# Guide to Indicator Fragments of Principal Prey Taxa in the Stomachs of Two Common Atlantic Crab Species: *Cancer borealis* Stimpson, 1859 and *Cancer irroratus* Say, 1817

Robert W. Elner, Peter G. Beninger,
Leslie E. Linkletter, and Steven Lanteigne

Biological Station,
St. Andrews, N. B., E0G 2X0

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Canada

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# GUIDE TO INDICATOR FRAGMENTS OF PRINCIPAL PREY TAXA IN THE STOMACHS OF TWO COMMON ATLANTIC CRAB SPECIES: *Cancer borealis* STIMPSON, 1859 AND *Cancer irroratus* SAY, 1817

by

Robert W. Elner, Peter G. Beninger[1], Leslie E. Linkletter[2], and Steven Lanteigne[1]

Invertebrates and Marine Plants Division
Fisheries Research Branch
Department of Fisheries and Oceans
Biological Station
St. Andrews, New Brunswick E0G 2X0

[1]Present address: Department de Biologie, Université de Moncton,
Moncton, Nouveau-Brunswick E1A 3E9

[2]Present address: Natural History Section, Nova Scotia Museum,
Summer Street, Halifax, Nova Scotia B3H 3A6

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## ABSTRACT

Elner, Robert W., Peter G. Beninger, Leslie E. Linkletter, and Steven Lanteigne. 1985. Guide to indicator fragments of principal prey taxa in the stomachs of two common Atlantic crab species: Cancer borealis Stimpson, 1859 and Cancer irroratus Say, 1817. Can. Tech. Rep. Fish. Aquat. Sci. 1403: iv + 20 p.

A guide to the identification of prey taxa from Cancer borealis and Cancer irroratus (Crustacea:Decapoda) stomach contents is presented. Fifty types of structures allowing taxonomic identification of prey are included. The crab populations studied were situated on the southwest coast of Nova Scotia (McNutts Island). The relationships between indicator fragment size and prey size for two typical prey species is determined. The study is intended to serve as a basis for facilitating investigations into crab and lobster feeding ecology, and also to indicate directions for further research in this field.

## RÉSUMÉ

Elner, Robert W., Peter G. Beninger, Leslie E. Linkletter, and Steven Lanteigne. 1985. Guide to indicator fragments of principal prey taxa in the stomachs of two common Atlantic crab species: Cancer borealis Stimpson, 1859 and Cancer irroratus Say, 1817. Can. Tech. Rep. Fish. Aquat. Sci. 1403: iv + 20 p.

Un guide de l'identification des taxons-proies des contenus stomacaux de Cancer borealis et de Cancer irroratus (Crustacea:Decapoda) est présenté. Cinquante types de structures permettant l'identification taxinomique des espèces-proies sont inclus. Les populations de crabes étudiées provenaient de la côte sud-ouest de la Nouvelle-Écosse (Ile McNutts). Les relations entre les dimensions des fragments indicateurs et les dimensions des proies sont déterminées pour deux espèces-proies typiques. Ce travail est destiné à servir de base dans l'étude de l'écologie alimentaire des crabes et des homards et elle indique ces voies de recherche ultérieures dans ce domaine.

## INTRODUCTION

Consideration of the natural diets of ubiquitous large decapod predators such as the Jonah crab, Cancer borealis, and the rock crab, Cancer irroratus, appears fundamental to understanding the ecological relationships in nearshore ecosystems around the Canadian maritimes. However, decapod crustaceans commonly fragment and may selectively ingest prey (Elner 1981; Carter and Steele 1982; R.W. Elner and L.V. Colpitts, unpublished data) making natural diet studies through stomach analysis techniques problematic.

In spite of the cryptic nature of much of the ingested food, identification of most dietary components in decapod stomachs is usually possible through the presence of indicator fragments of such relatively indigestible material as fish otoliths, gastropod opercula and crab leg tips (Weiss 1970; Gotshall 1977). Despite the obvious need for some type of catalogue relating indicator fragments to prey taxa, no such tool has yet been available to workers in this field for any decapod predator. Reliable guides are available for identification and estimation of the size of cephalopods from the characteristics of their beak remains in predator stomachs (Wolff 1984).

Prey types that are ingested along with many indicator fragments may appear overrepresented in stomachs compared to prey that are gleaned from their skeletal structures before being ingested or are comparatively soft-bodied and lacking in persistent indicators. Notwithstanding differential selectivity and identification problems, compiling prey in order of dietary importance is fraught with complications (see Berg 1979 and Hyslop 1980 for reviews). Due to the well-masticated nature of the stomach contents, the frequency of occurrence index and the subjective, estimated volume (points) index (Swynnerton and Worthington 1940) appear to be the only scoring methods readily applicable to ranking prey in the diets of crabs and lobsters, Homarus americanus; both methods have been commonly adopted (for portunid crabs, see Ropes 1968; Elner 1981; Williams 1981; for lobsters, see Ennis 1973; Scarratt 1980; Carter and Steel 1982). While acknowledging that each index tends to be subject to its own peculiar biases (Hyslop 1980; Williams 1981), stomach analysis on Cancer crabs may be expected to provide a qualitative listing of the majority of prey species together with some semi-quantitative indications of their relative importance. A compound index has been proposed by Stevens et al. (1982) to overcome the possible biases of individual indices. However, the ecological interpretation of compound indices remains to be validated and it may be that they add little new information when compared to any single measure (Macdonald and Green 1983) or serve to obscure the true diet picture by compounding artifacts present in constituent indices (Hyslop 1980).

The present guide is based on prey remains identified in the stomachs of Jonah crabs and rock crabs from sea urchin denuded barren grounds on the Atlantic coast of Nova Scotia. Indicator fragments for each of the major prey taxa are identified in order to facilitate future investigations into the natural diets of Cancer crabs. In addition, as analyses of green crab (Carcinus maenas) stomachs (Elner 1981) and lobster stomachs (Weiss 1970; Carter and Steele 1982; R. W. Elner, unpublished data) reveal dietary overlaps and similar indicator fragment patterns to Cancer crab, the guide may serve to identify prey items for other decapod species.

As well as identifying prey taxa ingested, it is frequently important in ecological studies to determine the size of the prey eaten. Well-defined prey size preferences may be displayed by both crabs (Elner and Raffaelli 1980; Hughes 1980) and lobsters (Elner and Jamieson 1979; Elner 1980) and may facilitate resource partitioning and the reduction of competition. To demonstrate that some indicator fragments can be readily used to "reconstruct" the size of the prey animal, conversions between indicator fragment size and whole prey size for two typical prey species have been performed.

## MATERIALS AND METHODS

Cancer borealis and Cancer irroratus were collected by SCUBA divers from a site near McNutt's Island in coastal southwest Nova Scotia from 1978 to 1982. Sampling was performed throughout the year on a wide range of sizes, thus eliminating possible size and seasonally-induced bias in the composition of the stomach contents.

Several samplings of macrobenthic flora and fauna were also performed by SCUBA divers in southwest Nova Scotia and in the Bay of Fundy; these specimens were used to assist in the identification of indicator fragments. Whole specimens were fragmented to simulate the ingested state, thus facilitating the identification of prospective indicator fragments.

Following extraction of the stomachs, the contents were carefully examined using a stereoscopic microscope and indicator fragments were isolated. Positive identification to the lowest possible taxonomic level was established using a number of reference works (see Discussion) and by comparison with the macrobenthic flora and fauna previously sampled. In certain cases, identification was established after examination of specimens in the reference collection of the Atlantic Reference Centre, St. Andrews, New Brunswick. As new indicator fragments were identified, they were catalogued and placed in the reference collection.

Linear regressions were performed on indicator fragments and whole specimens of two prey species: Nereis virens (jaw weight vs. whole body weight) and Buccinum undatum (operculum diameter vs. shell height). A simple linear (Model I) regression was utilized as the line was being fitted for purposes of prediction (Sokal and Rohlf 1981). These analyses were performed in order to establish a method of determining prey size based on indicator fragment size.

## RESULTS

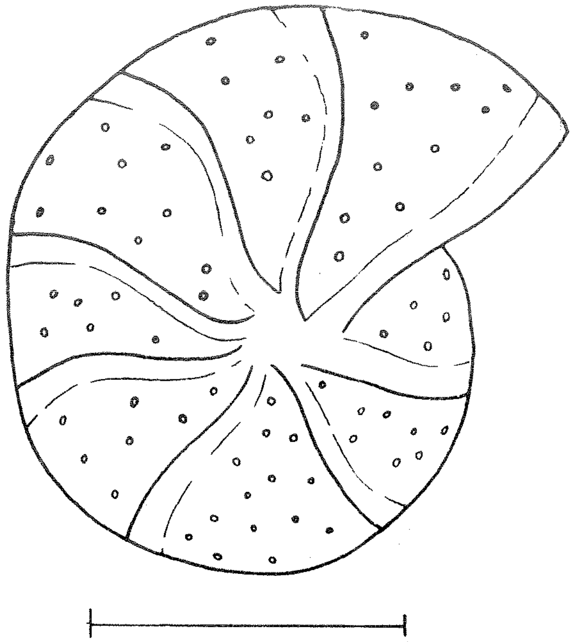
The indicator fragments observed in the two crab species are presented in Section A. Observations pertinent to the identification and interpretation of each prey type are also included. Scale measurements are approximate and are intended to represent typical fragment sizes found in crab stomachs.

In order to facilitate initial identification, a key based on indicator fragment form is presented in Section B.

Predictive relationships between indicator fragment size and whole prey size are shown in Section C for the polychaete *Nereis virens* and the gastropod *Buccinum undatum*.

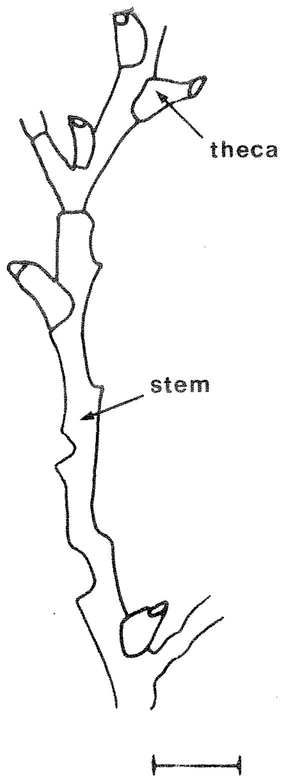
A. INDICATOR FRAGMENTS

1. Foraminifera



1.1. Foraminiferan test. Often observed whole and in great numbers; volumetric contribution to diet is very small. Numerous perforations present in test. Scale bar: 1 mm.

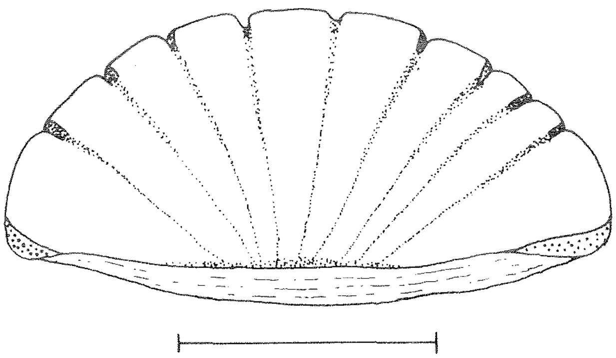
2. Hydrozoa



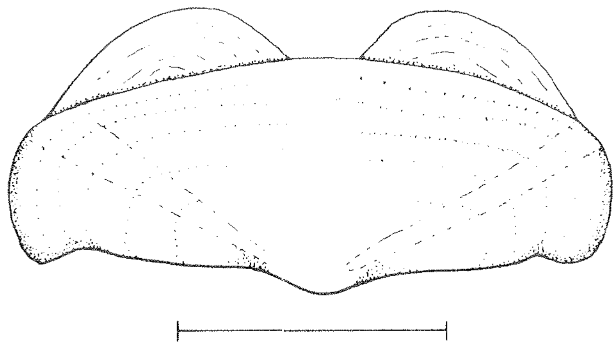

2.1. Hydrozoan fragment. Note form of theca compared to form of branched algae (see 7). Scale bar: 1 mm.

# 3. Mollusca

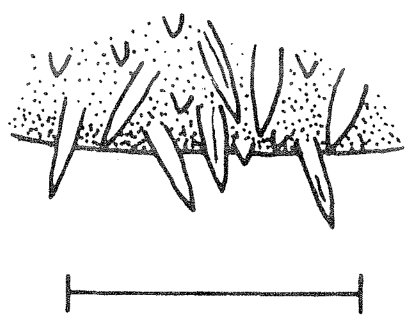
## 3.1. Amphineura



3.1.1. Internal surface of posterior valve of Ischnochiton spp. I. ruber has reddish valves whereas I. albus has whitish valves. Note irregular form and rounded contours, as compared to jagged contours of bivalve shell pieces (see 3.3). Scale bar: 2 mm.



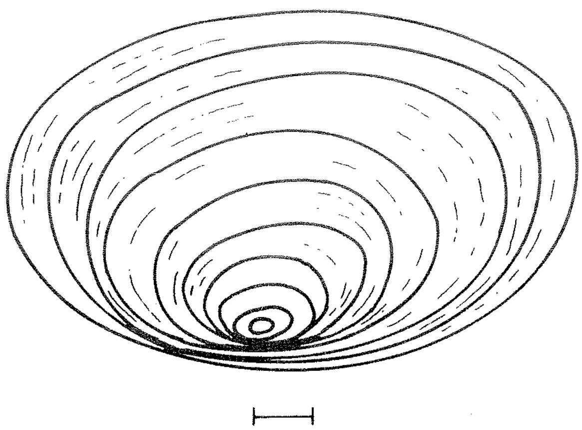
3.1.2. Internal surface of median valve. Note irregular and rounded contours. Scale bar: 2 mm.



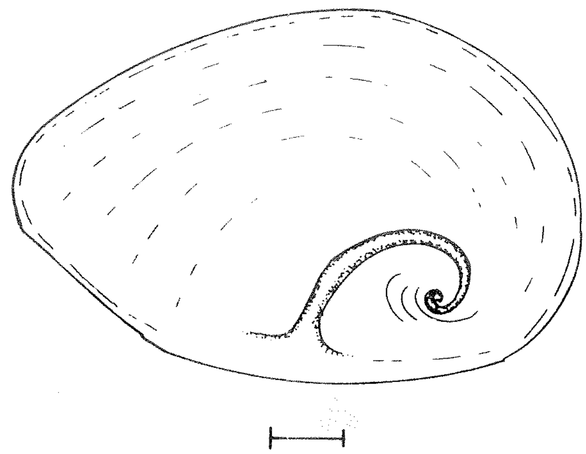
3.1.3. External view of part of the girdle and calcareous spines or scales. Scale bar: 0.2 mm.

3. Mollusca (cont'd.)

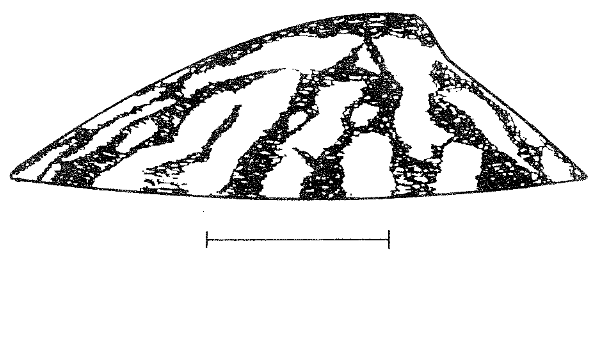
3.2. Gastropoda



3.2.1. External surface of the operculum of Buccinum undatum. Scale bar: 0.5 mm.



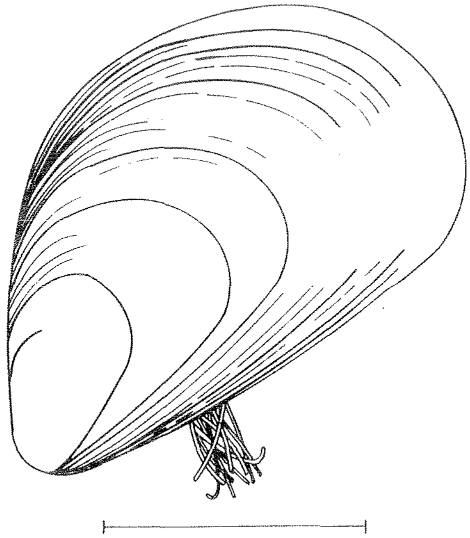
3.2.2. External surface of the operculum of Lacuna vincta. Scale bar: 0.5 mm.



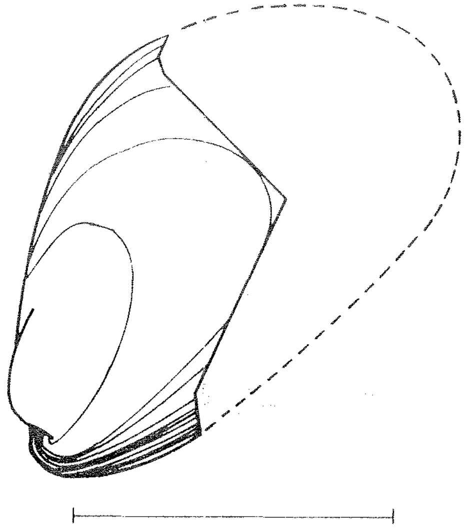
3.2.3. External surface of the shell of Acmaea testitudinalis. Note irregular coloration for fragment remains. Scale bar: 5 mm.

3. Mollusca (cont'd.)

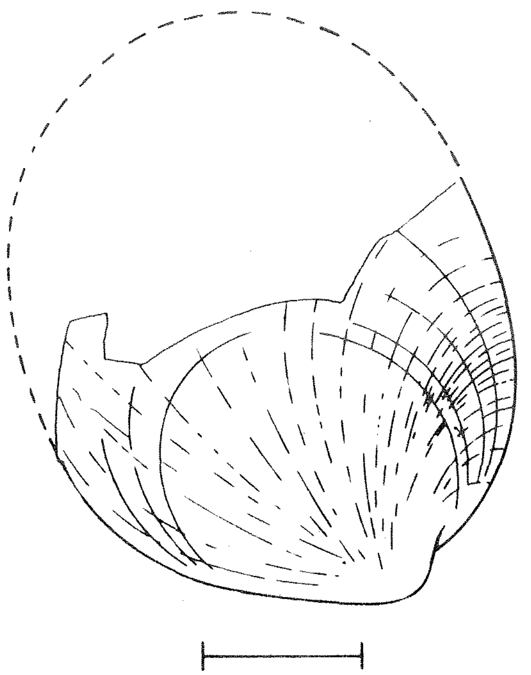
3.3. Bivalvia



3.3.1. External surface of the valve and byssus threads of Mytilus edulis. Note characteristic shape of umbo, the most typical indicator fragment. Scale bar: 2 mm.



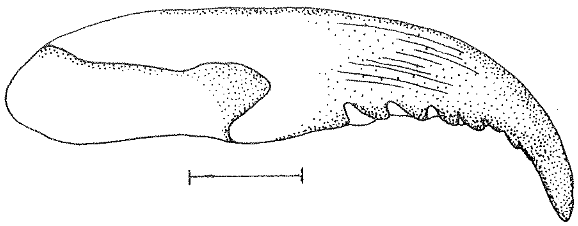
3.3.2. External surface of the valve of Modiolus modiolus. Note typical shape of umbo. Scale bar: 2 mm.



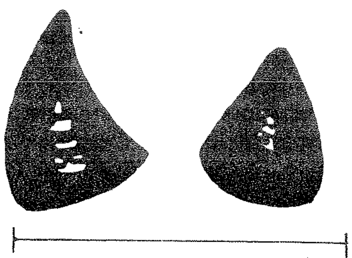
3.3.3. External surface of the valve of Crenella glandula. Note typical shape of umbo. Scale bar: 2 mm.

# 4. Polychaeta

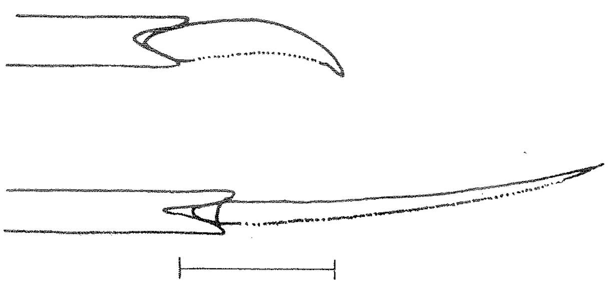
## 4.1. Nereidae. Note *Nereis pelagica* or *N. virens*



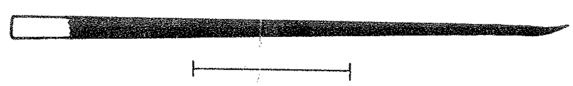
4.1.1. Jaw. Scale bar: 0.5 mm.



4.1.2. Denticles. Scale bar: 0.1 mm.



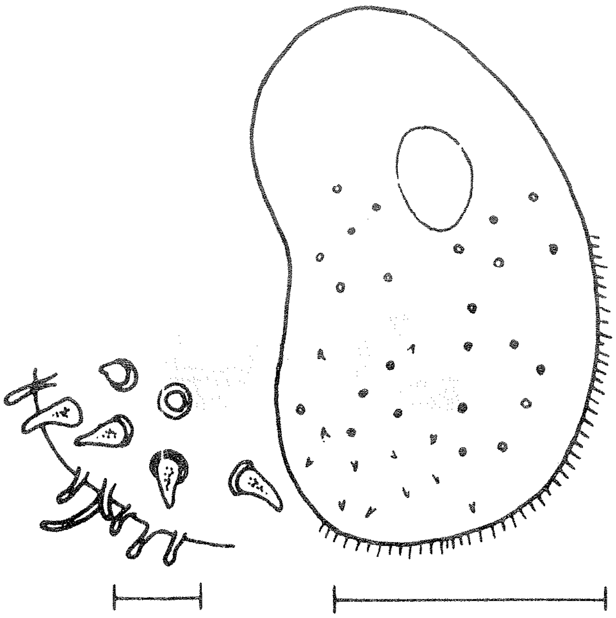
4.1.3. Compound setae. Scale bar: 0.1 mm.



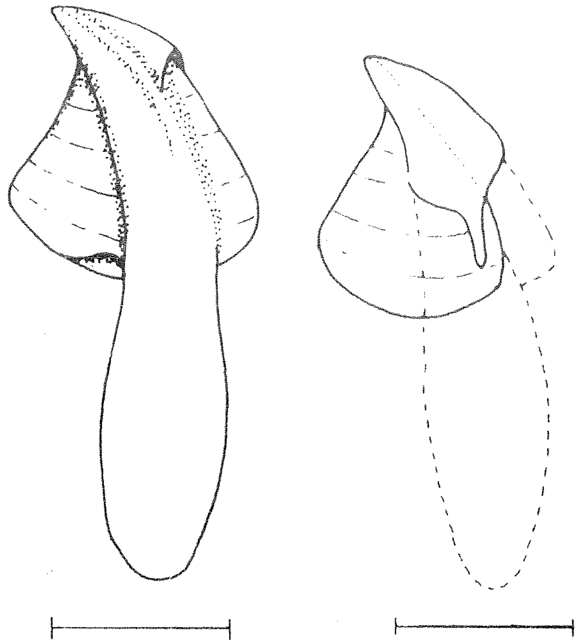
4.1.4. Aciculum. Colour white and black. Scale bar: 1 mm.

4. Polychaeta (cont'd.)

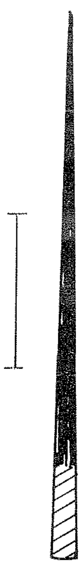
4.2. Polynoidae



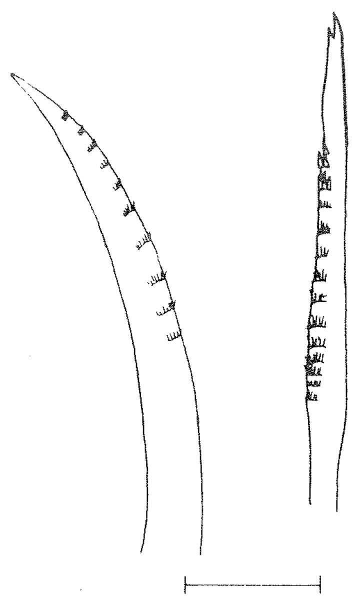
4.2.1. Typical elytron, with enlarged view of margin (insert). Fringe projections may be fine or coarse and tubercles of variable shape, depending on species. Resembles ostracod in form (see 5.1.1). Scale bars: 1 mm (top); 0.1 mm (bottom).



4.2.2. Jaws. Compare complete jaw (left) with Nereis spp. jaw (see 4.1.1). Common jaw fragment shown on right. Scale bar: 1 mm.



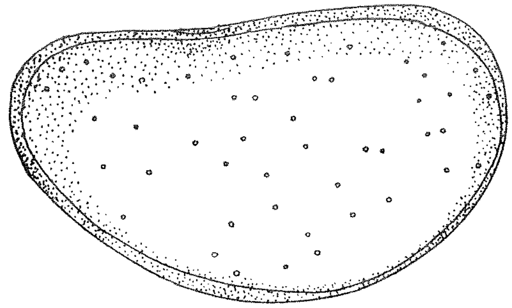
4.2.3. Aciculum. Colour greenish. Scale bar: 1 mm.

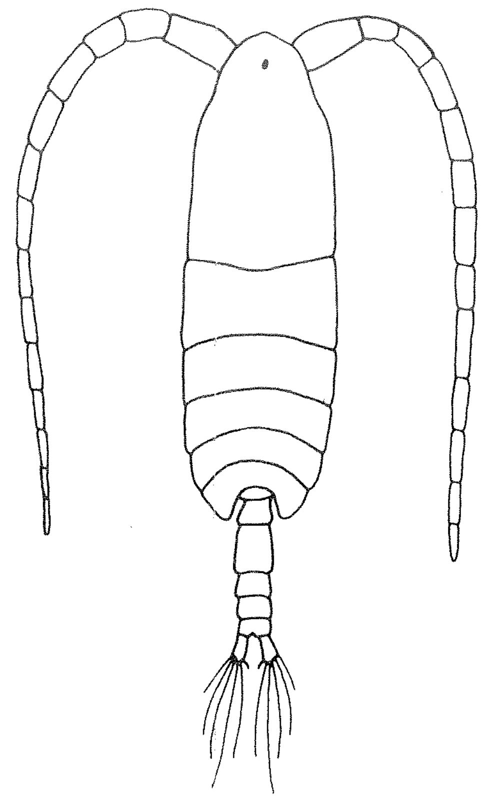


4.2.4. Setae. Note bifid tip characteristic of some Polynoidae. Scale bar: 1 mm.

5. Crustacea

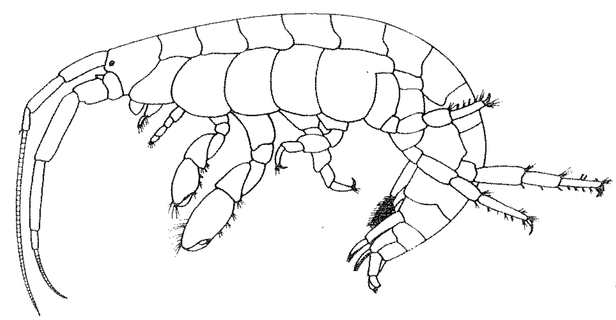
5.1. Small Crustacea





5.1.1. Ostracoda, lateral view. Can be found whole in crab stomach. Always less than 1 mm in length. Form resembles polynoid elytron (see 4.2.1). (After Moore, 1961).

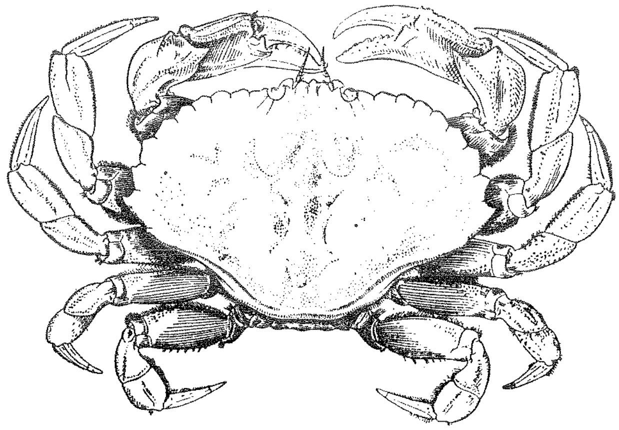
5.1.2. Copepoda, dorsal view. Can be found whole in crab stomach. Whole animal is about 1 mm in length. (After Roff, 1978).



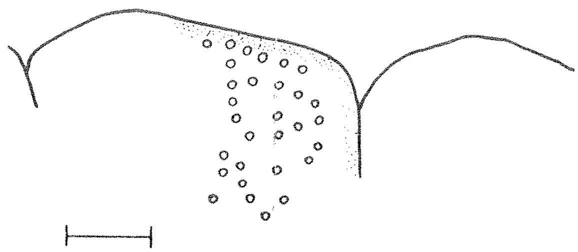
5.1.3. Amphipoda, Ampithoe rubricata, lateral view. Carapace plates and appendage pieces are most typical remains in stomach contents. Whole animal is about 1 mm in length.

5. Crustacea (cont'd.)

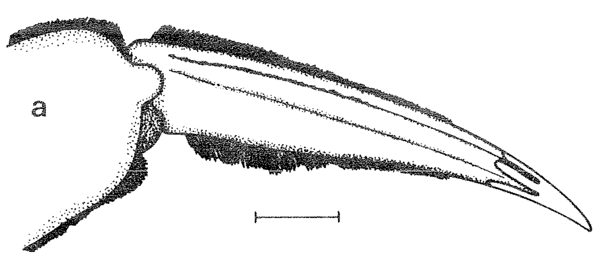
5.2. Decapoda

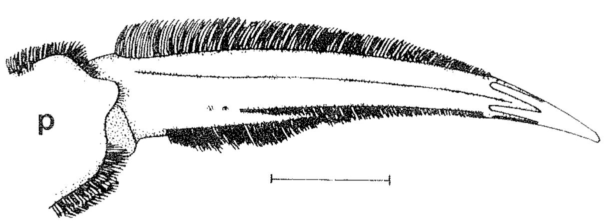


5.2.1. Cancer irroratus, external dorsal view of whole crab. (After Rathbun, 1929).



5.2.1.1. External aspect of the cephalothorax margin. Note smooth marginal teeth and relatively smooth surface in contrast to C. borealis. Scale bar: 1 mm.

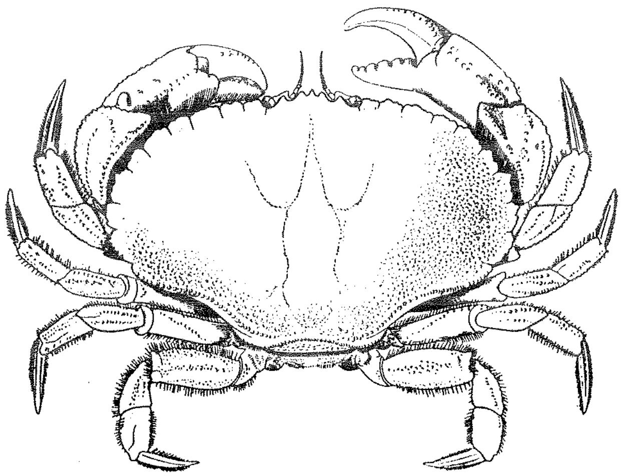


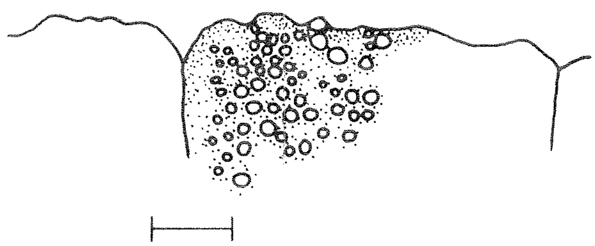

5.2.1.2. Anterior (a) and posterior (p) views of the 2nd left periopod. Note form of distal extremity of dactylus as compared with other decapods. Scale bars: 5 mm.

5. Crustacea (cont'd.)

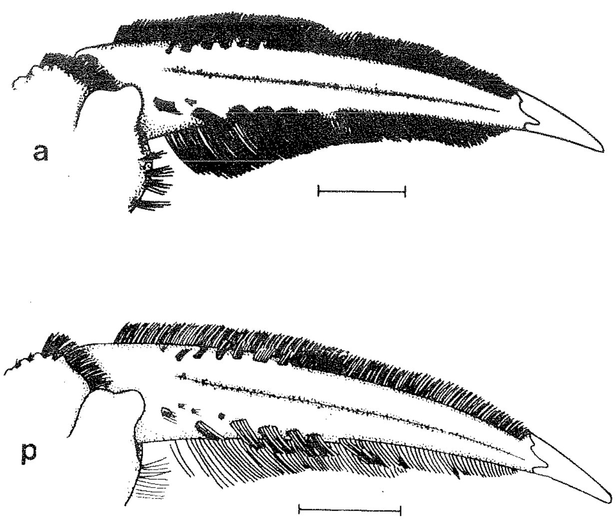
5.2. Decapoda (cont'd.)



5.2.2. Cancer borealis, external dorsal view of whole crab. (After Rathbun, 1929).



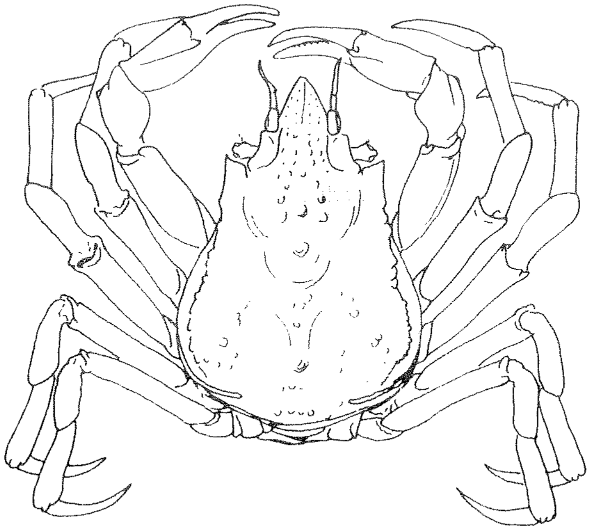
5.2.2.1. External aspect of the cephalothorax margin. Note jagged marginal teeth and granulated surface as compared to C. irroratus. Scale bar: 1 mm.



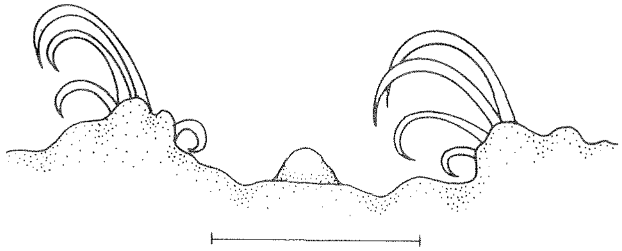

5.2.2.2. Anterior (a) and posterior (p) views of the 2nd left periopod. Note form of distal extremity of dactylus as compared to other decapods. Scale bars: 5 mm.

5. Crustacea (cont'd.)

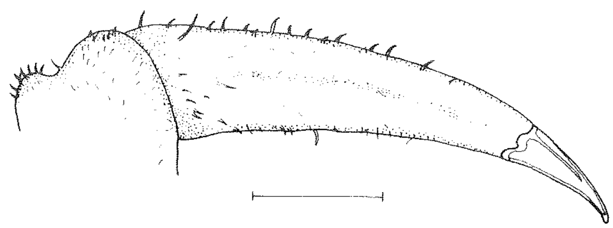
5.2. Decapoda (cont'd.)



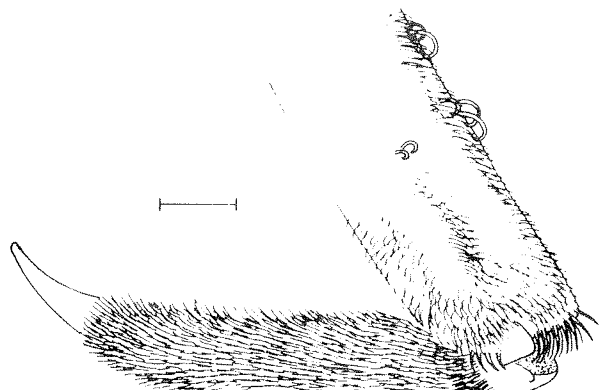
5.2.3. Hyas sp., external dorsal view of whole crab. (After Rathbun, 1929).



5.2.3.1. Hooks present on the thoracic appendages and carapace. Scale bar: 1 mm.



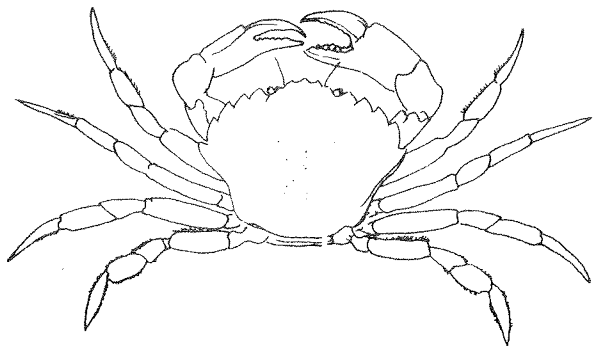
5.2.3.2. Anterior view of the 2nd left periopod of adult. Note distal extremity of dactylus as compared to other decapods. Scale bar: 5 mm.



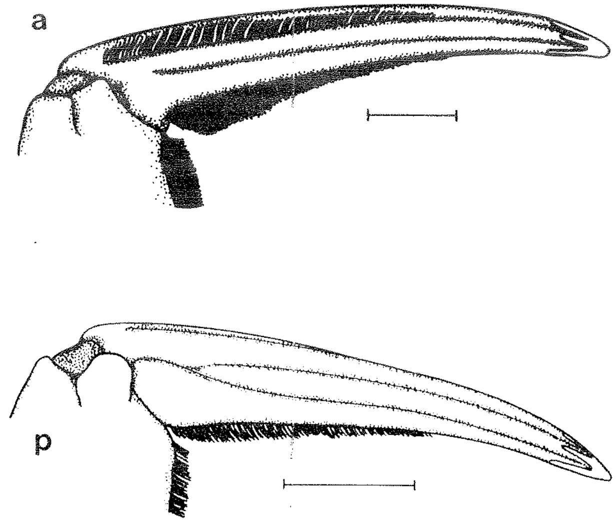
5.2.3.3. Anterior view of the 2nd left periopod o juvenile. Extemity of dactylus is similar to that of adult. Scale bar: 1 mm.

5. Crustacea (cont'd.)

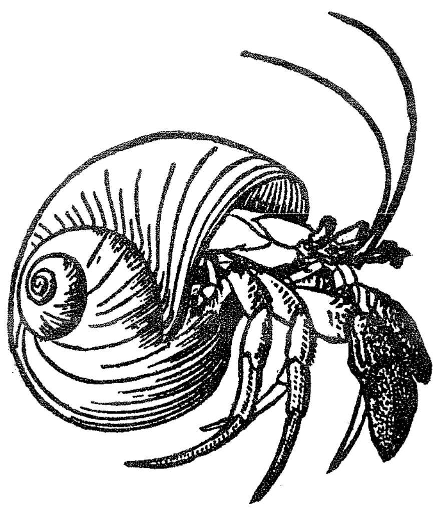
5.2. Decapoda (cont'd.)



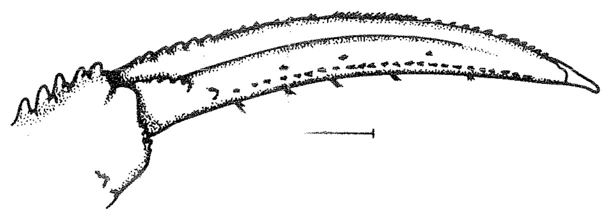
5.2.4. Carcinus maenas, external dorsal view of whole crab.




5.2.4.1. Anterior (a) and posterior (p) views of the 2nd right periopod. Note form of distal extremity of dactylus as compared to other decapods. Scale bars: 5 mm.



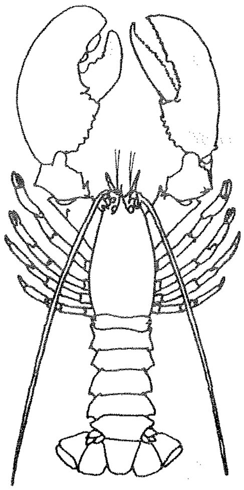
5.2.5. Pagurus acadianus, external view of whole crab, with gastropod shell. (After Rathbun, 1929).



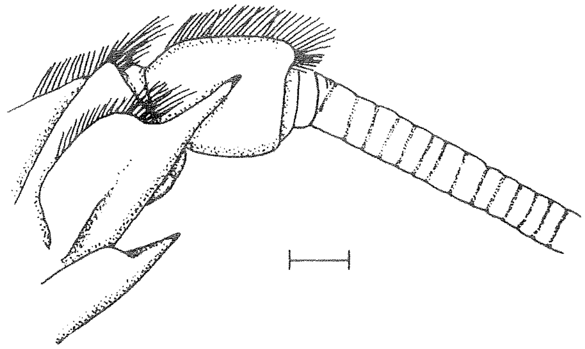
5.2.5.1. Posterolateral view of a left periopod. Note jagged proximal end of dactylus and form of distal extremity as compared with other decapods. Scale bar: 5 mm.

5. Crustacea (cont'd.)

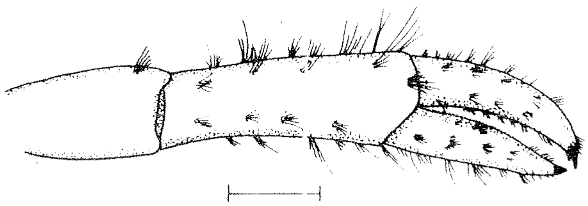
5.2. Decapoda (cont'd.)



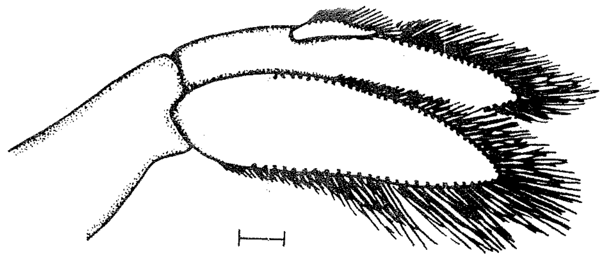
5.2.6. Homarus americanus, external dorsal view of whole lobster. (After Rathbun, 1929).



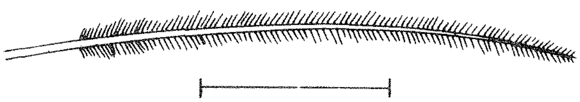
5.2.6.1. Part of antenna at cephalic junction. Scale bar: 2 mm.



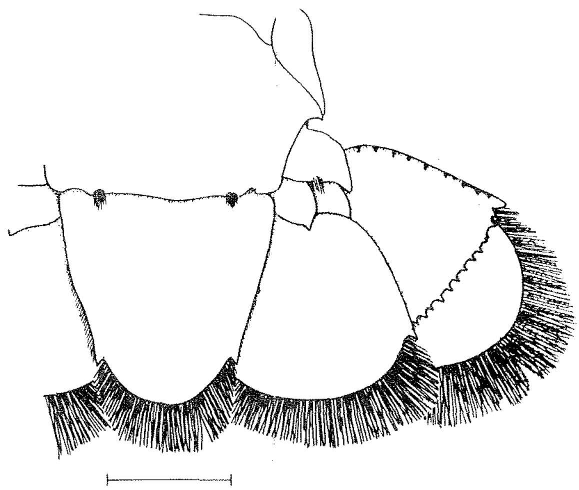
5.2.6.2. Anterior view of the 2nd right periopod. Note chela and distribution of setae compared with other Decapoda. Scale bar: 10 mm.



5.2.6.3. Pleopod. Note biramous dactylus. Scale bar: 2 mm.



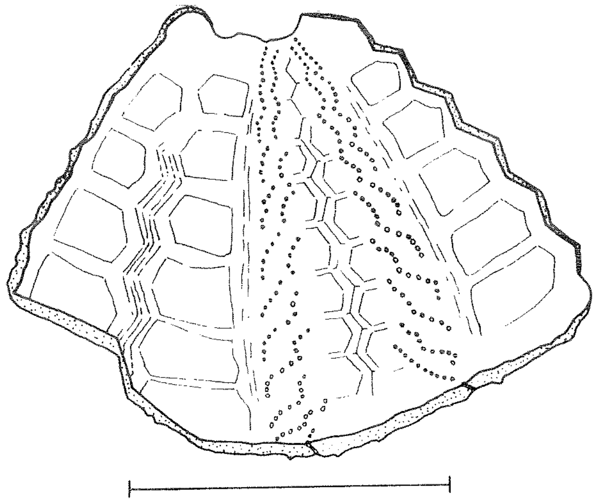
5.2.6.4 Typical seta found on appendages. Scale bar: 1 mm.



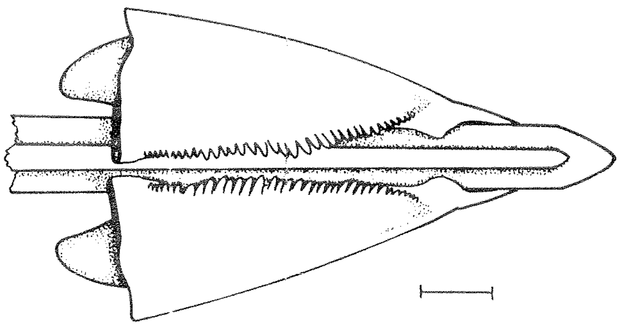
5.2.6.5. Right part of tail fan. Scale bar: 10 mm.

6. Echinodermata

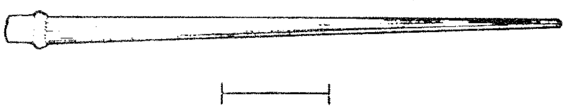
6.1. *Strongylocentrotus droebachiensis*



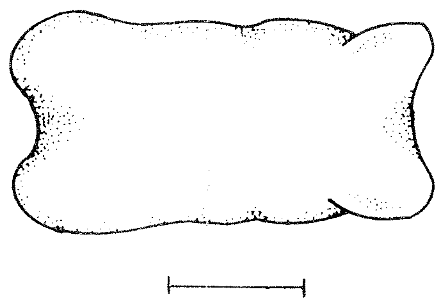
6.1.1. Internal surface of test. Note symmetrical organization of perforations and pentagonal plates. Scale bar: 10 mm.



6.1.2. Ossicle of Aristotle's lantern. Color pure white. Fragile, breaks in sheets. Scale bar: 1 mm.

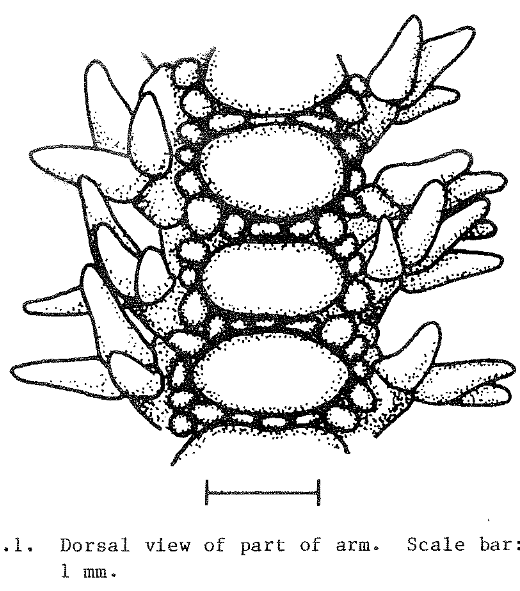


6.1.3. Spine. Much stouter than polychaete aciculum (see 4.1.4) with basal enlargement; longitudinal grooves on surface. Scale bar: 1 mm.

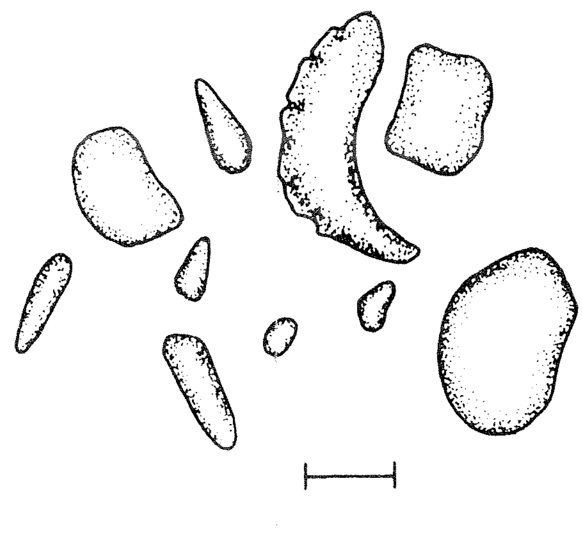


6.1.4. Rotula of Aristotle's lantern. Color pure white; very hard. Scale bar: 1 mm.

6.2. Ophiuroidea



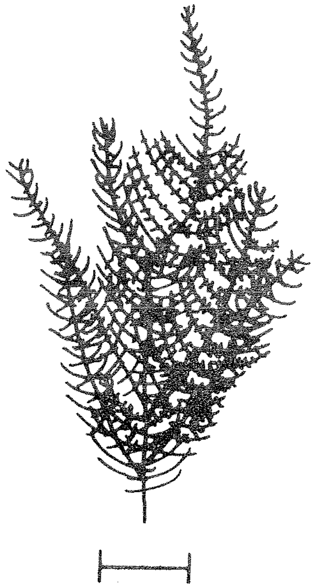
6.2.1. Dorsal view of part of arm. Scale bar: 1 mm.



6.2.2. Plates and spines found on arms. Harder than pieces of Aristotle's lantern; breaks into small pieces. Scale bar: 1 mm.

7. Algae

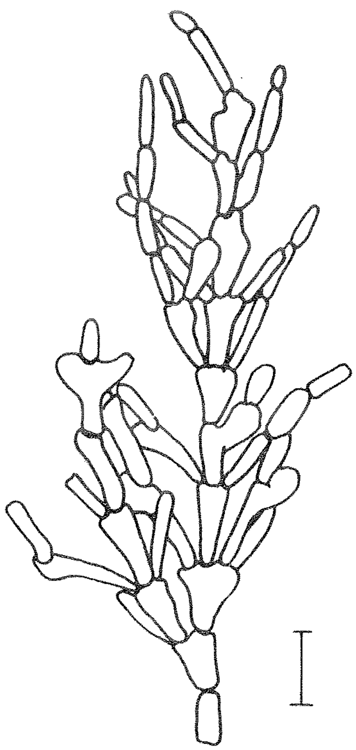
7.1. Ptilota spp.



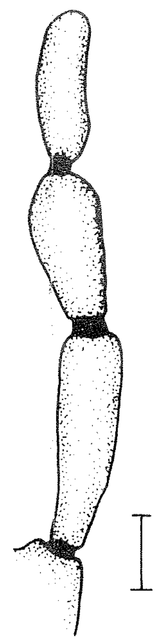
7.1.1. General view of part of thallus. Scale bar: 10 mm.

7.1.2. Detail of part of thallus. Scale bar: 1 mm.

7.2. Corallina officinalis.



7.2.1. General view of part of thallus. Scale bar: 1 mm.



7.2.2. Detail of part of thallus. Scale bar: 0.3 mm.

B. Form guide

| Form type | Figure |
| --- | --- |
| Plate-like | |
| a) Solid, smooth | |
| Amphineuran valves | 3.1.1, 3.1.2 |
| Operculum | 3.2.1, 3.2.2 |
| Limpet shell | 3.2.3 |
| Bivalve shell | 3.3.1, 3.3.2, 3.3.3 |
| Ostracod | 5.1.1 |
| Crab cephalothorax margin | 5.2.1.1, 5.2.2.1 |
| Lobster tail fan | 5.2.6.5 |
| b) Solid, tuberculous | |
| Polynoid elytron | 4.2.1 |
| Crab cephalothorax margin | 5.2.1.1, 5.2.2.1 |
| Sea urchin test | 6.1.1 |
| Ophiuroid arm | 6.2.1 |
| c) Perforated | |
| Foraminiferan | 1.1 |
| Sea urchin test | 6.1.1 |
| Spinous | |
| Jaw | 4.1.1, 4.2.2, 6.1.2 |
| Hook/spicule/seta/antenna | 3.1.3, 4.1.2, 4.1.3, 4.1.4, 4.2.3, 4.2.4, 5.2.3.1, 5.2.6.1, 5.2.6.4, 6.1.3, 6.2.2 |
| Appendage tip | 5.2.1.2, 5.2.2.2, 5.2.3.2, 5.2.3.3, 5.2.4.1, 5.2.5.1, 5.2.6.2, 5.2.6.3, 5.2.6.4 |
| Branched | |
| Hydrozoan | 2.1 |
| Alga | 7.1.1, 7.1.2, 7.2.1, 7.2.2 |
| Complex or amorphous | |
| Small crustacean | 5.1.1, 5.1.2, 5.1.3 |
| Sea urchin part | 6.1.2, 6.1.4 |
| Brittle star arm, plate and spine | 6.2.1, 6.2.2 |

C. Relationship between indicator fragment size and whole prey size

The results of the linear regressions of indicator fragment vs. whole prey size are presented in Figure 8 and demonstrate that some indicator fragments can be utilized to reconstruct the size of the prey for a given site and time period.

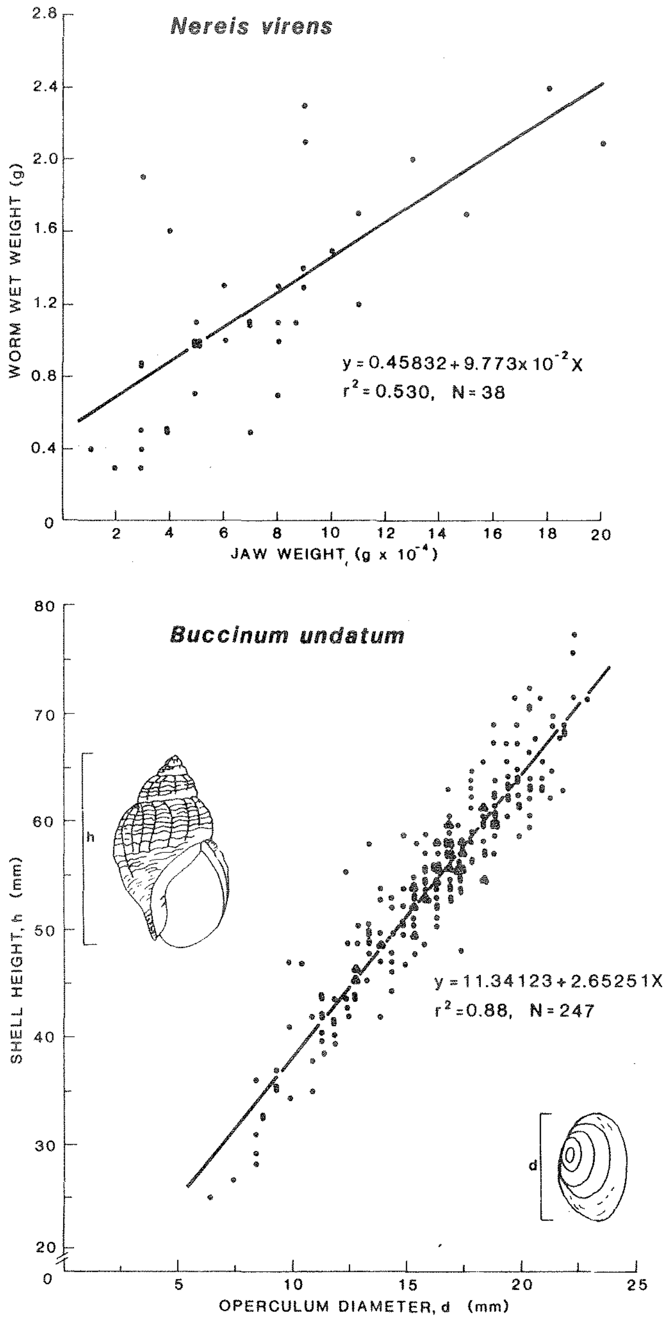



Fig. 8. Relationship between indicator fragment size and whole prey size for Nereis virens and Buccinum undatum.

DISCUSSION

Notwithstanding the scope and application of this guide, before starting stomach analyses proper, the investigator should identify and assess the occurrence and distribution of possible prey species in the habitat. In the laboratory, specimens of each potential prey species should be fragmented, to simulate their ingested state, and the form, color and size of prospective, distinctive indicator fragments ascertained. In this way, foundations provided by this guide may be expanded and a true prey profile generated.

As many indicator fragments are also key structures in taxonomic identification (bivalve hinges, polychaete jaws, etc.), standard keys and reference works may be very helpful in the correct identification of such fragments. To this end, the works used in the present study are highly recommended: Arnold (1968), Dawson (1956), Smith (1964), Meglitsch (1973, 1974, 1975), Williams (1974), Scott and Messieh (1976), Brinkhurst et al. (1975), Gosner (1979), Appy et al. (1980), and Abbott (1982).

It should be emphasized that decapod stomach contents may be expected to partly reflect regional differences in prey species and their distributions. Hence, the present guide does not represent an exhaustive inventory of possible indicator fragments, and further studies of this nature will be necessary in other geographical regions.

In using the guide, and in stomach analysis in general, the investigator should be aware of the myriad biases involved in the interpretation of stomach contents data. Some identified fragments may be ingested incidentally, such as hydroids on mollusc shells, and, thus, are not strictly 'prey'. The presence of a prey taxon in a stomach is no indication of the state of the prey at ingestion. Hence, the presence of fish otoliths, for example, may signify either the agility of the predator or simply predation on carrion. Similarly, fragments of conspecifics may be attributable equally to cannibalism, necrophagy or foraging on cast exuviae from molted animals. In essence, stomach analysis should be complementary to good natural history observations on the predator and prey under field conditions.

To understand how predators such as Cancer crabs affect community structure, it is necessary to know not only the quantities of the various prey species harvested but also the size-range of prey selected by a given-sized predator. Probing the dynamics of a predator-prey system on such a detailed scale is exceedingly complicated; however, optimal foraging theory (see reviews by Krebs 1978 and Hughes 1980) has been developed to predict the outcome of decisions governing the selection of prey by predators. While optimal foraging theory has often been successful in predicting predators' decisions under some simple laboratory (Elner and Hughes 1978) and field (Zach 1979) conditions, it is less amenable to validation in complex, 'real' environments. The ability to reconstruct the size of prey through measuring selected indicator fragments (Fig. 8) presents the promising possibility of applying optimal foraging theory to the complexities of a sublittoral environment. However, indicator fragments for prey size relationships may be influenced by site conditions (see Vermeij, 1978 for molluscs) or physiological/reproductive state (Note: the latter factors may explain the high variation about the N. virens regression Fig. 8); thus, investigators should construct predictive relationships with whole prey specimens collected simultaneously with the crab predators. Predictions from such an approach, modelled with aspects of the population dynamics of the predator and prey, could lead to a better understanding of community relationships.

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