28.0'N, 130°20.2'-130°19.9'E), 5567 m (photos by H. Saito, National Science Museum Tokyo).
Scale bars: A 10 mm, B, C 5 mm.

Systematics of Monoplacophora
(in accordance with Marshall 2006)
Class **Monoplacophora Odhner in Wenz, 1940**
Order **Tryblidiida Lemche, 1957**
Family **Neopilinidae Knight & Yochelson, 1958**
Genus ***Adenopilina* Starobogatov & Moskalev, 1987**
Type species: *Neopilina adenensis* Tebble, 1967, by original designation.

***Adenopilina adenensis* (Tebble, 1967)**
Neopilina adenensis Tebble 1967: 663, figs 1–3.

This species represents the sole record of a monoplacophoran from the Indian Ocean, it was described from the Alula-Fartak trench in the Gulf of Aden (13°50'N, 51°47'E), where it was collected between depths of 3000–3950 m.

Genus ***Laevipilina*** **McLean, 1979**
Type species: *Vema (Laevipilina) hyalina* McLean, 1979, by original designation.

Laevipilina antarctica **Warén & Hain, 1992**
Laevipilina antarctica Warén & Hain 1992: 167, figs 2–5, 6–8, 10–16, 19, 27.

This species, originally described from the Weddell and Lazarev seas, Antarctica, had a bathymetric range from 210–644 m (Warén & Hain 1992). Recent additional reports by Schrödl *et al*. (2006) include a first abyssal record for this species. The abyssal specimen comes from soft bottom terraces 3 km to the SW edge of the Wegener Canyon (70°38.46'S, 14°42.87'W–70°39.19'S, 14°43.44'W), Weddell Sea, where it was collected at 3102–3136 m depth.

This was not only a considerably range extension but also the first indication that this genus is found at abyssal depths.

Genus ***Monoplacophorus*** **Moskalev, Starobogatov & Filatova, 1983**
Type species: *Monoplacophorus zenkevitchi* Moskalev, Starobogatov & Filatova, 1983, by original designation.

Monoplacophorus zenkevitchi **Moskalev, Starobogatov & Filatova, 1983**
Monoplacophorus zenkevitchi Moskalev, Starobogatov & Filatova 1983: 993, figs 5, 11–13.

The species is known from the holotype only, described from the Central Pacific, north of Johnston Islands, west of Hawaii (20°41.7'N, 170°52.9'W) from 2000 m depth. However, the first record of the species dates back to Filatova *et al*. (1968), who mentioned it as undetermined Monoplacophora.

Genus ***Neopilina*** **Lemche, 1957**
Type species: *Neopilina galatheae* Lemche, 1957, by monotypy.

Neopilina bruuni **Menzies, 1968**
Neopilina (Neopilina) bruuni Menzies 1968: 2, figs 1c, 4A–E, 5.

Although the holotype was originally described from the Anton Bruun Cruise 11, Station 197 (from the south-eastern Pacific, Milne Edwards Deep of the Peru-Chile Trench: 11°30'S, 79°25'W, 6146–6354 m), a few pages later (p. 8) the author listed the species being from Station 179: Milne Edwards Deep of the Peru-Chile Trench, Southeast Pacific (08°54'S, 80°41'W). It is most likely that this latter station is correct and the original "197" numbers were mixed up, as other monoplacophorans were reported from Station 197 (*Vema ewingi* (Clarke & Menzies, 1959; *Neopilina* sp.), and no other monoplacophoran was listed under this station (which indicates that the species was not mixed). It seems necessary to restrict the type locality to Station 179. The holotype was thus found at a depth of 4823–4925 m as cited without comments in recent works (e.g., Warén & Hain 1992, Counts 2006, Haszprunar 2008).

***Neopilina galatheae* Lemche, 1957**
(Fig. 1A)
Neopilina galatheae Lemche 1957: 414, figs 1–4.

Due to the presence of 10 specimens from the type locality: East Pacific, off Costa Rica (09°23'N, 89°32'W), 3590 m, the first record of a living representative of the monoplacophora was not only a sensation but also led to numerous detailed studies of the morphology and anatomy of this representative of an ancient lineage.

Later the species was recollected in abyssal depths from the following localities:

- specimen number unknown; 3000 km further north of the tip of the southern end of Baja California, 2780–2810 m [it remains unclear whether the author refers to *N. galatheae* or only to *Neopilina* sp.] (Wolff 1961)
- 3 specimens from Mexico, Baja California, off Cape San Lucas (22°32.5'N, 109°40.8'W), 2781–2809 m (Parker 1961)
- 1 specimen from the East Pacific, off Costa Rica (10°07'N, 89°50'W), 3718 m (Menzies & Layton 1962)
- 1 specimen (mentioned as "*Neopilina* aff. *Galatheae*") from the southeastern Pacific, off Chile (05°51.7'S, 81°48.8'W), 5300–5320 m (Moskalev 1977).

***Neopilina rebainsi* Moskalev, Starobogatov & Filatova, 1983**
Neopilina (Neopilina) sp. Filatova *et al*. 1974: 675.
Neopilina (Lemchephyala) rebainsi Moskalev, Starobogatov & Filatova 1983: 988, figs 5, 7–9.

The holotype is known from the following locality: Southeast of the Falkland Islands (56°29.0'S, 50°51.1'W), 4660–5630 m.

Neopilina of uncertain taxonomic position

- 18 specimens of *Neopilina* sp. from the southeastern Pacific, Peru-Chile Trench, 2000–6000 m (Menzies 1963)
- number of specimens unknown; as *Neopilina* sp. from the southeastern Pacific, Milne Edwards Deep of the Peru-Chile Trench, southeastern Pacific (08°52'S, 80°47'W), 6146–6313 m (Menzies 1968)
- number of specimens unknown; as *Neopilina* sp. from the southeastern Pacific, Milne Edwards Deep of the Peru-Chile Trench, southeastern Pacific (08°46'S, 80°44'W), 3909–3970 m (Menzies 1968)
- number of specimens unknown; as *Neopilina* sp. from the southeastern Pacific, Milne Edwards Deep of the Peru-Chile Trench, southeastern Pacific (11°30'S, 79°25'W), 6146–6354 m (Menzies 1968)
- 1 specimen mentioned as *Neopilina (Neopilina)* sp. from the northwestern Scotia Ridge, southeast of the Falkland Islands (54°43'-54°45'S, 55°3'-55°37'W), 1647–2044 m (Rosewater 1970)
- 1 specimen mentioned as *Neopilina* sp. from the southeastern Pacific off Chile (23°50'S, 71°06'W), 4600 m (Moskalev *et al*. 1983)

Genus ***Rokopella* Starobogatov & Moskalev, 1987**
Type species: *Neopilina oligotropha* Rokop, 1972, by original designation.

***Rokopella brummeri* Goud & Gittenberger, 1993**
Rokopella brummeri Goud & Gittenberger 1993: 74, figs 1–10.

This is so far the single record of an abyssal monoplacophoran from the northern Atlantic Ocean. The species was described from east of the Mid-Atlantic Ridge (45°21.3'N, 27°09.1'W) from a depth of 2162 m.

***Rokopella oligotropha* (Rokop, 1972)**
Neopilina (Neopilina) oligotropha Rokop 1972: 91, figs 1–9.

Only one specimen and a shell fragment of this species have so far been collected at abyssal depths. The species was described from the central North Pacific, approximately 680 miles north of Hawaii (30°05'N, 156°11'48"W), 6065–6079 m.

Genus ***Veleropilina* Starobogatov & Moskalev, 1987**
Type species: *Neopilina veleronis* Menzies & Layton, 1963, by original designation.

***Veleropilina* sp.**
unidentified Monoplacophora Levin & Lonsdale 1983: 1017.
Veleropilina sp. Warén & Gofas 1996: 222, figs 1D, 8A, B, 9E, F, 10A–C, 15A.

The species is here included in the list of species from below 2000 m, because the record of the single specimen: off the southern point of Baja California (20°48.5'N, 109°17.4'W), 1950 m depth at a submarine volcano, was close enough to 2000 m that it is likely that it also occurs somewhat deeper.

***Veleropilina veleronis* (Menzies & Layton, 1962)**
Neopilina (Vema) sp. Menzies & Robinson 1961: 338, fig. 1.
Neopilina (Neopilina) veleronis Menzies & Layton 1962: 402, pl. 7, figs A–F, pl. 8, fig. G, pls 9, 10.

The 14 specimens known from the original description are all from the type locality: Mexico, Baja California, off Cedros Island, slope of the Cedros Trench, 30 miles off Natividad Island light (27°52'25"-27°51'30"N, 115°44'30"-115°45'15"W) and were collected at a depth between 2730–2769 m.

Apart from the shallow water species *Micropilina arntzi* Warén & Hain, 1992 (17), and the abyssal species *Vema ewingi* (Clarke & Menzies, 1959) (11) and *Neopilina galatheae* Lemche, 1957 (10), this species was most numerous at a single station (14).

Genus ***Vema* Clarke & Menzies, 1959**
Type species: *Neopilina (Vema) ewingi* Clarke & Menzies, 1959, by original designation.

***Vema bacescui* (Menzies, 1968)**
Neopilina (Vema) bacescui Menzies 1968: 2, figs 1a, 2A–C, 3.

The holotype of this rather large species (28 mm) was collected in the southeastern Pacific, Milne Edwards Deep of the Peru-Chile Trench (08°44'S, 80°45'W), at a depth of 5986–6134 m.

***Vema ewingi* (Clarke & Menzies, 1959)**
Neopilina (Vema) ewingi Clarke & Menzies 1959: 1026, fig. 1.

Besides the type material, which was collected from two closely situated locations within the southeastern Pacific, off Peru, northern end of the Peru-Chile Trench [(a) 07°30'S 81°25'W, 5841–5854 m (type locality, 2 specimens) and (b) 07°35'S 81°24'W, 5817–5834 m (2 specimens)], the species is also known from the following locations:

- number of specimen(s) unclear (cited from Menzies 1963); from the southeastern Pacific, Milne Edwards Deep of the Peru-Chile Trench (08°10.5'S, 81°08.1'W), 6002 m (Menzies 1968)

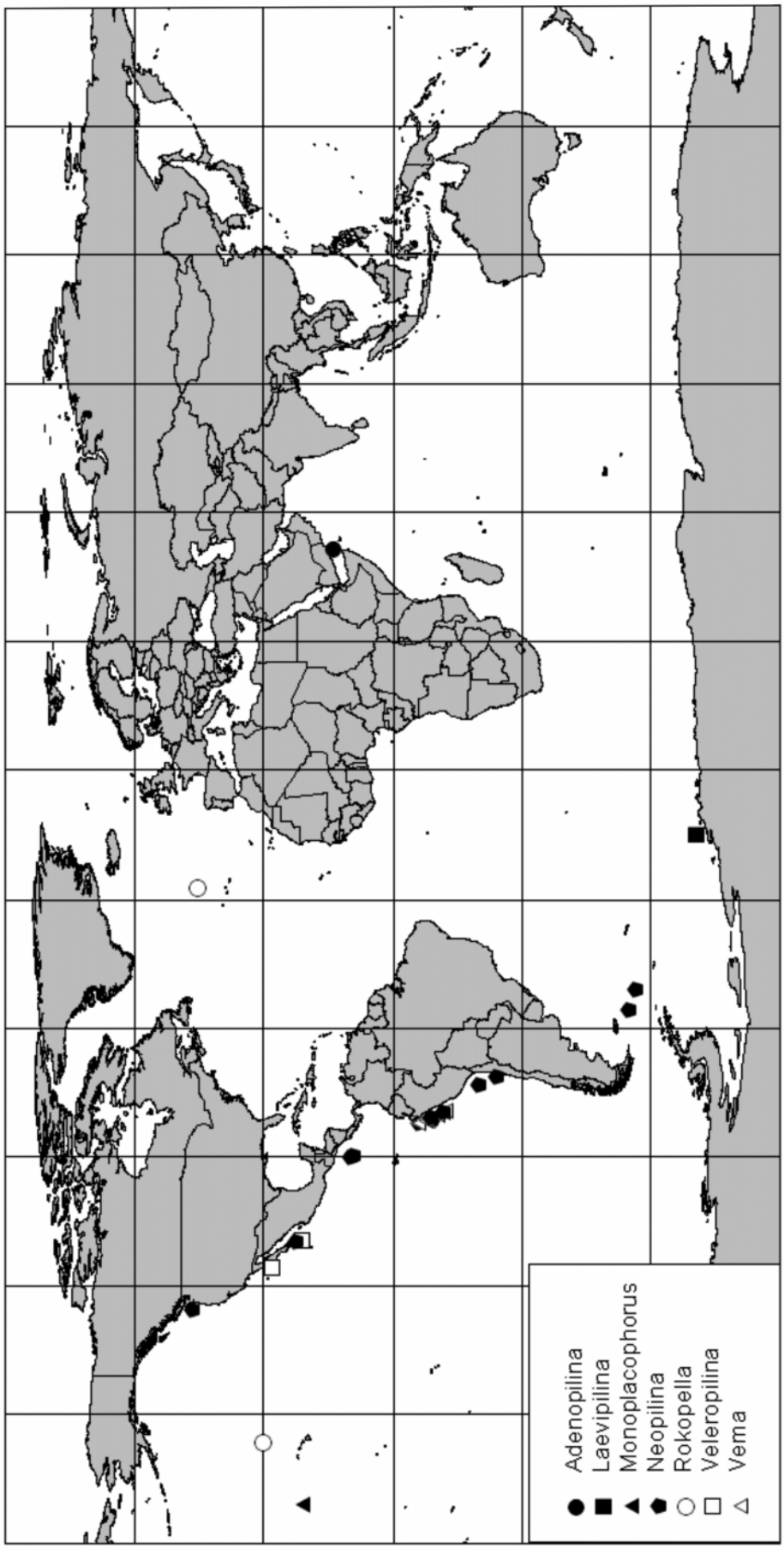

FIGURE 2. Generic distribution of abyssal and hadal Monoplacophora.

- number of specimen(s) unclear in each case; from the southeastern Pacific, Milne Edwards Deep of the Peru-Chile Trench: 11°30'S, 79°25'W, 6146–6354 m; 08°16'S, 81°05'W, 6156–6489 m; 08°20'S, 81°04'W, 6260–6364 m; 08°25'S, 81°05'W, 6052–6260 m (all from Menzies 1968)
- 1 specimen; southeastern Pacific, off Peru, north end of the Peru-Chile Trench (12°02'S, 79°08'W), 5607–5614 m; 4 specimens; southeastern Pacific, off Peru, north end of the Peru-Chile Trench (10°13'S, 80°05'W), 6324–6329 m (Menzies 1968) [cited from "Clarke & Menzies 1959" but not mentioned in that report; specimen number from Menzies & Layton 1962]
- at least 1 specimen; from the southeastern Pacific off Peru (11°30'S, 79°25'W), 6146–6354 m (Moskalev *et al.* 1983) [mentioned as form "B"]
- 1 specimen; from the southeastern Pacific off Peru (05°51.7'S, 81°48.8'W), 5300–5320 m (Moskalev *et al.* 1983) [mentioned as form "E"]
- 2 specimens; from the southeastern Pacific off Peru (08°10.4'S, 81°04.5'W), 6040 m (Moskalev *et al.* 1983) [mentioned as forms "C & D"]
- 1 specimen; from the southeastern Pacific off Peru (08°23.1'S, 81°00.8'W), 6200–6240 m (Moskalev *et al.* 1983) [mentioned as form "C"]
- 11 specimens; from the southeastern Pacific off Peru (07°56.6'S, 81°10.3'W), 5770–5800 m (Moskalev *et al.* 1983) [mentioned as forms "A–C"]

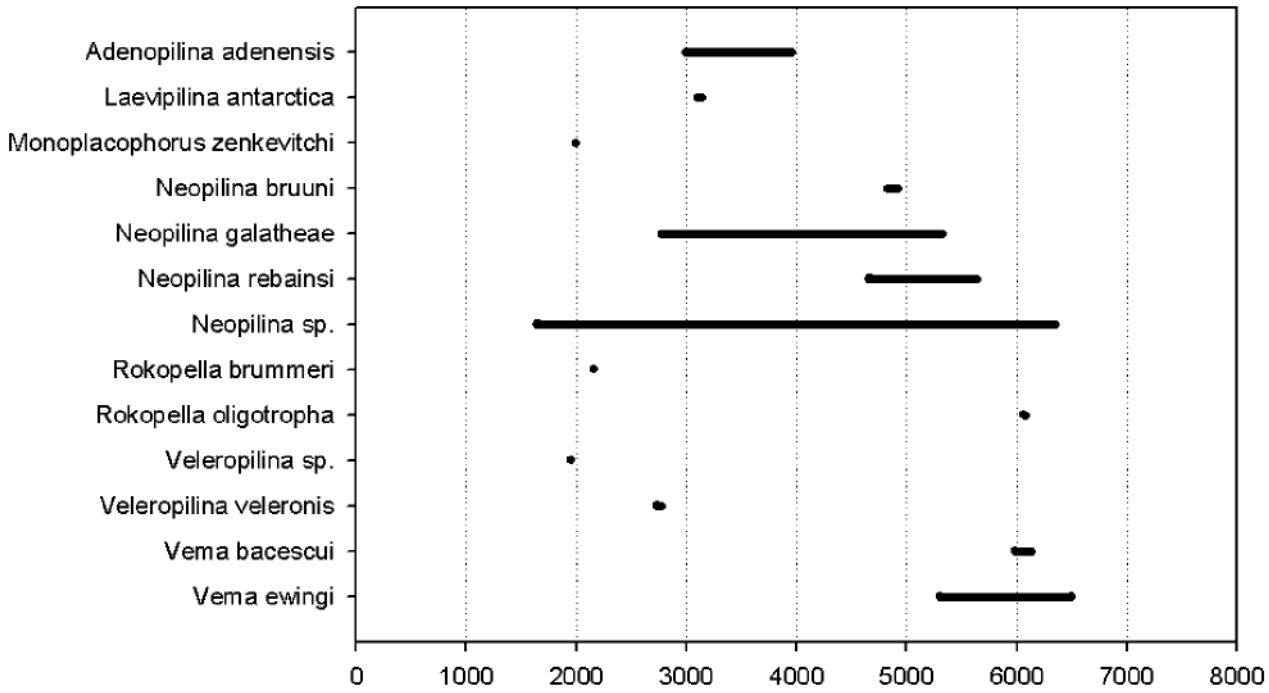

FIGURE 3. Depth range (m) of abyssal and hadal Monoplacophora.

Systematics of Polyplacophora

Class **Polyplacophora Gray, 1821**

Subclass **Neoloricata Bergenhayn, 1955**

Order **Lepidopleurida Thiele, 1909**

Suborder **Lepidopleurina Thiele, 1909**

Family **Ferreiraellidae Dell'Angelo & Palazzi, 1991**

Genus ***Ferreiraella* Sirenko, 1988**

Type species: *Ferreiraella caribbensis* Sirenko, 1988, by original designation.

***Ferreiraella bartlettae* (Ferreira, 1986)**
Lepidopleurus bartletti Ferreira 1986: 99, figs 1–6.

Besides the type locality "Netherlands Antilles, Venezuela Basin, roughly 150 miles North East of Bonaire (13°45'N, 67°45'W), 5046 m" where two specimens were collected, the author originally reported three specimens from the Caribbean Sea, Venezuela Basin (15°08'N, 69°12'W), 3867–4009 m depth and a single specimen from (13°30'N, 64°45'W), 3516–3550 m depth.

***Ferreiraella caribbensis* Sirenko, 1988**
Lepidopleurus sp. A Wolff 1979: 121, 126, pl. 5, fig. C.
Ferreiraella caribbensis Sirenko 1988: 1778, figs 1–2.

The large number of specimens (34) collected at the type locality for this species, Caribbean Sea, Cayman Trench (19°39'N, 76°37'W), 6740–6780 m, is noteworthy.

***Ferreiraella plana* (Nierstrasz, 1905)**
Lepidopleurus planus Nierstrasz 1905: 9, pl. 1, fig. 6, pl. 3, figs 56–59.

The holotype was collected in Indonesia, Sulawesi Utara, west of Kepulauan Sangihe (03°27.1'N, 125°18.7'E), at 2053 m.

***Ferreiraella scrippsiana* (Ferreira, 1980)**
Lepidopleurus scrippsianus Ferreira 1980: 55, figs 1–11.

The author originally mentioned 4 specimens from off Baja California Sur, southwest of Cabo San Lucas (22°30.8'-22°37.2'N, 110°03.8'-110°15.5'W), 2507–2891 m depth.

Three additional specimens were collected in the Panama Basin (05°09.8'N, 81°41.2'W), at 3900–4000 m depth (Sirenko 1997).

***Ferreiraella soyomaruae* (Wu & Okutani, 1984)**
Lepidopleurus soyomaruae Wu & Okutani 1984: 5, pl. 2, figs 5–13, pl. 3, figs 1–8.

Two specimens were collected at the type locality: Japan, Izu Islands, near Torishima Island (30°46.5'N, 141°24.2'E), 3100 m.

***Ferreiraella tsuchidai* Saito, 2006**
(Figs 1B, C)
Ferreiraella tsuchidai Saito 2006: 92, figs 1–10.

The type material consists of two specimens both from the type locality: Philippine Basin between Mindanao Island and Palau Islands (05°30.8'-05°28.0'N, 130°20.2'-130°19.9'E), 5567 m.

Family **Leptochitonidae Dall, 1889**

Genus ***Leptochiton* Gray, 1847**

Type species: *Chiton cinereus* (*sensu*) Montagu 1803 (*non* Linnaeus, 1767) = *Leptochiton asellus* (Gmelin, 1791), subsequently designated by Gray (1847).

***Leptochiton alveolus* (M. Sars MS, Lovén, 1846)**
Chiton alveolus M. Sars MS, Lovén 1846: 159.

The species was subsequently reported from the following localities:

- specimen number unknown; from Spain, Galicia, west of Cabo Finisterre (43°01'N, 09°37'W), 2018 m (Locard 1898) [locality data kindly provided by Virginie Héros, France]
- 1 specimen from the Bay of Biscay (44°10'N, 04°16'W), 2170 m; 1 specimen from the Bay of Biscay (46°27'N, 10°26'W) 4825 m; 1 specimen from the Bay of Biscay (44°10'N, 05°15'W), 1870–2000 m (Kaas 1979)

Remarks: There are several more abyssal records of *Leptochiton alveolus* in the literature, but the present author divided the data into Atlantic records (*L. alveolus*) and Indo-Pacific records (*L. belknapi*, see below), following the opinions of Kaas & Van Belle (1987).

***Leptochiton assimilis* (Thiele, 1909)**
Lepidopleurus assimilis Thiele 1909: 11, pl. 1, figs 30–39.

Without further comments, Jakovleva (1952) mentioned that this species occurs in the Sea of Japan in a bathymetric range from 8 to 2000 m. No subsequent paper confirmed the occurrence of this species at an abyssal depth.

***Leptochiton batialis* Sirenko, 1978**
Leptochiton batialis Sirenko 1978: 118, fig. 1.

Originally seven specimens were described from the type locality: Japan, Honshu, off Kuji [36°29’N, 140°44’E], 2500 m.

***Leptochiton belknapi* Dall, 1878**
Leptochiton belknapi Dall 1878: 1.

While the species was originally described from the Bering Sea of the Alaskan Aleutian Islands, from a depth of 1840 m “only”, there are subsequent deeper records of this species from the following localities:

- specimen number unknown; [described as *Leptochiton benthus*, which is a junior synonym] from the North Pacific, 15° north of Hawaii (35°41'N, 157°42'E), 4206 m (Haddon 1886)
- specimen number unknown; [described as *Lepidopleurus mesogonus*, which is a junior synonym] from Canada, British Columbia, off the Queen Charlotte Islands [53°06’N, 132°14’W], 2904 m (Dall 1902)
- specimen number unknown; [described as *Lepidopleurus halistreptus*, which is a junior synonym] from Mexico, off Acapulco (14°46'N, 98°40'W), 3436 m (Dall 1902) [locality data from Dall 1908]
- 3 specimens [described as *Lepidopleurus giganteus*, which is a junior synonym] from Indonesia, south of Sulawesi Tengarra, Banda Sea (06°24'S, 124°39'E), 2798 m (Nierstrasz 1905)
- specimen number unknown; [described as *Lepidopleurus opacus*, which is a junior synonym] from the Gulf of Panama (07°05'30"N, 79°40'W), 2323 m (Dall 1908)
- specimen number unknown; [described as *Lepidopleurus opacus*] from between the Galapagos Islands and the Peruvian coast (04°33'S, 87°42.5'W), 3667 m (Dall 1908)
- 1 specimen [as *Lepidopleurus (Leptochiton) benthus* (Haddon, 1886)] from the eastern Pacific (15°N, 125°W), 4000 m (Hanselman 1977)
- *Lepidopleurus benthus* (Haddon, 1886) was generally mentioned as occurring at a depth below 4000 m (Sirenko 1977)
- 4 specimens [as *Leptochiton alveolus*] from the United States of America, Oregon, off Lincoln County

(44°33.5'N, 125°14.6'W), 2000 m (Ferreira 1979) [this is "CASIZ RV *Ancona*", data from: http://www.calacademy.org/research/izg/iz_coll_db/index.asp]
- 3 specimens [as *Leptochiton alveolus*] from the United States of America, California, 10 miles SE off Farallon Islands, SW by S1/4 S (37°48'N, [122°58'W]), 2341–2741 m (Ferreira 1979) [this is "CASIZ USS Mulberry; RV *Scofield*", data from: http://www.calacademy.org/research/izg/iz_coll_db/index.asp]
- 3 specimens [as *Leptochiton alveolus*] from Mexico, off Nayarit, Las Tres Marias Islands (21°25'N, [106°28'W]), 2996–2999 m (Ferreira 1979) [this is "CASIZ 009520", data from: http://www.calacademy.org/research/izg/iz_coll_db/index.asp]
- 1 specimen [as *Leptochiton alveolus*] from Japan, near Northern Honshu, 2500 m (Ferreira 1979) [this is "CASIZ 001818", data from: http://www.calacademy.org/ research/izg/iz_coll_db/index.asp]
- 1 specimen [as *Leptochiton alveolus*] from off Baja California Sur southwest of Cabo San Lucas (22°30.8'-22°37.2'N, 110°03.8'-110°15.5'W), 2507–2891 m (Ferreira 1980)
- 1 specimen from off northeastern Honshu, Japan (38°21.7'N, 143°25.9'E), 2930–3020 m (Wu & Okutani 1984)
- 4 specimens from south of Izu-Shoto, Japan (30°37.0'N, 140°40.5'E), 2140 m (Wu & Okutani 1984)
- 1 specimen from Izu-Shoto, Japan (31°58.1'N, 140°21.0'E), 2230–2245 m (Wu & Okutani 1984)
- 1 specimen from the Philippines (06°08'N, 125°58'E), 2800 m (Kaas 1990)
- 2 specimens from the Philippines (05°02'N, 125°15'E), 3250 m (Kaas 1990)
- 1 specimen from the Philippines (14°05'N, 120°02'E), 2050 m (Kaas 1990)
- specimen number unknown; from the Commander Islands [54°48'N, 166°59'E], 100–4400 m (Sirenko & Agapova 1997)

***Leptochiton benthedi* (Leloup, 1981)**
Lepidopleurus benthedi Leloup 1981: 2, text-figs 2, 3, pl. 1, fig. 5.

Originally seven specimens were described from two different stations at the northern end of the Mozambique Channel, southeast of Îles Glorieuses [11°34'S, 47°18'E], in 3700 and 3716 m depth.
Additional specimens were reported by Kaas (1985) from the northern end of the Mozambique Channel:
- 9 specimens from southeast of Îles Glorieuses (11°44'S, 47°35'E), 3716 m
- 1 specimen between Mayotte and the North Geyser Bank (11°59.8'S, 45°42.6'E), 3450 m
- 1 specimen from the northern end of the Mozambique Channel, northeast Geyser Bank (12°12.7'S, 46°40.8'E), 2300 m

***Leptochiton incongruus* (Dall, 1908)**
Lepidopleurus incongruus Dall 1908: 355.

Ferreira (1979) mentioned two specimens of this species from Mexico, Gulf of Tehuantepec, off Salina Cruz (15°40'N, 95°20'W), 3541–3612 m.

***Leptochiton japonicus* (Thiele, 1909)**
Leptochiton japonicus Thiele 1909: 11, pl. 1, figs 21–29.

Sirenko (1977) gave the general bathymetric range of this species from 150 to 2500 m depth, without further comments.

***Leptochiton pergranatus* Dall, 1889**
Leptochiton pergranatus Dall 1889a: 414.

Dall (1889b) mentioned the occurrence of this species between the Gulf of Mexico and Dominica at depths between 208 and 2160 m.

***Leptochiton rissoi* (Nierstrasz, 1905)**
Lepidopleurus rissoi Nierstrasz 1905: 6, pl. 1, fig. 5, pl. 2, fig. 52, pl. 3, figs 53–55.

Of the 10 specimens the author mentioned in the original description, only one was collected at an abyssal depth. This specimen comes from: Indonesia, Sulawesi Utara, west of Kepulauan Sangihe (03°27.1'N, 125°18.7'E), 2053 m.

***Leptochiton vanbellei* Sirenko, 2001**
Leptochiton vanbellei Sirenko 2001: 53, figs 97–111, 180–181.

Although the original description listed a bathymetric range of 775–1550 m for this species, Sirenko (2001) also reidentified a specimen as *Leptochiton vanbellei* that Kaas (1991) identified as *Leptochiton (Leptochiton) belknapi* from New Caledonia (21°16'S, 166°44'E), 2340 m.

***Leptochiton vaubani* Kaas, 1991**
Leptochiton (Leptochiton) vaubani Kaas 1991: 13, figs 13–23.

The two specimens Kaas (1991) mentioned as *Leptochiton (Leptochiton) belknapi* from New Caledonia (22°10'S, 167°33'E), 2100–2110 m, were reidentified by Sirenko (2001) under a name originally restricted to the holotype specimen from 720 m depth.

***Leptochiton vitjazae* (Sirenko, 1977)**
Lepidopleurus vitjazi Sirenko 1977: 1108, figs 1–13.

Three specimens were originally described from the Bougainville Trough [6°S, 153°E] in the Solomon Sea, 6920–7657 m.

***Leptochiton* sp. 1**

Kaas (1991) reported two specimens of an unidentifiable *Leptochiton* from New Caledonia (21°16'S, 166°44'E), 2340 m.

***Leptochiton* sp. 2**

Sirenko (1994) mentioned the occurrence of his "*Leptochiton* sp. 1" at the Commander Islands, southwest of Bering Island [54°45'N, 166°21'E] at 3797–4401 m.

Family **Protochitonidae Ashby, 1925**
Genus ***Deshayesiella* Carpenter MS, Dall, 1879**
Type species: *Lepidopleurus (Deshayesiella) curvatus* Carpenter MS, Pilsbry, 1892, subsequently designated by Pilsbry (1892).

***Deshayesiella sinica* (Xu, 1990)**
Hanleya sinica Xu 1990: 374, fig. 1.

The species is here included in the list of species from below 2000 m because the collecting site of the holotype: East China Sea (26°40'N, 126°30'E), 1680–1950 m, is so close to 2000 m that it is likely that it also occurs somewhat deeper.

Order **Chitonida Thiele, 1909**
Suborder **Chitonina Thiele, 1909**
Superfamily **Chitonoidea Rafinesque, 1815**
Family **Ischnochitonidae Dall, 1889**

Genus ***Lepidozona*** **Pilsbry, 1892**
Type species: *Chiton mertensii* von Middendorff, 1847, by original designation.

Lepidozona abyssicola **(A. G. Smith & Cowan, 1966)**
Ischnochiton abyssicola A. G. Smith & Cowan 1966: 4, figs 1–19.

Of the 13 specimens mentioned in the original description, only one paratype was collected at an abyssal depth. This specimen was collected off the coast of Oregon, USA (44°33.5'N, 125°14.6'W), at 2000 m.

Subsequently, Clark (2000) reported this species from near the Farallon Islands [37°44’N, 123°03’W], California, 2750 m.

Genus ***Stenosemus*** **von Middendorff, 1847**
Type species: *Chiton albus* Linnaeus, 1767, subsequently designated by Winckworth (1926).

Stenosemus chiversi **Ferreira, 1981**
Stenosemus chiversi Ferreira 1981: 325, figs 1–9.

Together with the holotype a second specimen was collected at the type locality: northeastern Pacific (14°52'N, 125°26'W), 4390 m. Another paratype comes from the “north of Equator and east of Hawaii”, where it was collected at 4572 m depth.

Stenosemus exaratus **(G. O. Sars, 1878)**
Lophyrus exaratus G. O. Sars 1878: 113, pl. 8, figs 1a–k.

Kaas & Van Belle (1990) gave a bathymetric range for this species from 100 to 2580 m depth. Unfortunately the present author failed in getting a more precise citation for the abyssal record(s) of this species.

Stenosemus **sp.**

Sirenko (1994) mentioned this species from the Commander Islands, West Bering Island [54°59’N, 166°04’E] from 2240 m.

Polyplacophora of uncertain taxonomic position

- Paul (1976) mentioned the occurrence of an unidentifiable polyplacophoran in the northeastern Pacific (14°17.5'N, 126°15.4'W), at about 4500 m.
- Menzies (1963) reported 5 chiton specimens from the southeastern Pacific, Peru-Chile Trench, 2000–6000 m, and a single specimen from the same area from 3147–3255 m.

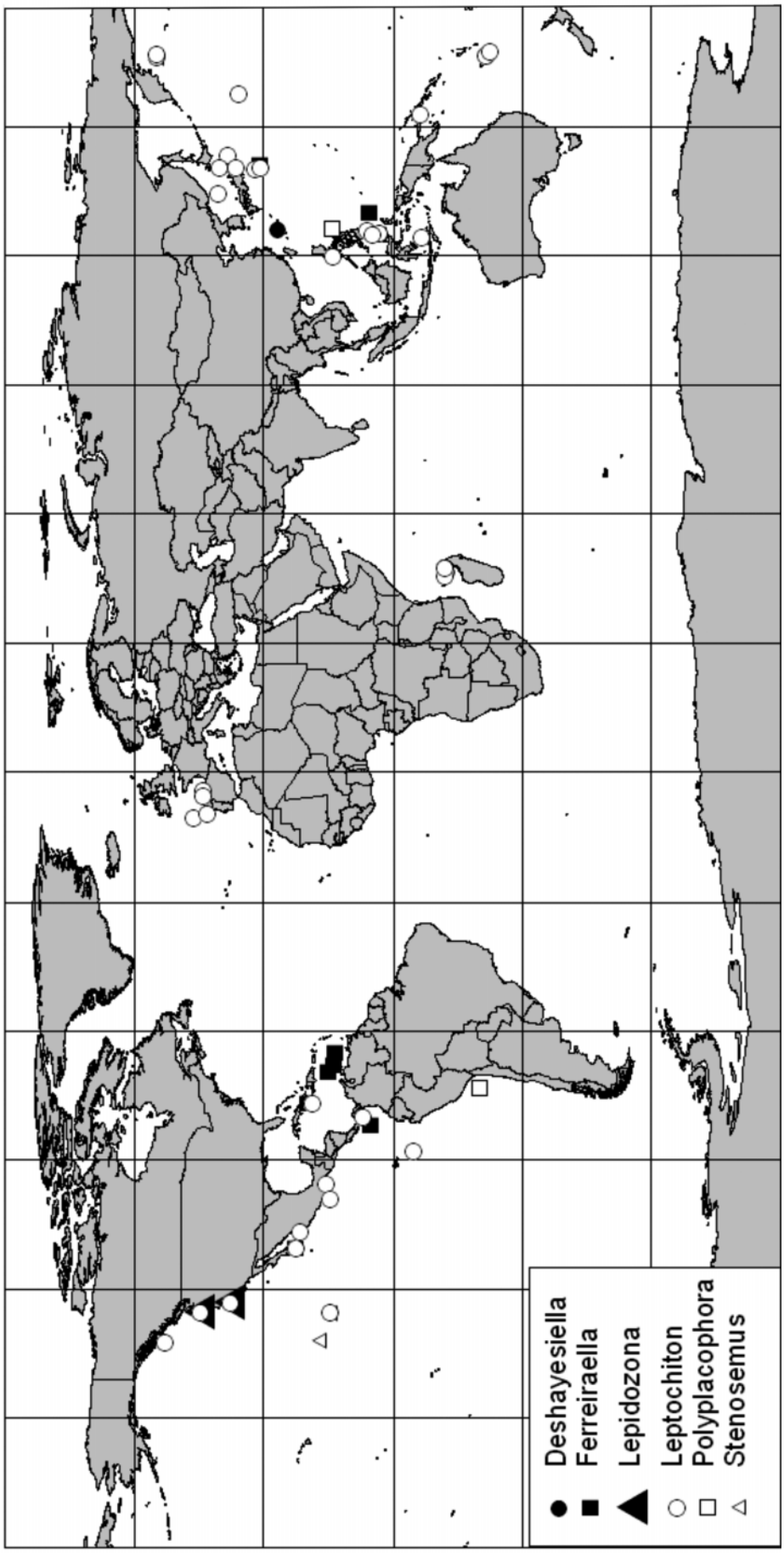

FIGURE 4. Generic distribution of abyssal and hadal Polyplacophora.

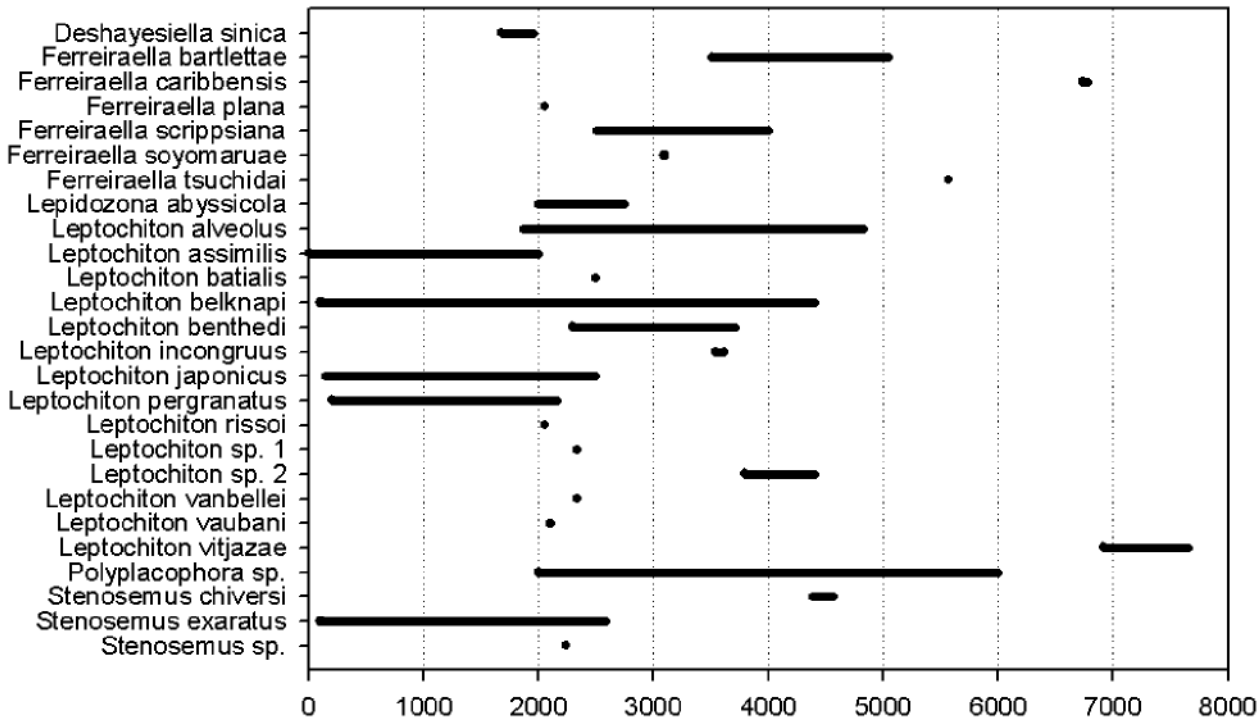

FIGURE 5. Depth range (m) of abyssal and hadal Polyplacophora.

Discussion

The present paper gives a summary of our current state of knowledge of the horizontal and vertical distribution of monoplacophoran and polyplacophoran species living on the continental slope down to the abyssal plain. The data show that 11 (about 35%) of the 31 described Recent monoplacophoran species worldwide live below 2000 m (Fig. 3). Of these 11, two are exclusively hadal. Assuming the existing records are representative, the highest numbers of individuals and species of monoplacophorans are from the eastern Pacific along the geotectonic trenches. In contrast, abyssal representatives of this class are completely lacking from the western Pacific and there is only a single species known from below 2000 m in the Indian Ocean (Fig. 2). This is quite interesting because abyssal chitons are rather common from these areas (Fig. 4). Of the 922 Recent chitons, there are 22 species (2.4%) reported to live below (or nearly below) 2000 m and two of them are restricted to the abyssal plain. Although genetic studies are lacking, at least six of these species are thought to be eurybathic and a few of them are reported as occurring from the sublittoral to abyssal depths. Sirenko (2004) demonstrated that a large number of the polyplacophorans from great depths, reported here, are herbivourous or xylophagous, which could explain the difference between the distribution of monoplacophorans and polyplacophorans in the world's oceans. To the author's knowledge the majority of the reported deep-water monoplacophorans where found attached to hard substratum (e.g. manganese nodules) and only a few of the abyssal polyplacophorans (e.g. *Lepidozona*, *Stenosemus*) share this habitat.

The high number of species of both groups that were discovered during recent decades leaves no doubt that deep sea habitats are far from being sufficiently examined (see also discussion in Marshall 2006). It is highly likely that unexplored deep sea regions will hold many more surprises.

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Notes added in proof

Two more species should be added to the list of species in this paper. There are 24 species (2.6%) of Polyplacophora and Monoplacophora reported to live below (or nearly below) 2000 m and two of them are restricted to the abyssal plain.

Leptochiton kerguelensis Haddon, 1886

Leptochiton kerguelensis Haddon 1886: 12, pl. 1 fig. 3, pl. 2, figs 3a–e.

Troncoso *et al.* (2007) mentioned the species from Antarctica, Bellinghausen Sea (Station MB 17) 68°54.88'S, 78°14.16'W, from a depth of 2044 m.

Placiphorella atlantica (Verrill & S. I. Smith *in* Verrill, 1882)

Placophora (Euplacophora) atlantica Verrill & S. I. Smith *in* Verrill 1882: 365 (foot note).

Kaas & Van Belle (1994) gave a bathymetric range for this species from 155 to 2000 m depth. Unfortunately the present author failed in getting a more precise citation for the abyssal record(s) of this species.

Additional References

Kaas, P. & Van Belle, R.A. (1994) *Monograph of living chitons. (Mollusca: Polyplacophora) 5, Suborder Ischnochitonina: Ischnochitonidae: Ischnochitoninae (concluded) Callistoplacinae; Mopaliidae; Additions to Volumes 1–4*, E.J. Brill / W. Backhuys, Leiden, 1–402.
Troncoso, J. S., Aldea, C., Arnaud, P., Ramos, A. & García, F. (2007) Quantitative analysis of soft-bottom molluscs in the Bellinghausen Sea and Peter I Island. *Polar Research*, 26, 126–134.
Verrill, A.E. (1882) Notice of the remarkable marine fauna occupying the outer banks off the southern coast of New England, No. 7, and of some additions to the fauna of Vineyard Sound. *American Journal of Science*, 24, 360–371.