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A new species of hermit crab of the genus *Parapagurodes* (Decapoda: Anomura: Paguridae) from the Eastern Pacific, with a description of its first zoeal stage

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A new species of the hermit crab genus *Parapagurodes*, is described and illustrated. This is the taxon described previously as simply *Pagurus* sp. from British Columbia, and as an 'undescribed species of Pagurus' from California. It is the first report of this genus from British Columbia, and the first complete description of its first stage zoea. A key to the species of the genus is provided.

KEYWORDS: *Parapagurodes*, Decapoda, Paguridae, hermit crab, new species, zoea I, British Columbia, California

Introduction

Knowledge of the decapod fauna of British Columbia is based in substantial part on the years of work by the late Josephine F. L. Hart. In her Handbook of *Crabs and their Relatives of British Columbia*, Hart (1982) illustrated and briefly described a brilliantly coloured hermit crab as *Pagurus* sp. We are pleased to formally describe and dedicate this species to her.

Having now examined specimens of this taxon from British Columbia and from California, we have found that the males have a small sexual tube on the coxa of the right 5th pereopod. This species, therefore, cannot be attributed to *Pagurus*, but must instead be assigned to *Parapagurodes* McLaughlin and Haig, 1973. The latter genus was described for two deep water California species, *Parapagurodes makarovi* McLaughlin and Haig, 1973 and *Parapagurodes laurentae* McLaughlin and Haig, 1973. The new species is sympatric with *P. laurentae* in California, and is the 'undescribed species of *Pagurus*' mentioned by McLaughlin and Haig (1973: 134).

Materials and methods

Material used in this study has come from the collections of the Royal British Columbia Provincial Museum, Victoria, B.C. Canada (RBCPM), the Allan Hancock Foundation, University of Southern California, Los Angeles, California, USA (AHF) [now housed in the Crustacea collection of the Natural History Museum of Los Angeles County (LACM)], and the personal collections of the authors. The borrowed specimens have been returned to their institutions of origin. Representatives from the senior author's (PMcL) collection have been distributed to the following institutions: Muséum

National d'Histoire Naturelle, Paris (MNHN), Natural History Museum, Smithsonian Institution, Washington, DC (USNM), Nationnal Natuurhistorisch Museum, Leiden (RMNH), Swedish Museum of Natural History, Stockholm (SMNH), and The Natural History Museum, London (NHM).

Larvae were hatched by an ovigerous female being held in the laboratory at the Shannon Point Marine Center. Upon collection, these larvae were preserved in 70% ethyl alcohol, as circumstances did not permit a full-scale rearing endeavour. The preserved zoeae were stained with 1% chlorazol black (*cf.* Bidle and McLaughlin, 1992), dissected using a Wild M-5 microscope, mounted in polyvinyl alcohol lactophenol, and examined with the aid of a Wild M-20 compound microscope. All drawings were made with the aid of a camera lucida. Zoeal terminology follows that of McLaughlin and Gore (1988). The shield length (SL) of adults, as measured from the tip of the rostrum to the posterior margin of the shield, and carapace length (CL) of zoeae measured, with an ocular micrometer, from the tip of the rostrum to the midpoint of the posterior carapace margin, provide an indication of specimen size.

Systematic account

Parapagurodes McLaughlin and Haig, 1973

Eleven pairs phyllobranchiae. Antennal peduncle with supernumerary segmentation. Crista dentata well developed, with accessory tooth. Maxillule with external lobe of endopod not recurved. Fourth pereopods with propodal rasp consisting of more than one row of corneous scales. Males with short sexual tube developed on coxa of right 5th pereopod; left usually without, rarely with short sexual tube; three unpaired, unequally biramous left pleopods. Females with paired gonopores; without paired pleopods; with four biramous left pleopods. Telson with transverse suture; posterior lobes separated by median cleft; terminal margins armed with small spines or spinules.

Parapagurodes hartae sp. n.

(Figs 1–4)

Pagurus sp.: Hart, 1982: 148, fig. 56; Jensen, 1995: 66, no. 124.

Material examined

HOLOTYPE: ♂ (SL = 2·8 mm), Chatham Sound, gap between Henry and Dancay Is., Welcome Harbour (54°00·7′N. 130°28·4′W), British Columbia, Canada, 3 July 1974, ≤ 18 m, coll. Lambert and Kerfoot [identified as *Pagurus* sp. by J. F. L. Hart] RBCPM 974-00368-22. PARATYPES. British Columbia, 1 ♀ (SL = 1·8 mm), Queen Charlotte Is. (52°01′N, 131°16′W), 240 m, 19 March 1991, coll. P. Lambert *et al.*, RBCPM 991-00301-1. 4♂, 4♀, 10 ovig. ♀, 1 sex not determined (SL = 1·1–2·15 mm), Taylor Is., Barkeley Sound, Vancouver Is., 10 m, 18 June 1994, coll. G. Jensen, NHM 1995.152.153 MNHN Pg 5238, RMNH D 46053, SMNH 4649, USNM 270047. California. 23♂, 1♀, 9 ovig. ♀ (SL = 1·0–2·3 mm), *Velero* IV 1937–50, 34°01′32″N, 119°27′10″W, 69–79 m, 24 March 1950, LACM 50–17·7 (AHF). 2♂, 1♀ (SL = 1·6–2·1 mm), *Velero* III 1412–41, 1·5 mi S Crook Point., San Miguel I., 75–79 m, 16 Sep 1941, LACM 41–192·8 (AHF). 1♂ (SL = 2·2 mm), *Velero* III, 978–39, 33°27′35″N, 119°02′35′W, 38–51 m, 28 May 1939, LACM 39–82·6 (AHF). 1♂ (SL = 2·3 mm), *Velero* III 1856–49, Santa Barbara Basin, 635 m, 14 June 1949, LACM 49–142·10 (AHF). 1♂ (SL = 2·0 mm), *Velero* III 1145–40, E. Side Santa Barbara I., 75–86 m, 30 June 1940, LACM 40–119·4 (AHF). 2♀ (SL = 1·5, 2·9 mm), Farnsworth Bank,

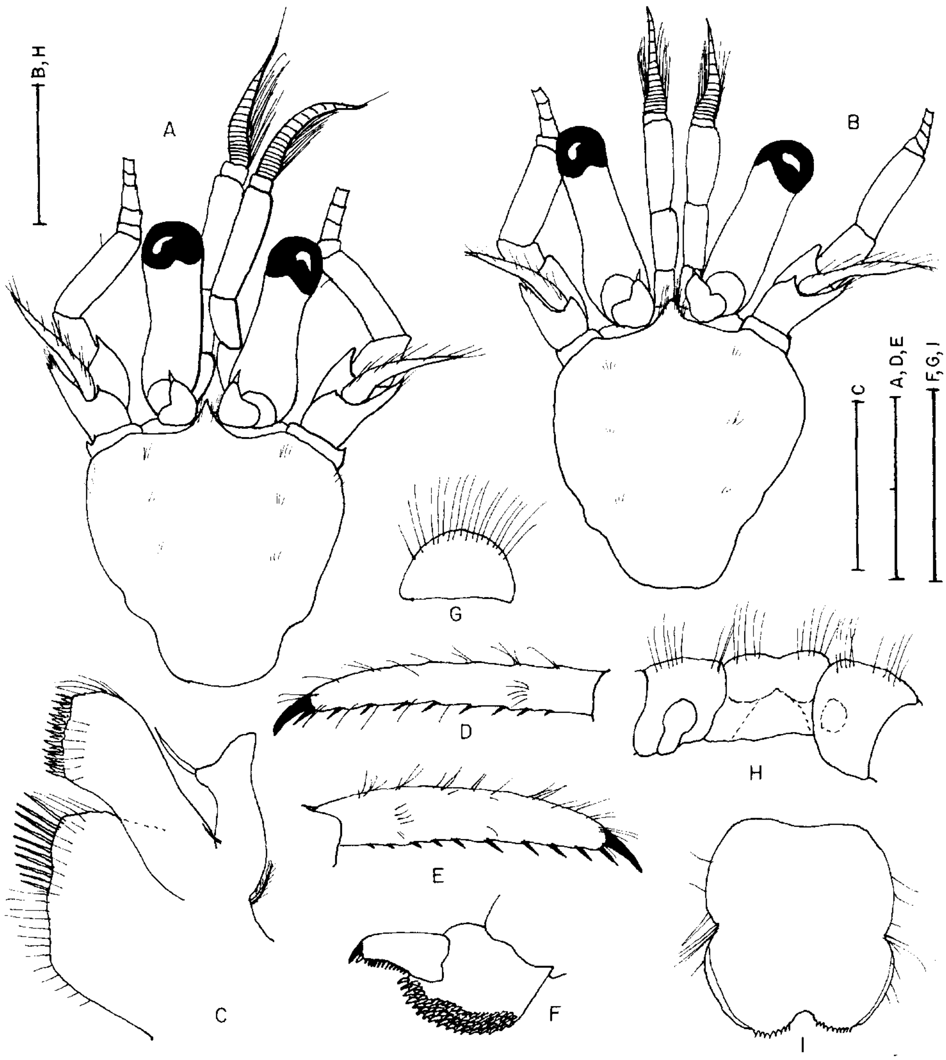

FIG. 1. *Parapagurodes hartae* sp. n.: (A) D–I ♂ holotype RBCPM; (B) C ♀ paratype, PMcL. A, B, shield and cephalic appendages; (C) maxillule; (D) dactyl of right 2nd pereopod, mesial view; (E) dactyl of left 3rd pereopod, mesial view; (F) dactyl and propodus of left 4th pereopod, lateral view; (G) anterior lobe of sternite of 3rd pereopods; (H) sternite and coxae of 5th pereopods, ventral view; (I) telson. Scales equal 0·25 mm (C), 0·5 mm (H), 1·0 mm (B, F, G, I) and 2·0 mm (A, D, E).

Santa Catalina I., 42 m, 16 December 1970, coll. C. Swift and G. Flatt LACM 70–305·1 (AHF 1971–3). 4♂, 2♀ (SL = 1·0–1·6 mm), *Velero* III 1430–41, 7·5 mi SE Seal Rocks, Santa Catalina I., 280–366 m, 25 Oct 1941, LACM 41–210·4 (AHF). 1♂ (SL = 2·0 mm), *Velero* III 1018–39, 33°00′45″N, 118°42′00″W, 91–274 m, 23 Nov 1939. LACM 39–122·5. 2♂ (SL = 1·6, 2·1 mm), *Velero* III 1239–41, 33°00′30″N, 118°32′20″W, 95–112 m, 22 February 1941, LACM 41–19·18 (AHF). 1♂ (SL = 2·0 mm), *Velero* III 1012–39, 32°45′55″N, 118°26′10″W, 100–126 m, 9 November 1939, LACM 39–116·8 (AHF).

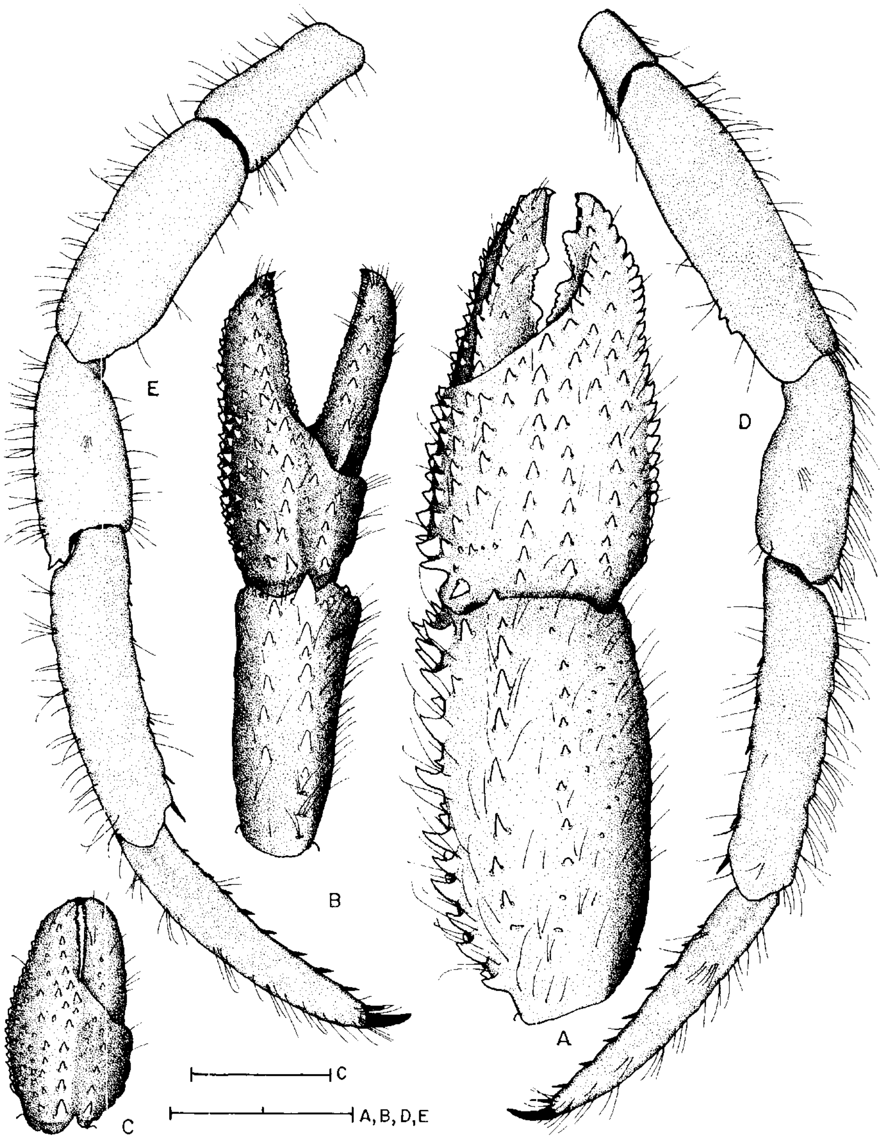

FIG. 2. *Parapagurodes hartae* sp. n.: (A), (B), (D), (E) ♂ holotype RBCPM; (C) ♀ paratype, PMcL. (A) chela and carpus of right cheliped; (B) chela and carpus of left cheliped; (C) chela of left cheliped; (D) right 2nd pereopod, lateral view; left 3rd pereopod, lateral view. Scales equal 2·0 mm (A, B, D, E) and 1·0 mm (C).

Adult morphology
(Figs 1, 2)

Description

Shield (Fig. 1A, B) with anterior margin between rostrum and lateral projections concave, anterolateral margin somewhat terraced, posterior margin roundly truncate. Rostrum triangular, well developed, usually reaching well beyond bases of ocular acicles, terminating acutely or subacutely, and often with terminal spinule. Lateral projections broadly rounded or obtusely triangular, sometimes nearly obsolete, unarmed. Dorsal surface of shield with few tufts of setae, anterior margin often with fine setae frequently obscuring distal portion of rostrum. Ocular peduncles moderately stout, 0·66 to 0·8 length of shield, and shorter than both antennular and antennal peduncles; with corneae slightly dilated. Ocular acicles ovate or subovate, terminating subacutely and with very strong submarginal simple, bi- or rarely trifid spine; separated basally by approximately basal width of one acicle.

Antennular peduncles overreaching ocular peduncles by 0·25 to 0·75 length of ultimate segment. Ultimate and penultimate segments with few scattered setae; basal segment with strong, acute spine laterally. Antennal peduncles overreaching ocular peduncles by 0·5 to 0·75 three-fourths length of ultimate segment; with supernumerary segmentation. Fifth and 4th segments with few scattered setae. Third segment with or without spine at ventrodistal angle. Second segment with dorsolateral distal angle produced, terminating in acute simple or bifid spine, mesial and lateral margins with few setae, and occasionally one small spine on mesial margin in distal half; dorsomesial distal angle usually with acute spine. First segment with spine at dorsolateral distal margin, sometimes very small in small specimens, ventrolateral margin with pair of acute spines distally. Antennal acicle somewhat arcuate, often reaching beyond base, but not exceeding distal margin, of cornea; terminating in small spine, mesial margin with sparse row of setae. Antennal flagellum not overreaching extended right cheliped, one or two moderately short setae every, or every other, article proximally, every article in distal half.

Maxillule (Fig. 1C) with one moderately short stiff seta on anterior lobe of endopod, posterior lobe moderately well developed, not recurved. Third maxilliped with crista dentata well developed and one accessory tooth; merus and carpus each usually with small spine at dorsodistal margin. Sternite of 3rd maxillipeds with spine on either side of midline.

Right cheliped (Fig 2A) overreaching ambulatory legs little, if at all, in small specimens, more elongate in large males. Dactyl approximately equal to or exceeding palm by 0·33–0·5 own length; cutting edge with one or two prominent and several small calcareous teeth in proximal half to two-thirds, row of small corneous teeth distally, terminating in small corneous claw; dorsomesial margin with row of small, blunt or acute spines, dorsal surface elevated in midline and armed with row of spines extending entire length of dactyl, ventral surface with few scattered setae. Palm approximately 0·5 length of carpus, dorsomesial margin not clearly delimited but with irregular single or double row of spines, dorsal surface convex, usually with five, frequently irregular, longitudinal rows of spines, median row most prominent, dorsolateral margin with low protuberances proximally, becoming distinct spines on fixed finger; mesial face with scattered small spines or spinulose tubercles, ventral surface with scattered tubercles; cutting edge of fixed finger with two usually prominent calcareous teeth and two smaller corneous teeth interspersed with corneous denticles; terminating in small corneous claw; dorsal surface of fixed finger with few scattered spines and one or two distinct rows of spines, ventral surface with scattered setae. Carpus approximately as long as merus or slightly longer; dorsomesial margin with row of strong or very strong spines becoming double row distally, dorsal surface with longitudinal row of spines slightly mesiad of midline and 2nd, still smaller row laterad of midline, dorsolateral margin weakly indicated by row of low, spiniform protuberances or spinules; lateral surface with scattered low protuberances, laterodistal margin with row of spines extending on to ventrolateral margin distally, low protuberances on ventrolateral margin proximally; mesial face with scattered low protuberances, mesiodistal margin with row of small spines extending on to ventromesial margin distally; ventral surface with scattered setae distally. Merus subtriangular; dorsal margin with scattered setae and sometimes very low, transverse ridges with short setae; mesial and lateral faces with scattered setae, ventromesial and ventrolateral margins each with row of acute spines; ventral surface with scattered tubercles or small spines. Ischium usually with row of small spines or spinules on ventromesial margin, frequently one more prominent spine near ventromesial distal angle.

Left cheliped (Fig. 2B, C) reaching at least to carpal-propodal margin of right and often to beyond base of dactyl; dactyl and fixed finger arched ventrally, at least in large males. Dactyl long, nearly 3 × length of palm in large males, but appreciably shorter (only 0·33–0·5 longer) in small specimens; dorsal surface slightly elevated in midline, unarmed or with short row of spinules in midline proximally, row of widely-spaced tufts of setae on dorsomesial margin; cutting edge with row of corneous teeth; terminating in moderately strong corneous claw. Palm elevated in mid-line and with irregular, double row of spines, becoming single row and extending to tip of fixed finger; dorsomesial margin frequently not well defined, but with row of low spines or tubercles, dorsolateral surface sloping (quite sharply in large males), armed on palm with scattered small blunt or acute spines or tubercles and distally with row of small spines, extending on fixed finger adjacent to spinose margin; cutting edge of fixed finger with row of very small calcareous teeth proximally, interspersed with corneous teeth distally; terminating in corneous claw. Carpus approximately as long as merus, but longer in large males; dorsomesial and dorsolateral margins each with row of prominent spines; mesial face sometimes with very short transverse ridges and long setae, distal margin usually with one to four small spinules; lateral face with small spinules dorsally, distal margin often with one or two small spinules, ventrolateral margin with row of spines; ventromesial margin with few small protuberances, ventral surface with long setae. Merus subtriangular; dorsal margin with moderately long setae; mesial and lateral faces with scattered setae, ventromesial margin with row of somewhat irregular small spines, ventrolateral margin with row of stronger spines. Ischium with row of small spines on ventromesial margin.

Ambulatory legs (Figs 1D, E, 2D, E) with dactyls varying from slightly shorter to slightly longer than propodi, right longest; dorsal margins with tufts of moderately long setae and few corneous spinules; mesial faces sometimes with few widely-spaced stiff bristles or small corneous spinules near ventral margin; ventral margins each with row of seven to nine (2nd) 8-11 or rarely 13 (3rd). Propodi each with one strong corneous spine at ventrodistal angle and row of smaller, widely-spaced spines on ventral margin; dorsal surfaces with low protuberances and tufts of moderately long setae. Carpi slightly shorter than meri; dorsal margins each with row of low, sometimes minutely spinulose, protuberances and tufts of long setae, rarely with spiniform protuberance or small spine in proximal half (2nd); one spine at dorso-distal angle, smaller on 3rd. Meri with spine on ventrolateral distal angle and one or two additional smaller spines distally of 2nd right; 2nd left and 3rd unarmed or occasionally with corneous spinule; dorsal and ventral surfaces with tufts of long setae. Ischia with tufts of long setae on dorsal and ventral margins. Propodal rasps of fourth pereopods (Fig. 1F) consisting of two rows of corneous scales distally and four rows proximally; small preungual process at base of claw. Sternite of third pereopods with anterior lobe (Fig. 1G) subsemicircular to subrectangular, anterior margin with long marginal setae.

Coxa of right 5th pereopod of male (Fig. 1H) with very short, frequently posteriorly directed, sexual tube; coxa of left with simple gonopore. Pleopods of male with exopods moderately well developed, endopods reduced (3rd and 4th), 5th with endopod vestigial. Females with pleopods 2–4 with both rami moderately well developed, 5th pleopod as in male or with endopod rudimentary. Uropods asymmetrical. Telson (Fig. 1I) with moderately prominent median cleft; terminal margins of posterior lobes oblique or rounded, each lobe with row of small corneous spines, often one or two at or adjacent to outer angle strongest, lateral margins slightly thickened.

Colour (in life). Chelipeds with orange palms and fingers; meri and carpi also orange but with mesial and lateral faces covered by large patches of deep violet bordered by crimson. These distinctive and brilliant markings appear particularly intense when viewed *in situ*, and make this species easy to identify in spite of its small size. Ambulatory legs with similar but less intense markings on the faces of the dactyls, propodi, carpi, and meri, with patches varying from pale blue to ivory. Shield colour varying from pink, orange, or purplish-red to nearly white, with dark red and white spots; remainder of carapace a dark purplish-red with white dots. Ocular peduncles translucent with an irregular reddish band proximally and reddish stripes; cornea yellowish-green and black. Antennules with red, white, and/or blue bands; antennal flagellum transparent, unbanded, and with pale orange mesial and lateral margins.

Variation

There is a marked sexual dimorphism in the chelipeds, with those of males becoming elongate and more slender with increasing body size. The fingers of the left chela not only are lengthened, but develop a pronounced ventral curvature. From our limited sample, it would appear that the spination of the chelipeds is stronger in specimens from California, with the marginal spines of the palms and carpi becoming distinctly tubular in shape, but this may prove inaccurate when more large males from British Columbia are examined. In females and small males from both areas the chelae are much shorter and broader; the spines more triangular. In the length-breadth ratio of the dactyls of the ambulatory legs, the large males again exhibit differences. The dactyls of the left pereopods become more elongate in proportion to their breadth (viewed laterally); the propodi similarly become longer.

Etymology

This species is named for the late Dr Josephine F. L. Hart, who first recognized this taxon as an undescribed species, and who, during her life, contributed substantially to our knowledge of the decapod fauna of British Columbia.

Ecology

Parapagurodes hartae sp. n. is common in rocky, subtidal areas of Barkeley Sound, on the west side of Vancouver Is., British Columbia. The specimens collected there in June 1994 occurred in dense assemblages under large (*ca* 0·3 m diameter) rocks and in crevices at depths of 10 m or more. At these shallow depths, they appeared to be restricted to areas of fairly strong current or wave surge that were free of silt of fine sediments; associated decapods included *Discorsopagurus schmitti* (Stevens, 1925) and the porcelain crabs *Paschycheles pubescens* Holmes, 1900 and *Petrolisthes eriomerus* Stimpson, 1871. The species is also reported from bottoms with sand or gravel and broken shell (Hart 1982).

The geographical distiribution of *P. hartae* sp. n. reflects two patterns that appear in some other Pacific coast species. The first, usually assumed to be temperature related, is the tendency for species found in shallow water in the north to be restricted to cold, deep water in the southern part of their ranges (Morris *et al.*, 1980). In southern California *P. hartae* sp. n. has been recorded from 38–635 m, while in British Columbia it occurs as shallow as 6 (Hart, 1982) and as deep as 240 m. The second is the major discontinuity in its distribution, having been reported from southern California and British Columbia but not from Washington, Oregon, or northern California. Although a possible artifact of sampling effort, similar large discontinuities have been noted in other taxa including the hippolytid shrimp *Heptacarpus taylori* (Stimpson, 1857) (Green and Butler, 1988), and two species of kelpfish (Clinidae; Hart, 1973).

Distribution

Queen Charlotte and Vancouver Is., British Columbia, Canada; southern California, USA; 6–635 m.

Affinities

The presence of a short right sexual tube in males sets *P. hartae* sp. n. apart from all other North Pacific pagurid species. The vivid colouration and patterns of this species in life immediately distinguish it from all other Eastern Pacific pagurid taxa. In the absence of colour, North Pacific adults of *P. hartae* sp. n. bear a superficial resemblance to *Pagurus dalli* (Benedict, 1892), in having a well developed rostrum, spinose chelipeds, and a subtriangular (transverse-section) left chela. However, the distinct spination of the carpus of the right cheliped, the absence of a row of spines on the dorsal carpal margins of the ambulatory legs and the armature of the telson immediately distinguish *Parapagurodes hartae* sp. n. There is also a general similarity between *P. hartae* sp. n. and *Pagurus brandti* (Benedict, 1892); however, the latter species lacks a prominent rostrum, has a row of spines on the carpi of the ambulatory legs, and a strongly spinose telson. In California waters, *Parapagurodes hartae* sp. n. most closely resembles *P. laurentae*. Males of both species have short right sexual tubes; however, that of *P. hartae* sp. n. is usually appreciably shorter. The most reliable character for separating the two taxa is the presence, in *P. hartae* sp. n., of a row of spines in the midline of the dactyl of both left and right chelae, and the lack of a row of long, stiff setae on the dorsal margins of the dactyls of the ambulatory legs. In small males and females, the length–breadth ratio of the dactyls and propodi, particularly those of the left 3rd pereopods may be used to separate the two taxa; the dactyl and propodus are long and slender in *P. laurentae*, shorter and broader in *P. hartae* sp. n. However, as previously noted, this character is subject to change in large males. Similarly, the number of corneous spines on the ventral margins of the dactyls of the ambulatory legs is usually greater in *P. laurentae* (typically 10–11 on second, 11–14 on 3rd), but occasionally individuals having overlapping numbers have been observed in both species. The lack of spines on the dorsal surface of the right chela of *P. makarovi* immediately distinguishes this species from the other two.

Remarks

If it were not for her detailed colour description, the species we recognize here as *Parapagurodes hartae* sp. n. would not easily be identified with Hart's *Pagurus* sp. (1982). Her description, apparently based on a large male that we have not be able to locate, was brief and rather general. Her figure (Hart, 1982, fig. 56a) shows a specimen with a very weakly produced, rounded rostrum, long and moderately slender ocular peduncles, long left chela with an extremely elongate dactyl, and relatively strongly armed telson (Hart, 1982, fig. 56b). As our description and illustrations reflect, *Parapagurodes hartae* sp. n. actually has a very well developed, acute or subacute rostrum that usually reaches well beyond the bases of the ocular acicles. However, its appearance is deceptive, as the rostrum itself is frequently less calcified than the anterior margin of the shield, and some fine setae often obscure its presence. The left chela shows marked allometric growth. In large males, it is long and slender, the dactyl noticeably elongate; in small specimens neither the chela, as a whole, nor the dactyl are lengthened; the general appearance is stoutly subtriangular. The telson armature is most commonly less prominent than in the specimen illustrated by Hart.

The presence, in males, of a very short sexual tube, immediately distinguishes this species from all other North Pacific species, however, the tube is quite small, usually translucent, and often curved posteriorly, making it easily overlooked in casual examination. A character not mentioned by Hart (1982), but one which aids to readily identify specimens of either sex in British Columbian waters, is the armature of the dorsal surface of the carpus of the right cheliped. Regardless of specimen size, the carpus bears a row of strong spines on the dorsomesial margin, a somewhat smaller longitudinal row mesiad of the midline and an even smaller row slightly laterad of the midline; the dorsolateral margin is not delineated.

As previously mentioned, *Parapagurodes hartae* sp. n. occurs in California waters with the two other species of the genus, *P. makarovi* and *P. laurentae*. McLaughlin and Haig (1973) reported considerable variation in both of the latter species, and, as noted above, variation is quite common in the specimens of *P. hartae* sp. n. that we have examined. *Parapagurodes hartae* sp. n. and *P. laurentae* occur sympatrically in southern California, although the range of *P. hartae* sp. n., as reported by Hart (1982), does not appear to extend into Mexican waters. The 'undescribed species of *Pagurus*' referred to by McLaughlin and Haig (1973) is, in fact, *Parapagurodes hartae* sp. n. Both McLaughlin and Haig (1973) and Hart (1982) either overlooked the small right sexual tube of the male or interpreted it as an artifact of preservation. We have re-examined all of those specimens separated by McLaughlin and Haig (1973) as the undescribed '*Pagurus*', as well as the sympatric paratypes of *Parapagurodes laurentae*, and confirmed that these two taxa are distinct, albeit morphologically quite similar. *Parapagurodes laurentae* and *P. makarovi* both appear to be restricted to the warmer southern waters.

Key to the species of *Parapagurodes*

1 Dorsal surfaces of palms of right and left chelae unarmed or with only scattered small spinules or tubercles . . . . *P. makarovi*
– Dorsal surfaces of palms of right and left chelae armed with one or more rows of distinct spines 2

2 Dactyls of right and left chelae with row of spines in dorsal mid-line . *P. hartae* sp. n.
– Dactyls of right and left chelae without row of spines in dorsal midline . *P. laurentae*

Larval development
(Figs 3, 4)

First zoeal stage. CL = 0·92–1·00 mm.

Description

Carapace (Fig. 3A, B): with short, low keel anteriorly in dorsal midline, posterolateral marginal spines very short; eyes sessile. Rostrum elongate, approxi-

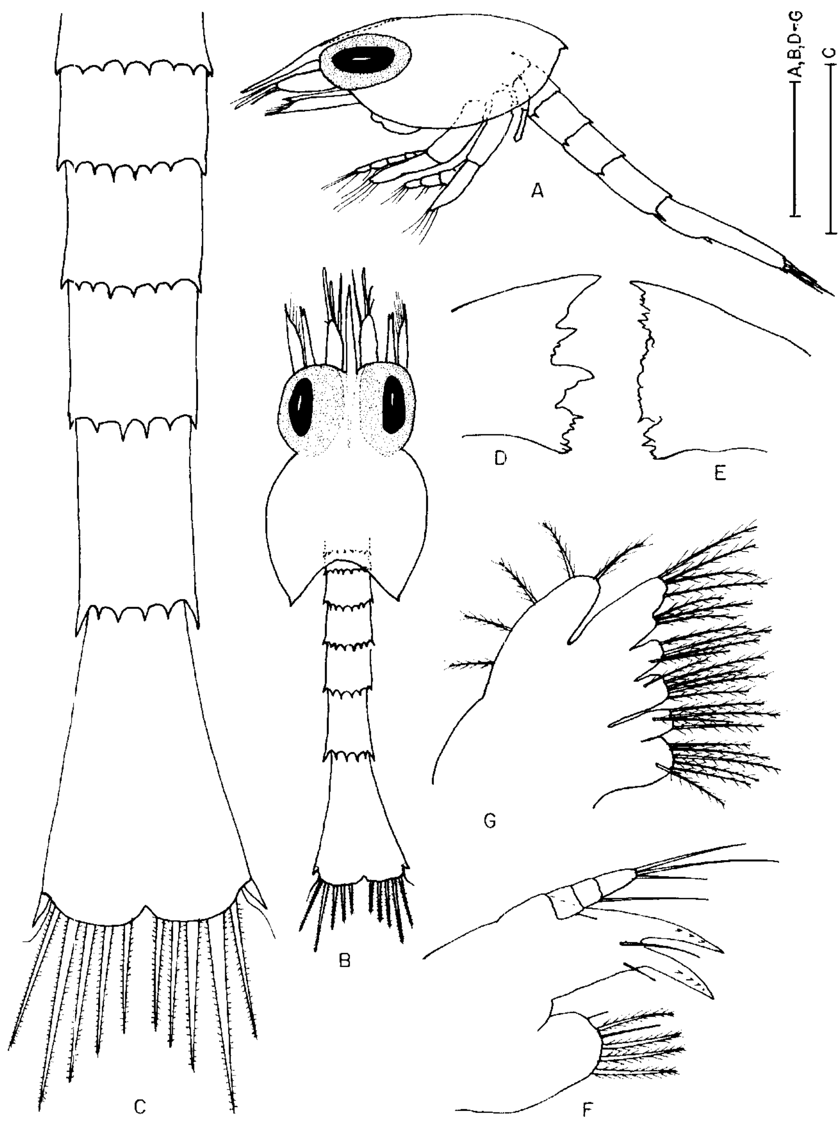

FIG. 3. *Parapagurodes hartae* sp. n., zoea I, CL 1·07 mm: (A) whole animal (lateral view); (B) whole animal (dorsal view); (C) abdomen and telson; (D) left mandible; (E) right mandible; (F) maxilllule; (G) maxilla. Scales equal 0·5 mm (A, B); 0·25 mm (C) and 0·1 mm (D–G).

mately equal or slightly longer than antenna, moderately slender, directed slightly ventrally.

Abdomen (Fig. 3B, C): with somites 1–5. Posterodorsal margins of somites armed as follows: 1st, 2nd and 3rd each with two small and one slightly larger pairs of spines, 4th and 5th each with two pairs of moderately strong spines; posterolateral margins of 1st–4th somites also with small pair of spines, 5th somite with slightly longer pair of posterolateral spines.

Telson (Fig. 3B, C): fused with 6th somite; elongate slightly fan-shaped; posterior margin rounded and with 7 + 7 processes (1, ii, 3, IV, 5–7), outermost, naked,

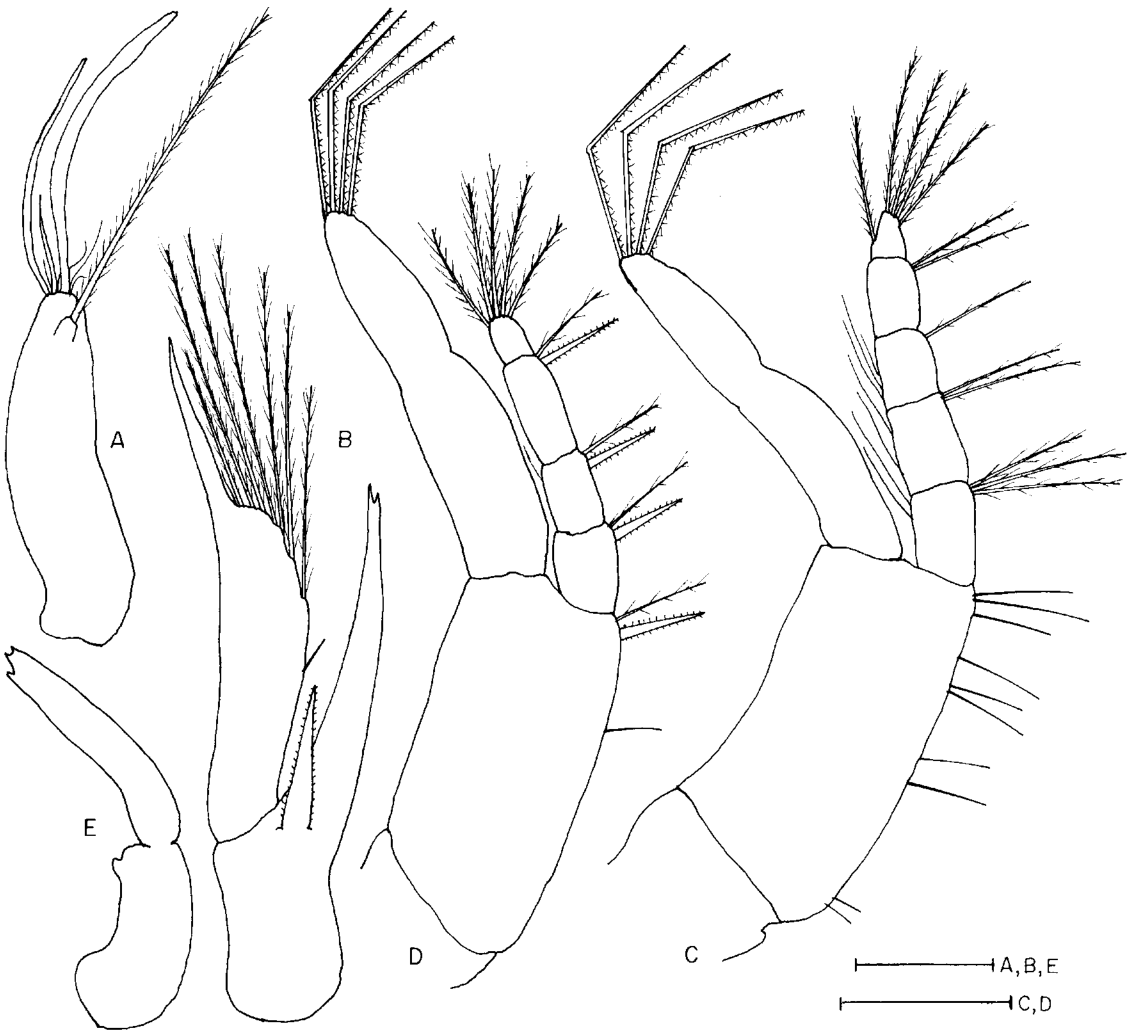

FIG. 4. *Parapagurodes hartae* sp. n., zoea I, CL 1·07 mm: (A) antennule; (B) antenna; (C) 1st maxilliped; (D) 2nd maxilliped; (E) 3rd maxilliped. Scales equal 0·25 mm (C–E) and 0·1 mm (A, B)

articulated, moderately small spine-like process (1), 2nd an anomuran hair (ii) 3rd through to 7th articulated, plumodenticulate processes, 4th longest; median cleft moderately deep; anal spine present.

Antennule (Fig. 4A): conical, slightly $<0{\cdot}5$ length of antenna; exopod fused to protopod, with two or three aesthetascs and three or four simple setae terminally; one long, plumose terminal seta on rudimentary endopodal bud.

Antenna (Fig. 4B): scaphocerite with strong distal spine, outer margin unarmed; inner margin with seven plumose setae and two short, simple setae, one distally adjacent to distal spine and one proximally; endopod equalling or slightly overreaching scaphocerite (exclusive of distal spine), terminating in unequally bifid spine; one strong protopodal spine armed with marginal denticles at base of endopodal junction.

Mandibles (Fig. 3D, E): asymmerically dentate; no palp bud.

Maxillule (Fig. 3F): coxal endite with one simple and four plumose setae marginally and one short, simple seta submarginally; basial endite with two strong, elongate, slightly curved, spine-like teeth armed with two to four moderately strong denticles and with two simple setae submarginally; endopod 3-segmented, setal formula progressing distally 1 or 2, 1, 3.

Maxilla (Fig. 3G): coxal and basial endites distinctly bilobed; coxal endite with one submarginal and five marginal plumose setae on proximal lobe, one submarginal and three marginal plumose setae on distal lobe; basial endite with three or four marginal and one submarginal setae on proximal lobe, three marginal and often one submarginal plumose setae on distal lobe; endopod weakly bilobed, with two or three plumose setae on proximal lobe and four plumose setae on distal lobe; scaphognathite fused to protopod proximally, distal lobe with five short plumose marginal setae.

First maxilliped (Fig. 4C): coxipod naked; basipod with setal formula progressing distally 1 or 2, 2, 2 or 3, 2 or 3; endopod 5-segmented, segmental setation proximal to distal 3, 2, 1, 2, 4 + I (Roman numeral denoting dorsolateral seta) and additional fine setae on lateral margins of three most proximal segments; exopod incompletely 2-segmented, with four terminal natatory setae.

Second maxilliped (Fig. 4D): coxipod also without setae; basipod with one simple marginal seta in distal half, one strong spinose process armed with marginal spinules and one weakly plumose seta at distal angle; endopod 4-segmented, segments 1–3 each with one strong spinose process armed with marginal spinules and one weakly plumose seta, distal segment with 4 + I plumose setae; exopod incompletely 2-segmented, with four terminal natatory setae.

Third maxilliped (Fig. 4E): protopod with developing endopod indicated by very small protuberance distally; exopod elongate, unsegmented, with bifurcate tip and one subdistal protuberance.

Remarks

Larval development in *Parapagurodes* has been known only from the description of the telson of what McLaughlin and Haig (1973) referred to as prezoeae of *P. makarovi* and *P. laurentae.* These telsons were illustrated from larvae hatching just at the time of preservation. At the time of McLaughlin and Haig's description (1973), prezoeal morphology in pagurids was poorly understood. Now that prezoeae of several species have been described (e.g., Hong, 1988; Quintana and Konishi, 1986, 1988), it is probable the fully developed telsonal processes illustrated by McLaughlin and Haig (1973: fig. 4) represent 1st zoeal telsons in these two species. In telson morphology, *P. hartae* sp. n. agrees extremely well with both species.

In certain other aspects of first zoeal morphology, *Parapagurodes hartae* sp. n. resembles three North Pacific species of *Pagurus*, *P. brandti*, *P. trigonocheirus* (Stimpson, 1858), and *P. undosus* (Benedict, 1892) as described by Ivanov (1979). Similarities are seen among all four species in the bifid tip of the antennal endopod, mandibular dentition, and development of the third maxilliped. *Parapagurodes hartae* sp. n. zoea I differs from *Pagurus brandti* and *Pagurus trigonocheirus* in having much shorter posterolateral spines on the carapace and abdominal somites, and having the 1st telsonal process articulated, not fused. *Parapagurodes hartae* sp. n. zoea I is distinguished from zoea I of *Pagurus undosus* in having seven plumose setae and two short simple setae on the inner margin of the scaphocerite; five or six 'pinnate' setae are present centrally and three short simple 'hair-like' setae distally in *Pagurus undosus* (Ivanov, 1979: 981). Additionally, *P. undosus* is described as having a pair of minute processes on telson adjacent to the median cleft, and the endopod of 3rd maxilliped approximately 0·33 the length of the exopod. In *Parapagurodes hartae* sp. n. there are no indications of additional telsonal processes, and the endopod of the 3rd maxilliped is only a tiny bud.

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