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Decapod Larvae from a Nearshore Area of Northeastern Newfoundland (Crustacea, Decapoda)

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Abstract

Nine species of decapod larvae, including lobster (*Homarus americanus*), from the plankton were identified in a nearshore study area in northeastern Newfoundland. Characteristics including illustrations for field identification of larvae of these species are given. Occurrences of Stages I–IV Zoea and Megalopa of the more abundant species indicate possibly more than one spawning or hatching during summer. Evidence of oogenesis being equal to embryogenesis is presented for the species *Eualus pusiolus* and *Crangon septemspinosa* in this area. The occurrence of larvae of *Caridion gordoni* gives a most northerly record for this species in the western North Atlantic.

Key Words: *Cancer*, *Caridion*, *Crangon*, *Eualus*, larvae, *pagurus*, plankton, spawning

Introduction

Decapod crustacean larvae, among other plankton, were taken by plankton collectors from inshore in a lobster fishing area at St. Chad's, Bonavista Bay, northeastern Newfoundland (Fig. 1), in summer 1971. The primary objective of the survey was to determine the distribution of lobster larvae near shore under various conditions of wind and weather (Ennis, 1983). The samples, however, contained other decapod larvae which were kept with appropriate documentation.

Zoea of shrimps, hermit crabs and crabs were collected and identified in a preliminary way. Final identification and occurrences of Stage I Zoea larvae in particular throughout the summer form the subject of the present paper. All larvae collected have previously been described in literature, but it is noted that recognition characters and drawings of Stage I or II Zoea larvae of each species given here would be valuable for field identification.

Materials and Methods

Samples from plankton surveys conducted during May to September 1971 in St. Chad's, Bonavista Bay, Newfoundland were studied for decapod larvae. These surveys as described by Ennis (1983), include the use of a diver-operated machine-driven plankton collector, with a 50 cm diameter #2 mesh plankton net. Five-minute tows were made from surface to bottom in depths up to 9 m and not more than 20 m from shore for the most part. A series of 3–7 tows were made in succession in each instance in a specified location. (A time difference in towing the plankton net occurred on 18–20 August when some 30 minute surface tows were made).

Total number of specimens of decapod larvae in the collection was 7 616 taken in 306 tows. Total plankton comprised mostly calanoid copepods, fish eggs and larvae and several other planktonic species. Some adult decapod crustaceans were also collected but not in the plankton net.

For this paper most species were identified by examining specimens with a dissecting microscope at not more than 80X magnification, but some checking was done with specimens stained in Acid Rose, mounted in glycerol on a slide and examined at 100X and 430X magnification.

Results

Specimens of the following species were examined and measured, and accompanying documentation included in tables and graphs.

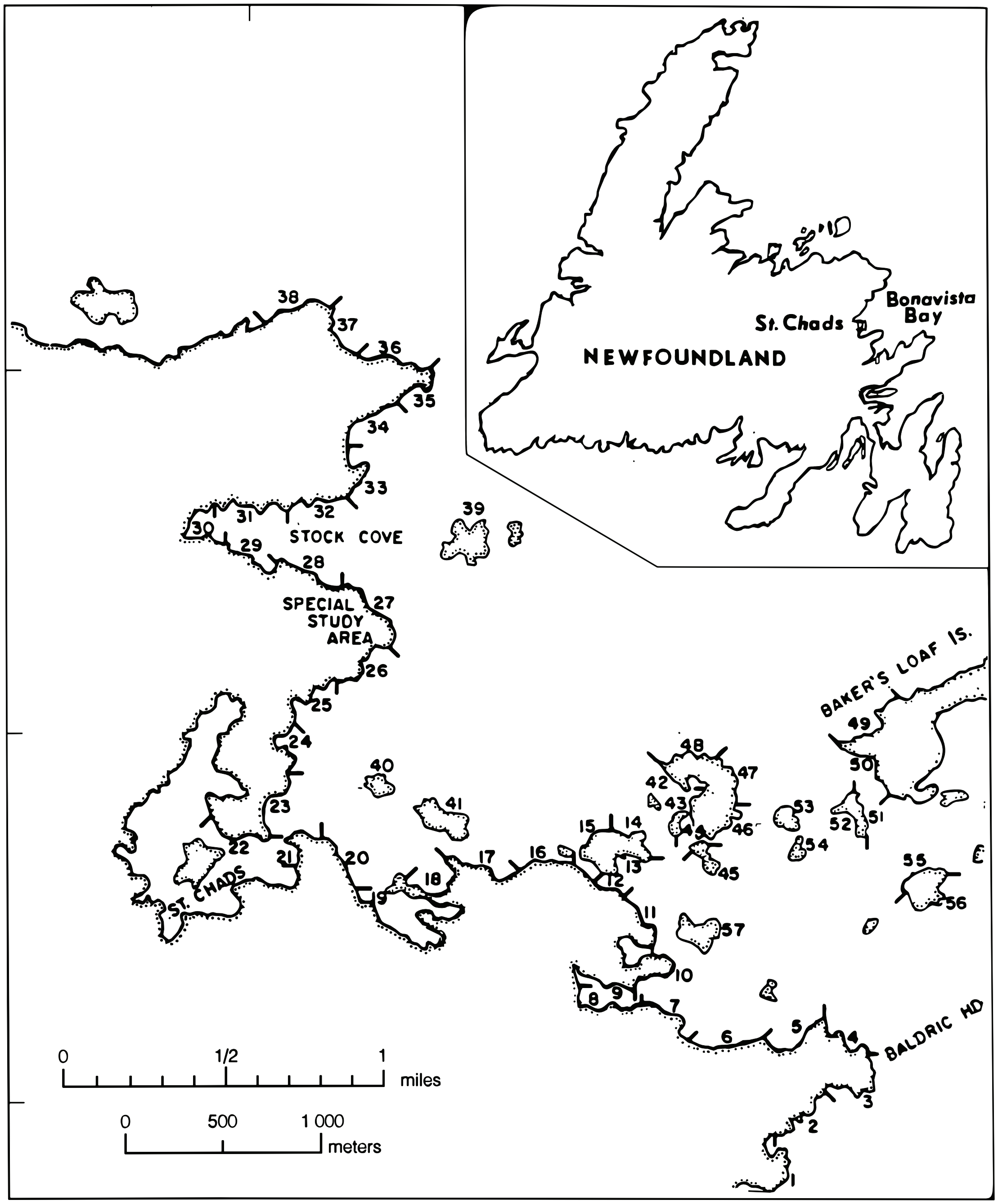

Fig. 1. Map of area of investigation at St. Chad's, Bonavista Bay, indicating the sampling area where plankton hauls were conducted in the survey. Only 16 areas provided data (14–29, 39), mostly from 14–20.

Family **Alopidae**

Caridion gordoni (Bate, 1858)

Fig. 2a

The larvae of this species had been described by Sars (1900), who thought they belonged to *Pandalus borealis*. The larvae were referred to the present species by Lebour (1930) with accompanying figures, but had previously been recognized by Hansen (1908). The larvae looks like a pandalid, because of its short carapace compared to the length of its abdomen (Fig. 2a), but is quite unlike it in other respects. In an overall view, the first impression is that the exopods on maxillipeds are very long. In Stage II and III Zoea the eyes are spread

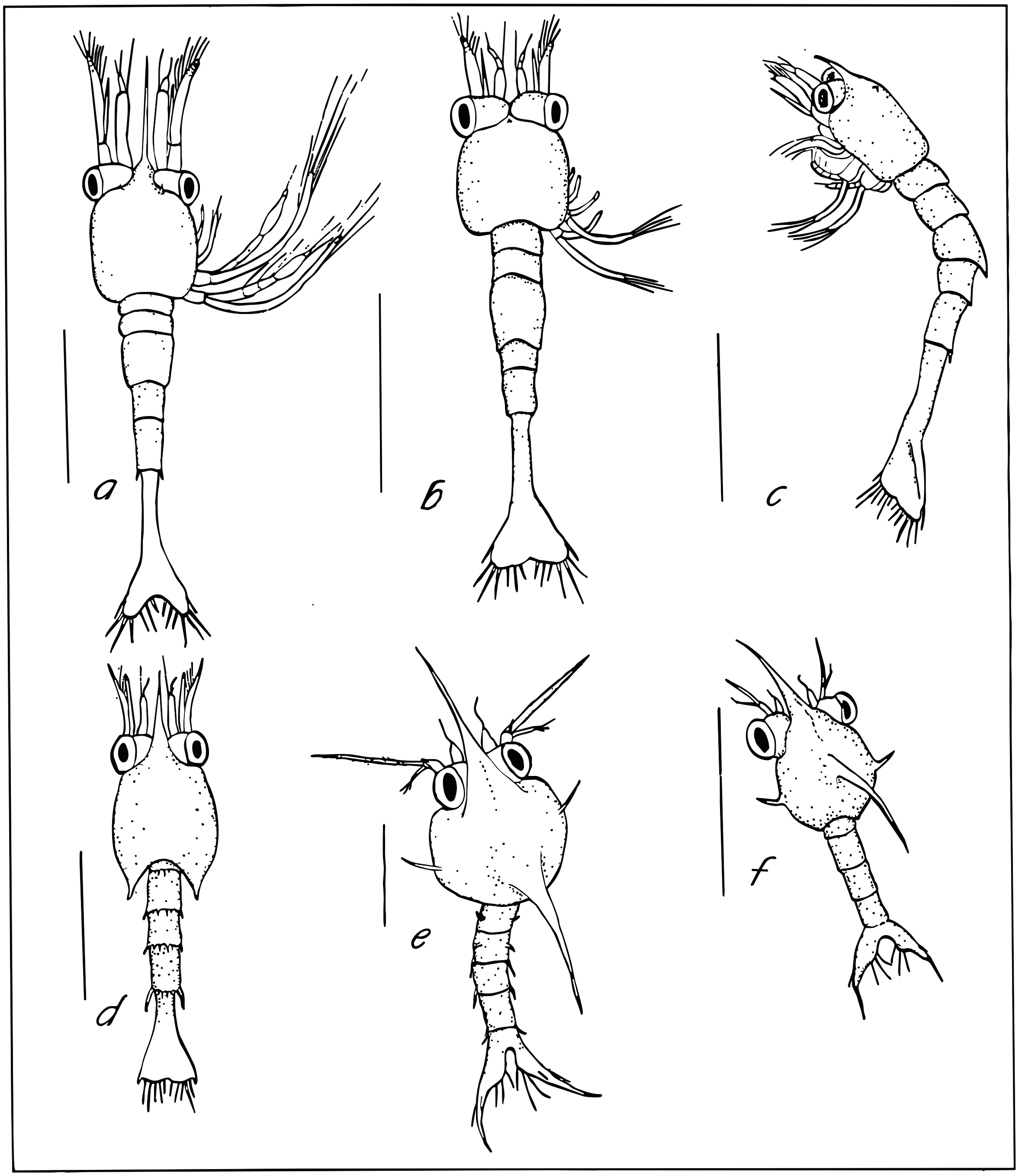

Fig. 2. Drawings of Stage 1 Zoea of a) *Caridion gordoni*; b) *Eulas pusiolus*; c) *Crangon septemspinosa*; d) *Pagurus arcuatus*; e) *Chionoecetes opilip*; and f) *Cancer irroratus* from collections at St. Chad's, Newfoundland. Scale, each line = 1 mm.

apart sideways rather than merely forward. Also the rostrum is as long as the carapace and thin and styliform, the telson is deeply notched and the penultimate segment of the endopod of the maxillipeds is somewhat inflated. The fifth abdominal somite has a postero-lateral pair of spines. In Stage I Zoea the pereopods are merely buds and the segmentation of the tip of the antennal scale shows its primitive development. It has no supraorbital spines in Stage I Zoea but they are present in Stage II–IV Zoea. Mandible has unusual long spike-like incisor in Stage I Zoea.

Total lengths of specimens examined (8 only) were: Stage I Zoea, 2.8–3.0 mm, Stage II Zoea, 3.5 mm, and Stage III Zoea, 4.1 mm. No other stages were obtained. Lengths recorded by Lebour (1930) for eastern Atlantic specimens were: Stage I Zoea, 3 mm, Stage II Zoea, 4 mm, and Stage III Zoea, 5 mm, apparently greater than lengths observed here except in Stage I.

Adult specimens have not been taken previously as far north in North America as these (Squires, 1990), but are reported from south of Newfoundland and off Nova Scotia. Also they are known from Greenland, and from Norway extending to the Bay of Biscay in Europe. Larvae were taken off Plymouth, England, before adults were encountered, and it was thought that the adults frequented rocky bottom where trawling was not possible (Lebour, 1930). Larvae were reported from Fortune Bay and the Gulf of St. Lawrence by Frost (1936).

Family **Thoridae**

Eualus pusiolus (Krøyer, 1941)

Fig. 2b

The larvae of this species have been described by Bull (1939) and Pike and Williamson (1961). It is recognizable by its small size, very short rostrum and no spines on the abdominal somites (Fig. 2b). As the pereopods develop, exopods are present on the first three pairs. In the present collection total lengths were as follows (numbers measured are in parentheses): Stage I Zoea, 2.2–2.4 mm (15); Stage II Zoea, 2.5–3.2 mm (14); Stage III Zoea, 3.2–3.8 mm (20); Stage IV Zoea, 3.4–4.3 mm (20), and Megalopa, 4.2–4.3 mm (23). These lengths are similar to those obtained for the species in the eastern Atlantic by Pike and Williamson (1961).

Total number of specimens of larvae of *E. pusiolus* examined from this collection was 450, most of which were in Stage I Zoea. Occurrences of the larvae of this species during 7 June–20 August showed four major peaks of abundance of Stage I Zoea (Fig. 3), possibly indicating production of four batches of eggs and/or four periods of hatching during the summer. Ovigerous females in the collection of adults examined supported this view. Those females carrying eggs showing eye spots had large ova in the ovaries, indicating that the time for oogenesis was about the same as for embryogenesis. It is therefore possible that after the eggs carried externally are hatched, the ova will be shortly extruded as the next batch. According to the peaks of occurrence of Stage I Zoea in Fig. 3, the time for oogenesis (or embryogenesis) is about 30 days. Incidentally, the adults carrying eggs which were about to hatch in late-August did not have large ova in the ovaries, at least in the few examined (4). This may mean they do not carry eggs externally over the winter. Some Stage I Zoea were captured in September (Fig. 3), a further indication that multiple spawning occurs spread throughout the warm summer from June–September. Zoeal stages later than Stage I appeared early in the summer. Stages up to IV were present in early July, but Megalopa were not seen until mid-August (Fig. 3). Two peaks of occurrence appeared in each zoeal stage from II to IV. Periods between moultings were not clear from these results.

The occurrence of more than one hatching period during the summer has been demonstrated previously in a shallow warm water area for *Crangon septemspinosa* at Port au Port Bay, Newfoundland (Squires, 1965; 1970), and possibly for the same species in the present paper, as well as for *E. pusiolus*.

Family **Pandalidae**

Pandalus borealis Krøyer, 1938

Only one specimen (Stage II Zoea) of this species was taken in a tow at 9 m depth, temperature 6.0°C. Recognition characters are: no postero-lateral spines on abdominal somites 4 or 5, supra-orbital spine in Stage II Zoea, antennal scale setae at least 15, exopods on first to third pereopods, and total length of 5–7 mm at Stage II Zoea. Other characters of this and other Zoeae of this species are as in Squires (1993).

Family **Crangonidae**

Crangon septemspinosa Say, 1818

Figure 2c

The larvae of this species have been described by Needler (1941). Recognition characters are: third abdominal somite with mid-dorsal pleura projecting as a spine in all zoeae, first pereopod with propodus somewhat inflated and with dactyl beginning to form a subchelate claw, pereopod I only with exopod. Very small larvae. Megalopa with the appearance of a small adult.

Total lengths of zoeae were as follows (numbers measured in parentheses): Stage I Zoea, 2.2–2.6 mm (32); Stage II Zoea, 2.3–3.0 mm (21); Stage III Zoea, 3.0–3.6 mm (21); Stage IV Zoea, 3.4–4.0 mm (23); Megalopa, 4.0–4.3 mm (6). These lengths were slightly larger at the early zoeal stages than those obtained by Needler (1941) but are otherwise similar.

Total number of larvae of this species examined in the collection was 174. Occurrences of Stage I Zoea of this species throughout the summer of 1971 showed three peaks, the first in early

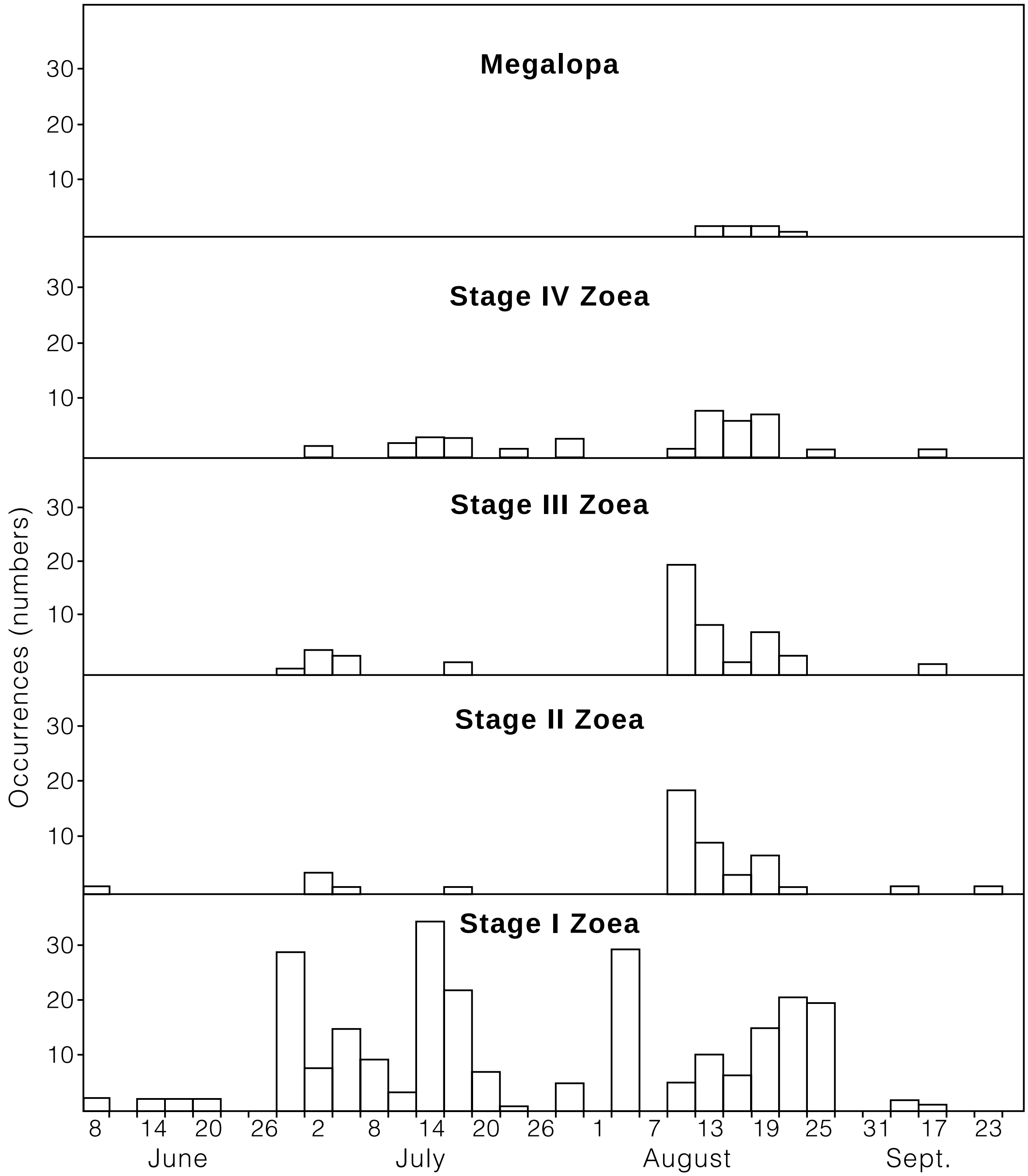

Fig. 3. Graphs of occurrences of Stages I–IV. Zoea and Megalopa of *Eualus pusiolus* during June–September, 1971, at St. Chad's, Bonavista Bay, Newfoundland.

June, the second in early July and the third in August (Fig. 4), possibly indicating three spawning (or hatching) periods. This is similar to occurrences of *Eualus pusiolus* as shown in this paper, and as demonstrated in the present species at Port au Port Bay (Squires, 1965; 1970).

Zoeal stages later than Stage I Zoea occurred as early as late June in this study (Fig. 4) Even the Megalopa appeared in early July. Although the numbers were few, two peaks of occurrence of each stage between II and IV indicated at least two broods during the summer. Relatively large numbers of all stages were captured in 30 minute surface tows on 18–20 August (Fig. 4) at sites 15–17 and 20 with moderate off shore winds and overcast conditions with sunny periods. The 30 minute tows, rather than the usual 5 minutes, account for the large numbers taken. The data indicated that the larvae were more surface oriented than in other species which did not reflect this anomaly by an increase in the numbers captured.

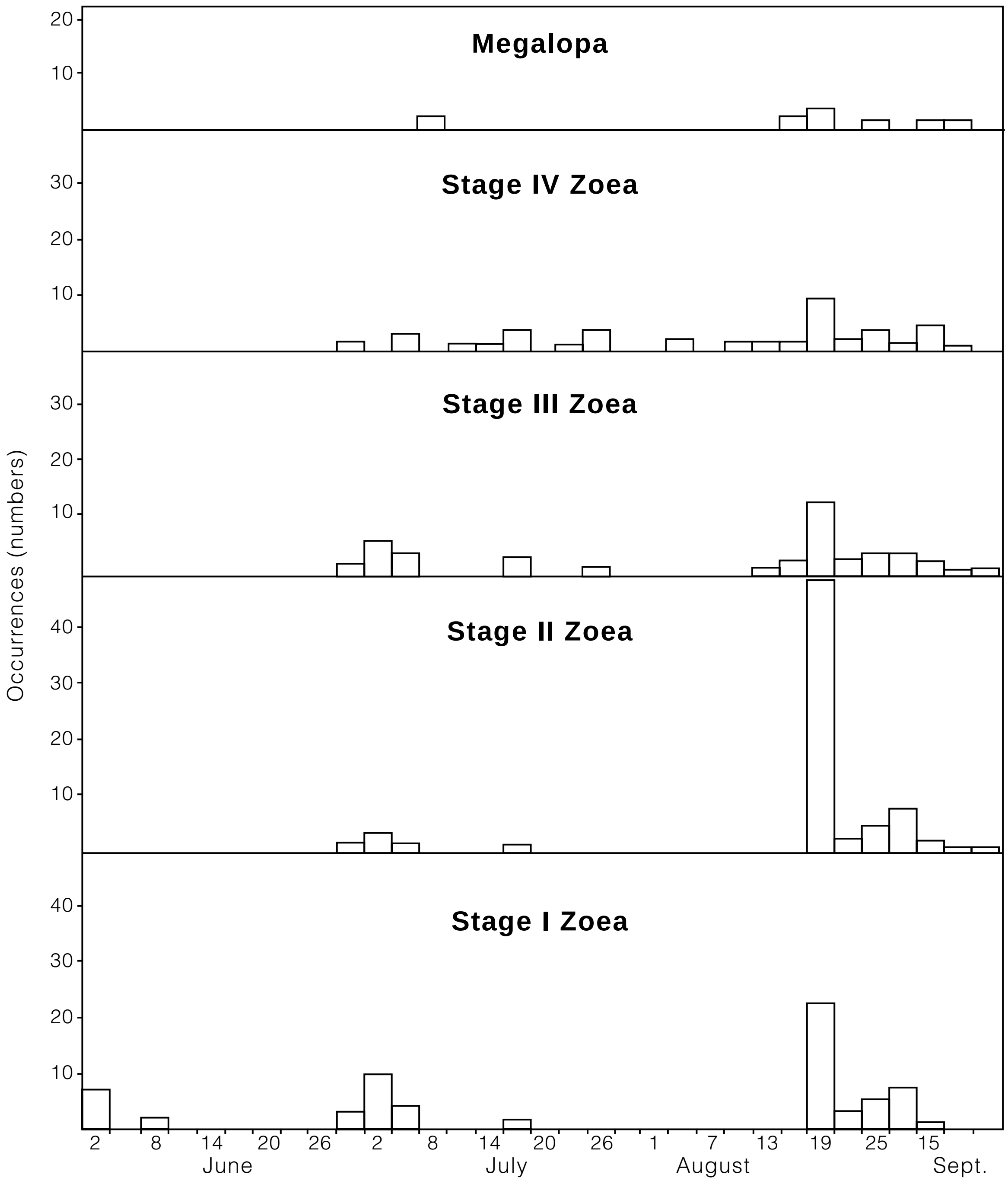

Fig. 4. Graphs of occurrences of Stages I–IV. Zoea and Megalopa of *Crangon septemspinosa* during May–September, 1971, at St. Chad's, Bonavista Bay, Newfoundland.

Family **Nephropidae**

Homarus americanus H. Milne-Edwards, 1837

The larvae of this species have been described by Herrick (1896). Compared with other decapod larvae from this area, lobster larvae were very large. Recognition characters are as follows: rostrum wide at base and tapering to fine point exceeding the antennae and with dorsal sulcus that extends on to the carapace, very strong dorsal spines on abdominal somites 2–5, and a small one on somite 6, also paired ventrolateral spines on abdominal somites 2–5.

Total lengths in Stage I Zoea are 7.3–8.0 mm, and carapace lengths 3.6–4.0 mm (19 specimens). Only 27 specimens were in the collection, obtained from 3 July–17 August (Table 1).

In this species it is known that there is only one annual hatching period for an individual female, and females carry eggs externally over the winter. It is also known that each may spawn several times in a lifetime. Since smaller females may spawn at a different time from larger ones, and there may be several sizes in a localized area, the hatching of larvae may occur over several weeks.

Family **Paguridae**

Pagurus acadianus Benedict, 1901

The larvae of this species of Hermit Crab were described by Roberts (1973). Recognition characters are: posteriorly the edges of the carapace are extended to form a strong spine on each side and the carapace covers the first two abdominal somites, the 5th abdominal somite has a very large ventrolateral spine posteriorly at each side, the rostrum is a long slightly descending thin spine, the endopod of the antenna is longer than the exopod or scale, corner spines of the telson are fused with the telson or not articulated like the others, in Stage IV Zoea the terminal spine on the exopod of the telson is double but without an accessory spine, and in the Megalopa the telson has short postero-lateral spurs and the 6th abdominal somite has a posterior mid-dorsal spine (Roberts, 1973).

Observed total lengths of the zoeae are as follows (numbers measured are in parentheses): Stage I Zoea, 2.5–3.1 mm (10); Stage II Zoea, 3.3–4.0 mm (8); Stage III Zoea, 4.3–4.8 mm (20); Stage IV Zoea, 5.3 mm (1). No Megalopa were captured. Total number taken was 79.

Occurrences of Stage I Zoea throughout the summer showed two major peaks one in early to the middle of June and the other about the middle of August (Table 2), possibly indicating two hatching periods in the warm shallow water of this bay. However, multi-hatchings have been suggested for the shrimps *Eualus pusiolus* and *Crangon septemspinosa* in this paper (and for the latter shrimp previously (Squires, 1965; 1970)), and a similar occurrence for this species could be possible in this nearshore area for the extended period of the summer.

TABLE 1. Occurrences (numbers) of Stage 1 Zoea of *Homarus americanus* and *Chionoecetes opilio* in shallow water at St. Chad's, Bonavista Bay, Newfoundland, during June to August, 1971.

Date		*Homarus americanus*	*Chionoecetes opilio*
June	2–4		1
	5–7		0
	8–10		0
	11–13		0
	14–16		0
	17–19		25
	20–22		1
	23–25		2
	26–28		0
	29–1		0
July	2–4	2	35
	5–7	0	15
	8–10	0	0
	11–13	12	45
	14–16	0	29
	17–19	0	0
	20–22	0	0
	23–25	2	0
	26–28	0	0
	29–31	8	1
August	1–3	0	0
	4–6	1	1
	7–9	0	
	10–12	0	
	13–15	0	
	16–18	1	

TABLE 2. Occurrences (numbers) of larvae of *Pagurus acadianus* during June–August 1971, in shallow water at St. Chad's, Bonavista Bay, Newfoundland.

Date		Zoeal Stages				
		I	II	III	IV	Megalopa
June	7–9					
	10–12	7				
	13–15	7				
	16–18	0				
	19–21	0				
	22–24	0				
	25–27	0				
	28–30	0				
July	1–3	0				
	4–6	0				
	7–9	1				
	10–12	0				
	13–15	0				
	16–18	0				
	19–21	0				
	22–24	0				
	25–27	0				
	28–30	0		23	2	
	31–2	0		0	0	
August	3–5	0		1	1	
	6–8	0		0	0	
	9–11	16	7	5	1	
	12–15		0	0		
	16–18		1	1		
	19–21					

Pagurus arcuatus Squires, 1964

Figure 2d

The larvae of this species of Hermit Crab were described by Squires (1996a). Recognition characters are as follows: the posterior edges of the carapace are extended into strong acuminate spines and the carapace covers the first two abdominal somites, the 5th abdominal somite has a pair of strong ventrolateral spines posteriorly, the rostrum is a long thin slightly descending spine, the endopod of the antenna is shorter than the exopod or scale Stages I–III Zoea, the terminal spine of the exopod of the telson is double and the inner one has an accessory middle spine in Stage IV Zoea, and in the Megalopa there are no postero-lateral spurs on the telson and no mid-dorsal spine on the 6th abdominal somite.

Observed total lengths were as follows (numbers measured are in parentheses); Stage I Zoea, 2.7–3.2 mm (11); Stage II Zoea, 3.7–4.4 mm (50); Stage III Zoea, 4.5–5.0 (2); Stage IV Zoea, 5.3–6.1 (24); Megalopa, 3.2–3.3 mm (9). Total number examined was 253.

Occurrences of Stage I Zoea throughout the summer showed three peaks: early-June, early-July and mid-August (Table 3), possibly indicating three hatching periods. However, the numbers of the various stages of zoea of this species were few. Multi-hatching of decapod species in warm shallow water areas is suggested for the shrimp species *Eualus pusiolus* and *Crangon septemspinosa* in this paper.

Captures of late Zoeal stages of both pagurid species appeared in late-July in 30-minute surface plankton tows off Brown's Store over deep water near sites 16 and 17 (Fig. 1) with light offshore wind and sunny conditions. The Megalopa did not appear until mid-August in 30-minute surface tows at sites 14–17 with calm conditions in drizzle and fog.

Family **Majidae**

Chionoecetes opilio (O. Fabricius, 1780)

Figure 2e

The larvae of this species were described by Motoh (1973). Notably, Stage I Zoea of this species are large. Recognition characters are as

TABLE 3. Occurrences (numbers) of larvae of *Pagurus arcuatus* during 7 June–29 August 1971, in shallow water at St. Chad's, Bonavista Bay, Newfoundland.

		Zoeal Stages				
Date		I	II	III	IV	Megalopa
June	7–9	22				
	10–12	8				
	13–15	7				
	16–18	0				
	19–21	1				
	22–24	0				
	25–27	0				
	28–30	4				
July	1–3	2				
	4–6	0				
	7–9	4				
	10–12	0				
	13–15	0				
	16–18	0				
	19–21	0				
	22–24	0				
	25–27	0				
	28–30	0	13	62	37	
	31–2	0	2	1	0	
August	3–5	3	0	0	0	
	6–8	0	0	0	0	
	9–11	3	1	0	0	
	12–14	2	4	6	0	15
	15–17				0	0
	18–20				0	5
	21–23				0	5
	24–26				1	2
	27–29					2

follows: as in larvae of most other crabs (Gurney, 1942), there is a long dorsal spine posterior to the middle of the almost spherical carapace, a shorter spine on each side of the carapace and a long rostral spine; also the telson is forked, each fork ending in a long spine and in Stage I Zoea, three pairs of setae in the notch. In this species the tips of the rostral, dorsal and lateral spines have minute spicules, on abdominal somites 2 and 3 are a pair of short hooked spines, and there is a pair of sharp ventro-lateral spines on somites 3–5. As indicated by Gurney (1942) the drawing of this species given by Stephensen (1935) is incorrect.

Only Stage I Zoea were taken in this collection. Total lengths were in the range of 3.9–4.3 mm (determined from a representative sample of 30 specimens). Total number of specimens captured was 165.

Occurrences during the summer of 1971 showed two peaks, one in mid-June and the other in early to mid-July (Table 1). However, the adult females of this species are not found in the shallow inshore area, and are most likely releasing their larvae in cold, deep water off shore, where they are not likely to spawn more than once a year.

Hyas spp.

The larvae of species *Hyas araneus* (Linnaeus, 1758) and *H. coarctatus* Leach, 1815, were both described by Christiansen (1973), and both species occur in this area (Squires, 1990). However specimens from the collection were inadvertently discarded but detailed records kept showed 1 228 Stage I Zoea, 78 Stage II Zoea and 10 Megalopa were taken in the plankton tows. They occurred from 1 June–28 August (Table 4). Recognition characters include: dorsal, rostral and lateral spines conspicuously spinulose, more so than in *Chionoecetes opilio*, conical knob laterally on abdominal somite 2 and smaller knob laterally on somite 3, ventrolateral long spines on somites 3 and 4 with shorter spines on somite 5. Zoeae of *H. araneus* are larger than those of *H. coarctatus* and the rostral spine of

TABLE 4. Occurrences (numbers) of *Hyas* spp. in shallow water at St. Chad's Bay, Bonavista Bay, Newfoundland, during 1 June–28 August 1971.

Date		Numbers of Specimens		
		Stage I. Zoea	Stage II. Zoea	Megalopa
June	1–5	309	0	0
	6–10	79	0	0
	11–15	21	0	0
	16–20	47	0	0
	21–25	27	0	0
	26–30	7	0	0
July	1–5	565	4	0
	6–10	77	0	0
	11–15	87	21	0
	16–20	0	0	0
	21–25	0	0	0
	26–31	4	43	3
August	1–5	0	8	3
	6–10	1	2	4
	11–15	0	0	0
	16–20	0	0	0
	21–25	0	0	0
	26–30	4	0	0

the latter has larger spinules. In this species there are only two zoeal stages and the Megalopa.

Pohle (1991) described larvae of *Hyas coarctatus alutaceus* from Nova Scotia, and Squires (1993) described larvae of *Hyas coarctatus* from the Arctic (Ungava Bay).

Occurrences of Stage I Zoea in plankton tows (Table 4) showed two peaks, one in early-June and the other in early-July. In Stage II Zoea, occurrences also showed two peaks in early to mid-July and late-July to early-August. Such occurrences may indicate two spawning periods during the summer.

Family **Cancridae**

Cancer irroratus Say, 1817

Figure 2f

The larvae of this species of Rock Crab were described by Connolly (1923). Recognition characters are as follows: carapace with smooth rostral, dorsal and short lateral spines; second abdominal somite with short upward curving spine on each side of the middle, and early stages are very small compared with other crab larvae present. As in other crabs from this area the telson is widely forked, each fork ending in a spine and with paired setae in the notch, in this species 3 pairs of plumose setae in Stage I Zoea.

Total lengths (tip of dorsal to tip of rostral spines) were as follows (numbers measured are in parentheses): Stage I Zoea, 1.6–1.8 mm (35); Stage II Zoea, 2.1–2.5 mm (10); Stage III Zoea, 3.0–3.4 mm (19); Stage IV Zoea, 3.8–4.1 mm (18); Megalopa, 3.8–4.1 (17). Lengths were similar to those given by Connolly (1923).

Very large numbers of this species occurred in the plankton (3 506 specimens of Stage I Zoea and 1 559 of other larval stages). The appearance of Stage I Zoea in the plankton is spread over only 1 1/2 months (Fig. 5) and may represent a single spawning of individual adult crabs of different sizes and ages, as in lobsters from the same area. Adult crabs were not present in the collection, so it was not possible to check for additional summer spawning incidence in this area.

Stage II Zoea did not appear in the plankton samples until early-July when there was a peak in occurrence and a later one in early-August. In Stage III Zoea two peaks of occurrence were in early- and late- August and a peak in September, but no sampling for two weeks in early September leaves a gap in the information. Peaks of occurrence were also evident in Stage IV Zoea, three appearing in August and one in September. These seem reflected in the Megalopae as well, where two peaks appeared in August and one in late-September (Fig. 5). Presumably these peaks in occurrences of stages later than Stage I Zoea represent growth

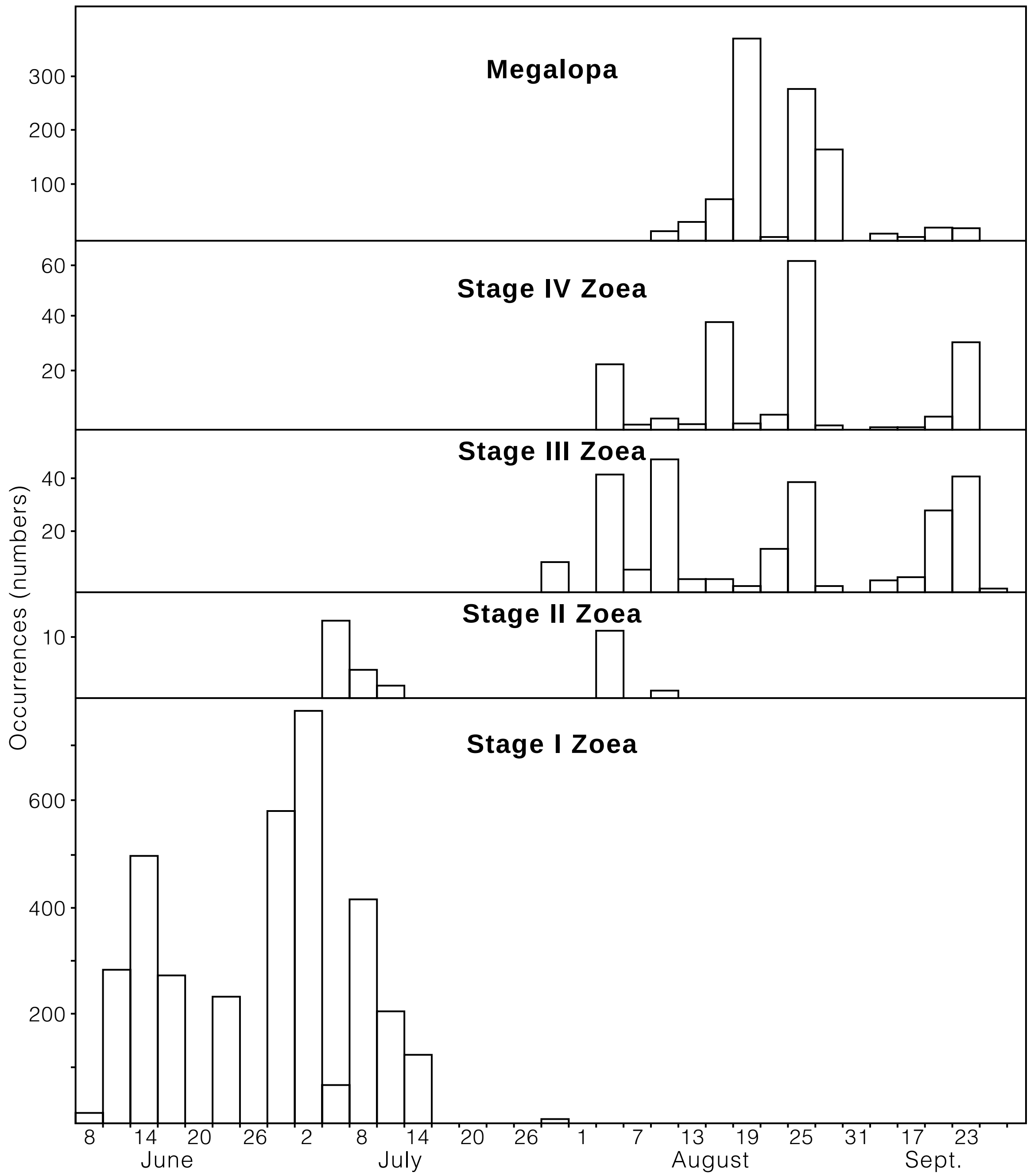

Fig. 5. Graphs of occurrences of Stages I–IV. Zoea and Megalopa of *Cancer irroratus* during June–August, 1971, at St. Chad's, Bonavista Bay, Newfoundland.

periods from which the time required to change from one stage to the other could be estimated. Thus the moulting to Stage II from Stage I appears to have taken one month, while moulting in other stages seemed shorter, approximating half a month from Stage III – Megalopa. It was observed that temperatures increased from about 10°C in late July to 16°C in late August.

Discussion

Nearshore sea areas in Newfoundland warm up considerably through insolation during the summer and, because of the high nutrient levels in subarctic waters, planktonic and benthonic organisms are known to flourish in great abundance and variety. During the present collection temperatures ranged between 6–16°C. In addition to the decapod larvae reported on in this paper, the collection contained calanoid and harpacticoid copepods, mysids, euphausids, fish eggs and larvae, ostracods, cladocerans, cyprinid larvae, polychaete larvae, amphipods, medusae, bivalve and gastropod larvae, and green filamentous algae. Such an inshore area therefore provides a feeding ground or nursery for larvae of indigenous fishes and decapods, some of which are of commercial importance. Cod (eggs), mackerel and lumpfish larvae, lobster, pandalid shrimp, the snow crab and toad crabs are examples taken in the present collection.

Although the method of collecting plankton used in this study was efficient, it is possible that larvae of some species were not captured. Only one specimen of *Pandalus borealis* was taken (at 9 m in depth), and few specimens of *Chionoecetes opilio* and lobster. Also, such species may avoid the narrow nearshore (to 20 m distance) area of towing. Avoidance of shore by species was discussed by Squires (1996b).

The occurrence of *Caridion gordoni* larvae is a most northerly record for this species in the western Atlantic. Although larvae of this species were previously reported a little more than 1° latitude further south (47°22' compared with 48°41'N latitude) by Frost (1936), they were from Fortune Bay and the Gulf of St. Lawrence. It is likely that the adults may be found in rocky untrawlable areas in Bonavista Bay, because it would not be likely for the larvae to drift against southerly flowing currents outside the bay. Plankton studies in more northern bays could verify whether the larvae of this species could drift from the Gulf of St. Lawrence where it has been reported previously (Squires, 1990).

Crangon septemspinosa, the sand shrimp, appeared in some abundance in the collection perhaps reflecting the number of extensive sandy beaches in the area such as at nearby Sandy Cove and Eastport. Apparently the smaller *Eualis pusiolus* would be more ubiquitous because of its preference for rocky areas. This would be true also for the rock crab, *Cancer irroratus*, whose very small larvae were captured in such abundance. Also their preference for a near shore area might make them more available to the plankton net in this instance.

Multi-hatching and -spawning in the warm summer season seems probable for the species *Crangon septemspinosa* and *Eualus pusiolus*. These occurrences are not likely due to a spread in one spawning/hatching of individuals over three months. In biological systems there are many examples of a tendency to synchronicity especially in reproduction (Tinbergen and Verway, 1945) and often in response to natural rhythms such as tidal flows. Peaks of occurrence of zoeal stages may therefore be evidence of distinct and separate individual hatching incidence of the species referred to in this area. Examinations of adults of both shrimp species has shown that when the eggs carried are ready to hatch, the ova in the ovaries are also large in size ready to be extruded. The indication is that the period of oogenesis in the ovaries is about equal to the embryogenesis taking place in the eggs carried externally after extrusion. These processes should also result in the hatching or release of larvae more than once during the summer season. Multiple spawnings of individual rock lobster over a few months at warm temperatures have been demonstrated in aquaria (Chittleborough, 1974) and of *Crangon crangon* in nature (Meredith, 1952).

Ennis (1983) indicated the correlations of captures of various species with onshore or offshore winds. The lobster, queen crab, rock crab and toad crab appeared to be captured more frequently with onshore winds. Some increased captures of *Eualus pusiolus* and *Crangon septemspinosa* occurred during 18–20 August and of *Pagrus arcuatus* during 28–30 July and 12–14 August with offshore winds. However, in these instances plankton net towing time had been changed to 30 minutes instead of the standard time of 5 minutes.

Zoeal stages later than Stage I of *Eualus pusiolus* and *Crangon septemspinosa* appeared in captures in early-July to late-August. Water temperatures had increased appreciably by that time (from 10–16°) and all stages were present. Peaks in occurrences seen in this survey suggest that moulting incidence of the later stages may have occurred over a shorter period than between earlier moults such as between stages I and II when water temperatures were lower.

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References

BULL, H. O. 1939. The newly-hatched larva of *Spirontocaris pusiola* (Krøyer). *Rep. Dove Mar. Lab.*, **6**: 43–44, Figs 1–9.

CHITTLEBOROUGH, R. G. 1974. Western rock lobster reared to maturity. *Aust. J. Mar. Freshwater Res.*, **25**: 221–225.

CHRISTIANSEN, M. E. 1973. The complete larval development of *Hyas araneus* (Linnaeus) and *Hyas coarctatus* Leach (decapoda, Brachyura, Majidae) reared in the laboratory. *Norwegian Journal of Zoology*, **21**: 63–89.

CONNOLLY, C. J. 1923. The larval stages and megalops of *Cancer amœnus* (Herbst). *Contr. Can. Zool.*, **17**: 337–352. Plates I–IV.

ENNIS, G. P. 1938. The effect of wind direction on the abundance and distribution of decapod crustacean larvae in a Newfoundland near-shore area. *Can. Tech. Rep. Fish. Aquat. Sci.*, **1138**: iv+19 p.

FROST, N. 1936. Decapod larvae from Newfoundland waters. *Fish. Res. Bull. Nfld.*, **3**: 11–24, Figs 1–9.

GURNEY, R. 1942. Larvae of decapod Crustacea. Ray Society, London, 306 p.

HANSEN, H. J. 1908. Crustacea Malacostraca I. *Danish Ingolf Exped.*, **3**: 1–120.

HERRICK, F. H. 1896. The American lobster. A study of its habits and development. *Bull. U.S. Fish. Comm.*, **15**: 1–252, Plates A–J, 1–54.

LEBOUR, M. V. 1930. The larval stages of *Caridion*, with a description of a new species, *C. steveni*. *Proc. Zool. Soc. London*, **100**: 181–194, Plates I–VIII.

MEREDITH, S. S. 1952. A study of *Crangon vulgaris* in the Liverpool Bay area. *Proc. and Trans. Liverpool Biol. Soc.*, **58**: 75–109.

MOTOH, H. 1973. Laboratory-reared zoeae and Megalopae of zuwai crab from the Sea of Japan. *Bull. Japanese Soc. Sci. Fish.*, **39**: 1233–1250.

NEEDLER, A. B. 1941. Larval stages of *Crago septemspinosa Say. Trans. Royal Can. Inst.*, **23**(50): 193–199.

PIKE, R. B., and D. I. WILLIAMSON. 1961. The larvae of *Spirontocaris* and related genera (Decapoda, Hippolytidae). *Crustaceana*, **2**: 187–208.

POHLE, G. W. 1991. Larval development of Canadian Atlantic oregonid crabs (Brachyura: Majidae) with emphasis on *Hyas coarctatus alutaceus* Brandt, 1851, and a comparison with Atlantic and Pacific conspecifics. *Can. J. Zool.*, **69**: 2717–2737.

ROBERTS, M. H. 1973. Larval development of *Pagurus acadianus* Benedict, 1901, reared in the laboratory (Decapoda, Anomura). *Crustaceana*, **24**: 303–317.

SARS, G. O. 1900. An account of the post-embryonal development of *Pandalus borealis* Krøyer, with remarks on the development of Pandali, and description of the adult *Pandalus borealis*. *Rep. Norweg. Fish. Mar. Invest.*, **1**: 1–45

SQUIRES, H. J. 1965. Decapod crustaceans of Newfoundland, Labrador and the Canadian eastern Arctic. *Fish. Res. Board Can. MS Rep. (Biol.)*, **810**: 212 p. Revised 1996. Can. *MS Rep. Fish. Aquat. Sci.*, **2359**: 234 p.

1970. Lobster (*Homarus americanus*) fishery and ecology in Port au Port Bay, Newfoundland, 1961–65. *Proc. National Shellfish Assoc.*, **60**: 22–39.

1990. Decapod Crustacea of the Atlantic coast of Canada. *Bull. Fish. Aquat. Sci.*, **221**: 532 p.

1993. Decapod crustacean larvae from Ungava bay. *J. Northw. Atl. Fish. Sci.*, *15*: 1–157.

1996a. Larvae of *Pagurus arcuatus* from the plankton (Crustacea, Decapoda). *J. Northw. Atl. Fish. Sci.*, **18**: 43–56.

1996b. The nearshore plankton holding zone. *J. Northw. Atl. Fish. Sci.*, **18**: 57–60.

STEPHENSEN, K. 1935. The Godthaab Expedition. Crustacea Decapoda. *Medd. om Grønland*, **80**: 1–91.

TINBERGEN, L., and J. VERWEY. 1945. Zur Biologie von *Loligo vulgaris* Lamark. *Arch. Neerlandaises de Zool.*, **7**: 213–286.