

(Bivalvia: Pectinoidea: Limidae), in the Northwest Atlantic

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Two large bivalve specimens collected in Bay d'Espoir, a deep fjord situated on the south coast of Newfoundland, are described and identified as belonging to the species *Acesta excavata* (Fabricius 1779). *In situ* observations onboard the manned submersible *PISCES IV* and color videos have provided information on the vertical distribution, density and habitat of the species. Maximum abundances of about 15 large individuals/m² occurred on sheltered rock outcrops at depth ranging from 550 to 775 m, where warm (6°C) continental slope water is found. Differences in shape and thickness between the valves of the two specimens appear to be related to the degree of exposure to rock falls (i.e., sheltered versus exposed habitat). Prior to this account, the European Giant File Clam had never been encountered west of the Azores Islands in the North Atlantic.

Key Words: *Acesta excavata*, European Giant File Clam, Limidae, Northwest Atlantic, fjord, Newfoundland.

Since the original description of the European Giant File Clam, *Acesta excavata*, by Fabricius (= *Ostrea excavata*; 1779), records for this species have shown a geographic range extending over most of the Northeast Atlantic, from the Norwegian and Greenland Seas to the Senegal coast (including the Azores and Canary Islands), and into the Mediterranean Sea (Barsotti 1975; Ghisotti 1979; Rocchini 1983; Carcassi 1983). Recorded depths vary between 90 m and 3200 m, although most occurrences reported since 1969 have been from the 200–800 m depth range (Ghisotti 1979). In the Krosfjord (Norway), the species is frequently encountered on rocky substrates between 100 and 400 m (Gilmour 1990). In many instances, *A. excavata* was found in association with the white deep-water coral *Madrepora oculata* (Rocchini 1983; Carcassi 1983). In the entire Atlantic Basin, only three other living species of Giant File Clams have been recorded: *A. bullisi* H. E. Vokes, 1963 from the Gulf of Mexico, *A. columbiana* H. E. Vokes, 1970 from the Caribbean Sea and *A. angolensis* Adam and Knudsen, 1955 from off the coast of Angola (Vokes 1963a, b, 1963, 1970). To date, *Acesta excavata* is the only giant file clam species to have been observed in the Northwest Atlantic (Haedrich and Gagnon 1991).

During a benthic study initiated in 1984 in Bay d'Espoir, a deep fjord situated along the south coast of Newfoundland, Canada, one large, sub-fossilized valve was recovered from sub-surface sediments by a grab, along with fragments of smaller but similar shells. These were tentatively identified to the genus *Acesta*. Although side-echoing of the depth sounder in this deep narrow fjord precluded reliable depth records, at least 740 m of wire had been released for the sample.

Bottom-triggered photographs from the same area revealed no such shells on the sediment surface.

In 1985, the availability of a manned submersible allowed a closer examination of an important portion of the benthos on slopes that could not be sampled by conventional methods. Results of two submersible dives down to almost 800 m have yielded a wealth of information on the fauna in the form of direct in-situ observations, colour videos and still photographs. In addition, one complete live specimen of Giant File Clam (Limidae) was recovered from the rock wall, using the hydraulic arm of the submersible.

This paper describes the specimens collected (valves and soft parts) and confirms their identity as *Acesta excavata* (Fabricius 1779), based on diagnostic characters of the valves: shape, size and external ornamentation, shape of the ligamental pit and development of the auricles. These specimens are deposited in the Mollusc Collection of the Canadian Museum of Nature, in Ottawa. We also report information on the density and distribution of that species in Bay d'Espoir in relation to substratum type, water temperature, salinity as well as depth. An overall description of the fauna and habitat based on observations obtained during the submersible dives is presented elsewhere (Haedrich and Gagnon 1991).

Description of the Environment

Bay d'Espoir is a fjord situated along the south coast of Newfoundland, Canada (Figure 1; 47° 40' N, 56° 08' W). In the eastern portion of its outer basin (near Goblin Head), where specimens of *Acesta* were found, maximum depth reaches 794 m. There, at least 30% of the bottom consists of rock walls with slopes greater

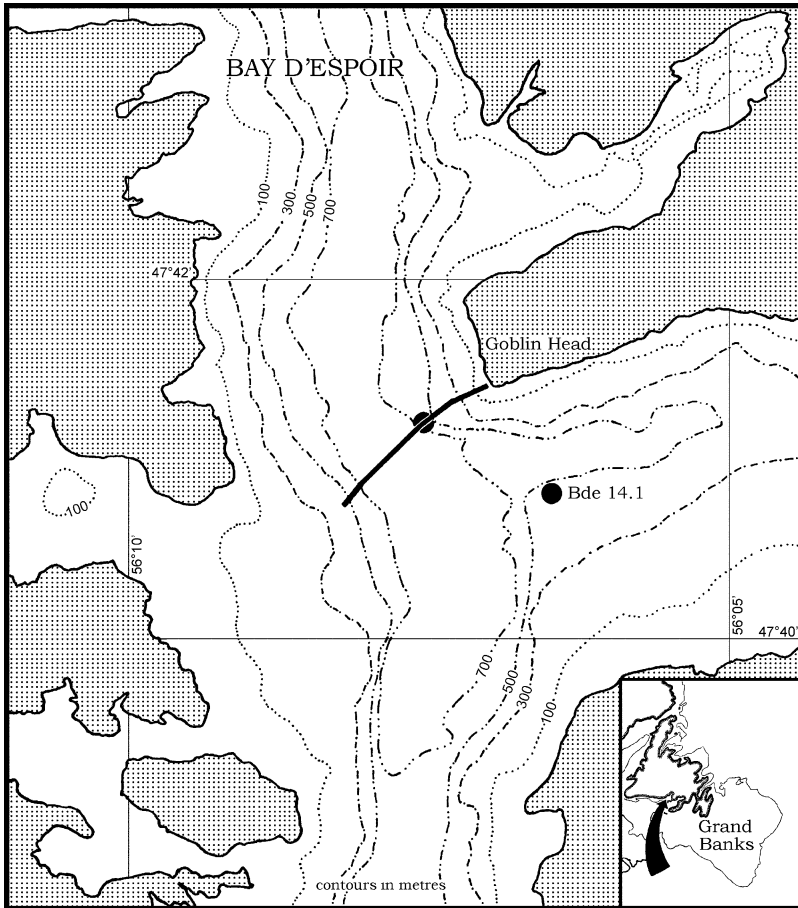


FIGURE 1. Collection sites of the Giant File Clam, *Acesta excavata*, (filled circles) in Bay d'Espoir, Newfoundland.

than 40 degrees and there are frequent overhangs (Figure 2). In areas where slopes are not as steep, the bottom is mostly made up of silty sediments. Benthic biomass in this basin appears to be important and primarily dominated by suspension and filter feeders such as sponges, several species of anemones, sea pens, the stalked cirriped *Arcoscalpellum mitchellianum*, and Giant File Clam (*Acesta*). This rich invertebrate fauna is supported by a high zooplanktonic biomass (Haedrich and Gagnon 1991), although no estimates of surface primary production are available for this area.

The water column in the outer basin is divided in four distinct layers on the basis of temperature and salinity (Haedrich and Gagnon 1991; Figure 2). Below 250 m, which corresponds approximately to the sill depth at the entrance of the fjord, benthic communities are exposed to a uniformly warm (5.0 to 6.5°C), saline (34.6‰) and stable water mass derived from the continental slope water. Above, a cold water layer (40-160 m, -1.0 to 1.0°C) associated with the less saline

Labrador Current and a transition layer (160-220 m, 1.0 to 5.0°C) maintain the deep isolated layer; only limited exchanges occur with the Laurentian Modified Slope Water from the outside (Hay and deYoung 1983; Richard and Haedrich 1987).

Materials and Methods

The first specimens of *Acesta* were collected during a benthic sampling program conducted in the outer deep basin of Bay d'Espoir, Newfoundland, Canada, on 10 December 1984. During that sampling, one large, complete valve and fragments of smaller valves were found in the anoxic, muddy sub-surface sediment of a 0.1m² van Veen grab sample from a site to the southeast of Goblin Head, at approximately 600-700 m depth (Figure 1; circa station Bde14.1, 47°40.8' N, 56°06.5' W). On 26 June 1985, during a dive onboard the manned submersible *PISCES IV*, a complete, living specimen was retrieved with the hydraulic arm from the rock wall at the foot of Goblin Head (47°41.2' N, 56°07.6' W), at 750 m depth (Fig-

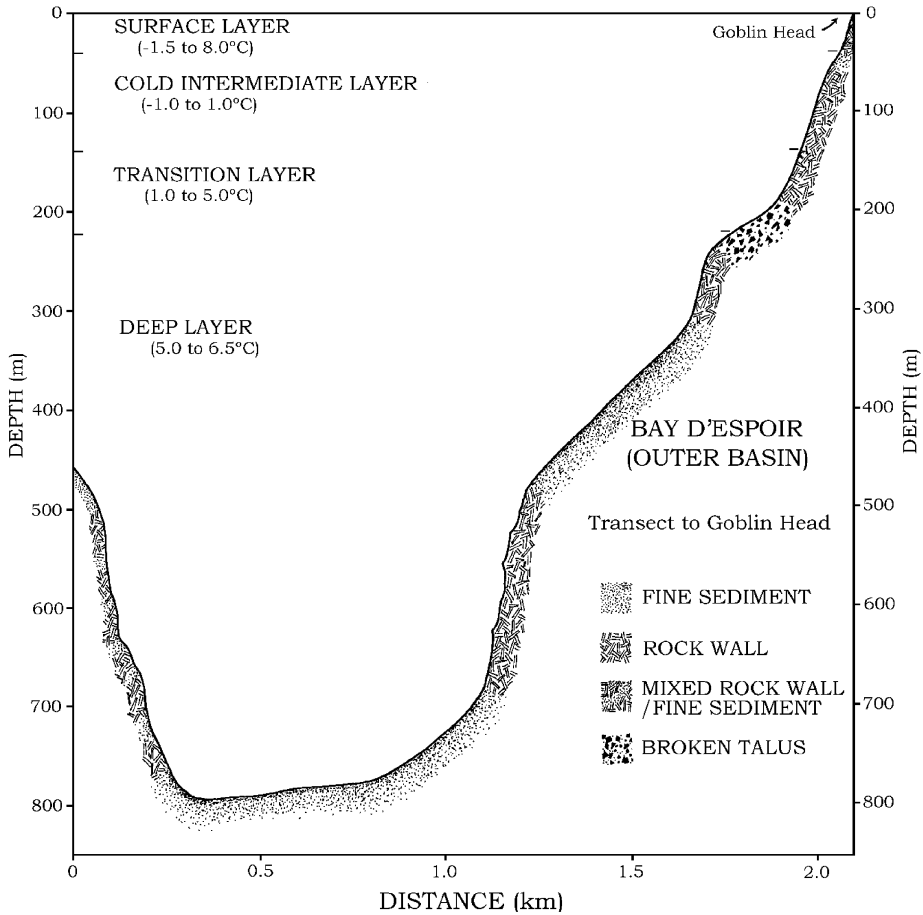


FIGURE 2. Cross-section of the outer basin along the submersible dive transect.

ures 1 and 2). Information on the density and vertical distribution of the species was also recorded during the dive of June 26 and 27 through direct in-situ observations, color videos using an external camera, and color photographs using an external Photosea camera and a hand-held camera through the port-hole.

Results and Discussion

Description of specimens

The first specimen of *Acesta excavata* (catalogue number CMNML 092957), which was collected with a bottom grab near Station BdE14.1, consisted of a complete right valve (height 112.5 mm, width 81 mm; Figures 3-5). The shell is relatively thin (0.93 mm), dark grey on the outside and white on the inside (Figures 3 and 4). Deterioration of the inner layer is evident as much of the luster on the nacre layer has disappeared. The external ornamentation of the valve, however, appears intact and is composed of weak, somewhat irregular radial ribs which are more developed in the anterior and posterior region of the valve. In the median portion of the shell surface, these ribs resemble

more shallowly impressed, irregular grooves (Figure 3). As described by Vokes (1963a) for *Acesta excavata*, the straightness of the ribs is mostly affected by the presence of pronounced growth rings. The anterior auricle is highly reduced through the encroachment of the large excavate lunule. The ligamental pit is strongly oblique (Figure 5).

There is a striking resemblance between this specimen from Bay d'Espoir (Figure 3) and those illustrated by Barsotti (1975), Ghisotti (1979) and Rocchini (1983). In fact, shell characteristics for this specimen correspond well to those of specimens of *Acesta excavata* examined from the Northeast Atlantic (including the Azores Islands), the Norwegian Sea, the Mediterranean Sea (Table 1). Its shell height/width ratio (1.39) falls within the variation of that observed in these European specimens (mean= 1.34, standard deviation= 0.049, n=27).

The second specimen (catalogue number CMNML 092958; Figures 6-8) was a complete, living individual, only slightly damaged during its recovery by the hydraulic arm of the submersible. The damage was

mainly due to the force necessary to break the byssal attachment to the rock wall. The left valve, however, shows signs of shell damage sustained by the animal earlier in its life (Figure 6). This past injury apparently resulted in abnormal growth of the animal. While the shell height (112.0 mm) is very similar to that of our first specimen, it is significantly wider (94.5 mm), with a height/width ratio of 1.19. The animal was originally injured in the posterior region of the shell (see Figure 6, shell margin at height 34 mm), causing a greater growth in that region of the shell relative to the rest and resulting in the wider, less elongated appearance of the specimen. The pathological condition of this specimen is also reflected by the distorted margin of the lunule (Figures 7-9). Valves are also thicker (1.1 mm) than that of the first specimen, and mostly white. Otherwise, the ornamentation of the shell, the shape of the ligamental pit and muscle scars are comparable to those of the first specimen. The differences observed between the two specimens may be the result of living in a sheltered vs. exposed habitat. As discussed in the following section, animals living under overhangs are protected from rock falls.

Very little information is available in the literature on the soft parts of *Acesta excavata*, hard parts being typically used to identify bivalves. Figures 9-11 show some important characteristics such as the long palial tentacles along the mantle margin (typical of all Limoida; Gilmour 1990), eight strong byssal treads and the deeply grooved foot. When freshly collected, margins of the mantle and its tentacles were bright orange, the remaining soft parts being mostly pale orange. Gilmour (1990) examined the significance of foot reversal in Limoida and described the arrangement of muscles on freshly collected *Acesta excavata* specimens from the Krosfjord in Norway. The overall pattern of muscle disposition on our specimen corresponds well with that described by Gilmour. The slight difference in the position of the anterior pedal retractor and the not readily visible anterior byssal retractor are not believed to be significant (T. H. J. Gilmour, personal communication).

In situ observations

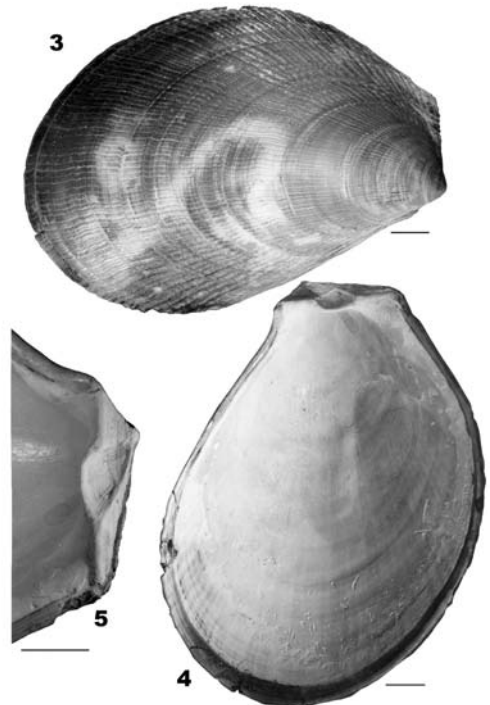
To our knowledge, this is the first *in situ* observation of the European Giant File Clam, *Acesta excavata*. The species was encountered on rock walls and outcrops only in the deepest part of the outer basin, between approximately 550 and 775 m. Water temperature within that depth range was $6.3 \pm 0.1^\circ\text{C}$. Because rock faces are infrequent between 500 and 300 m (Figure 2), it is not possible to establish an accurate upper limit to the bathymetric distribution of *A. excavata* in Bay d'Espoir.

In areas where the rocky substrate is exposed to sedimentation, and potentially to rock falls (Figure 12), total animal biomass appears much lower than in sheltered areas (Figure 13). The Giant File Clam shared these habitats primarily with anemones and

sponges; colonial anemones were particularly dominant under overhangs (Figure 13). We found no indication of the presence of the white coral *Madrepora oculata* which is frequently found in association with *Acesta excavata* in the Northeast Atlantic (Fosså and Mortensen 1998) and the Mediterranean (Parenzan 1974; Ghisotti 1979; Rocchini 1983; Carcassi 1983). Estimates of density are difficult to obtain due to the patchy distribution of *Acesta* on the rocky substrate and the lack of a reference scale when surveying with the submersible. When present, however, densities appear to vary from few to 10-15 individuals per metre²; this is probably a conservative estimate since only the large individuals that could be distinguished from the orange anemone *Actinauge* sp. were counted.

Origin of the Northwest Atlantic population

The discovery of *Acesta excavata* off southern Newfoundland represents a significant extension to its previously known geographic range by probably more than 2100 km. This Newfoundland population of *A. excavata* may be a relict from a previously wider distribution, although many deepwater species found in Bay d'Espoir are typically found on the Eastern Canadian continental slope and the St. Lawrence Channel. Alternatively, *A. excavata* may have a more

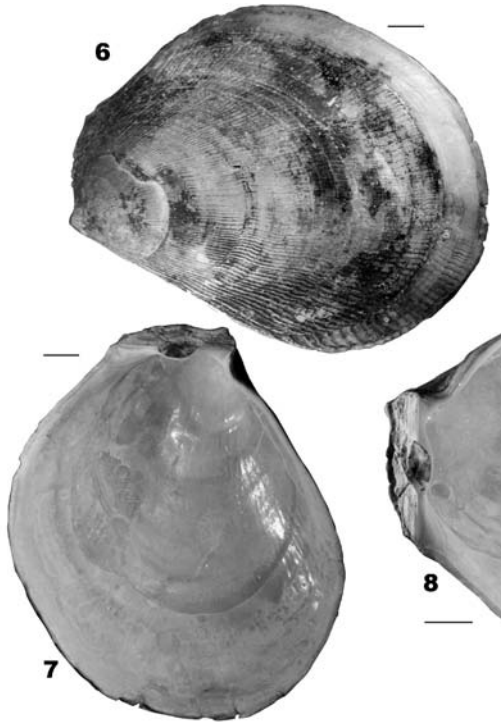


FIGURES 3-5. *Acesta excavata* specimen #1 (catalogue number CMNML 092957), right valve; height: 11.25 cm, width: 8.0 cm. 3. Exterior view. 4. Interior view. 5. Hinge view.

TABLE 1. Variability of height/width ratio in *Acesta excavata* over its extended geographic range, based on specimens examined in collections and values reported in the literature.

| Geographic region | Source / institution * | Specimen catalogue no. | Specimen description | Shell dimensions (mm) | | H/W ratio |
|------------------------------------|------------------------|------------------------|------------------------------|-----------------------|-------|-----------|
| | | | | height | width | |
| Newfoundland | CMN | CMNML 092957 | 1 valve | 112.5 | 81.0 | 1.39 |
| | CMN | CMNML 092958 | whole | 112.0 | 94.5 | 1.19 |
| | CMN | CMNML 042946 | 1 valve | 93.5 | 67.0 | 1.40 |
| | CMN | CMNML 042947 | 1 valve | 98.0 | 73.5 | 1.33 |
| Northeast Atlantic / Norwegian Sea | CMN | CMNML 009259 | whole | 97.0 | 71.0 | 1.37 |
| | BMNH | not available | whole | 97.5 | 70.5 | 1.38 |
| | BMNH | not available | whole | 61.0 | 48.0 | 1.27 |
| | BMNH | not available | whole | 69.0 | 51.0 | 1.35 |
| | FMNH | 160769 | 1 valve | 108.3 | 82.2 | 1.32 |
| | FMNH | 2404 | 2 valves | 120.9 | 88.0 | 1.37 |
| | MNHN | not available | whole | 163.0 | 117.0 | 1.39 |
| | UC/MOL | not available | 2 valves | 94.5 | 71.0 | 1.33 |
| | UC/MOL | not available | 2 valves | 107.0 | 107.0 | 1.29 |
| | UC/MOL | not available | 1 valve | 135.0 | 105.0 | 1.29 |
| | UC/MOL | not available | 1 valve | 215.0 | 160.0 | 1.34 |
| | UC/MOL | not available | 1 valve | 10.0 | 8.0 | 1.25 |
| | UC/MOL | 1223 | 2 valves | 109.0 | 81.5 | 1.34 |
| | UMM | not available | 1 valve | 161.0 | 119.0 | 1.35 |
| | McAndrew 1857 | not available | from Vokes 1963a | 140.0 | 108.0 | 1.30 |
| | Lamy 1930 | not available | from Vokes 1963a | 170.0 | 125.0 | 1.36 |
| | Philippi 1900 | not available | drawing | 135.0 | 105.0 | 1.29 |
| | Thiele 1918-20 | not available | text | 150.0 | 105.0 | 1.43 |
| | Abbott and Dance 1982 | not available | photograph | 100.0 | 75.0 | 1.33 |
| Mediterranean Sea | FMNH | 2401 | 2 valves | 135.6 | 103.1 | 1.32 |
| | Parentan 1974 | not available | text description | 140.0 | 103.0 | 1.36 |
| | Barsotti 1975 | not available | subfossil, text & photograph | 140.0 | 103.0 | 1.38 |
| | Ghisotti 1979 | not available | text description | 56.5 | 42.3 | 1.34 |
| | Carcassi 1983 | not available | text description | 50.0 | 35.0 | 1.43 |
| | Carcassi 1983 | not available | text description | 50.0 | 35.0 | 1.43 |
| | Carcassi 1983 | not available | text description | 65.0 | 50.0 | 1.30 |
| | Rocchini 1983 | not available | text description | 63.0 | 45.0 | 1.40 |

* CMN: Canadian Museum of Nature, Ottawa, Canada; BNHM: The (British) Natural History Museum, London, England; MNHN: Muséum national d'histoire naturelle, Paris, France; UMM: University of Manchester Museum, Manchester, England; UC/MOL: University of Cambridge/Mollusc Collection, Cambridge, England; FMNH: The Field Museum of Natural History, Chicago, U.S.A.



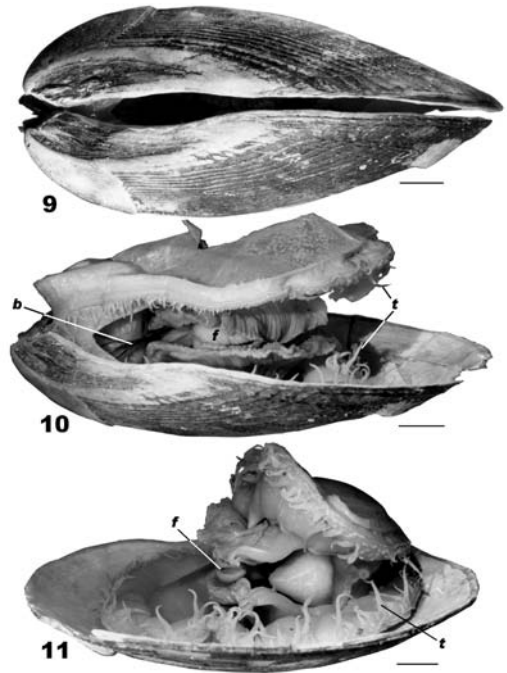
FIGURES 6-8. *Acesta excavata* specimen #2 (catalogue number CMNML 092958), left valve; height: 11.2 cm, width: 9.45 cm. 6. Exterior view. 7. Interior view. 8. Hinge view of left valve.

continuous distribution in the Northwest Atlantic at present but has only been recovered from Bay d'Espoir.

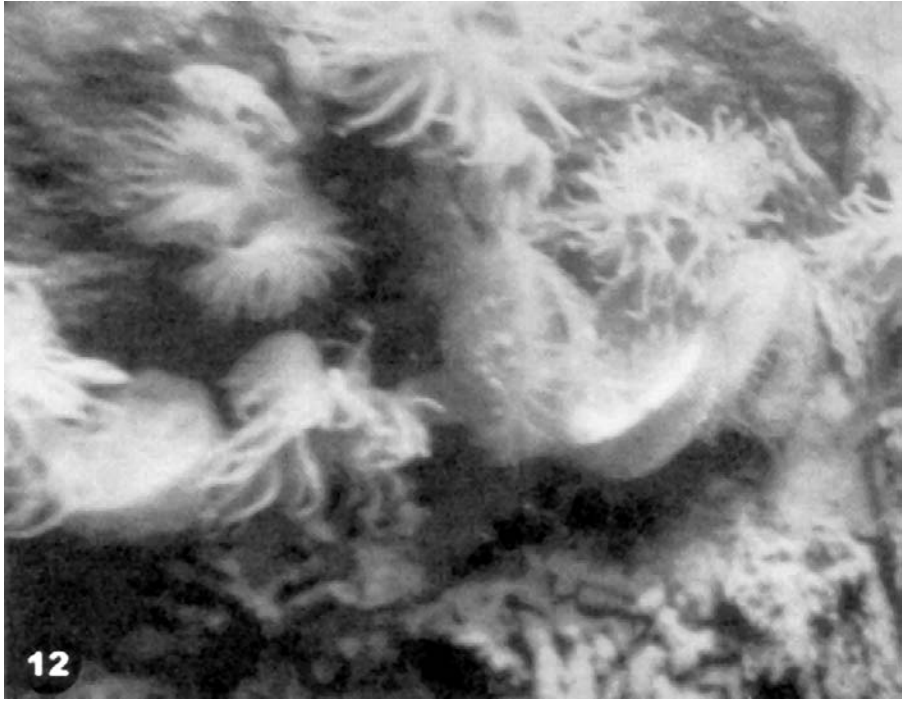
There have been relatively few surveys of bathyal communities in the Northwest Atlantic (Grassle et al. 1975; Haedrich et al. 1980), and particularly on deep-water hard substrata along the eastern Canadian and Greenland continental slopes (Houston and Haedrich 1984). The few surveys that have been undertaken along the eastern Canadian and United States slopes, including photographic explorations of the wreck of the RMS *TITANIC* (P. Pocklington, personal communication), did not reveal the presence of *A. excavata*. Further sampling surveys are necessary in areas of the Northwest Atlantic where suitable *A. excavata* habitats (e.g., deep-basin bays, continental slope and bathyal rocky outcrops) exist to determine the full extent of its distribution. Also needed is information on the larval stages of *A. excavata* and their dispersal in the water column, to establish whether they occur in prominent ocean current systems between the Northeast and Northwest Atlantic and could account for the establishment of the European Giant File Clam in Bay d'Espoir, Newfoundland.

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FIGURES 9-11. *Acesta excavata* specimen #2 (catalogue number CMNML 092958). 9. Anterior view of complete animal. 10 and 11. Anterior and ventro-posterior views of animal in right valve, showing byssus (*b*), grooved foot (*f*), and pallial tentacles (*t*).



FIGURES 12-13. Living *Acesta excavata* on the rock walls of Bay d'Espoir. 12. Sheltered under overhang, circa 650 m. 13. Exposed, circa 550 m.

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