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FRANCES J.E. WAGNER

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MOLLUSCA OF THE STRAIT OF CANSO AREA

ABSTRACT

Molluscs collected from the Strait of Canso in 1973 as part of the study undertaken by the Environmental Marine Geology Section of the Atlantic Geoscience Centre are useful indicators of environmental change in the area. Differences in the surface faunas compared with the uniform faunal representation below a 10 to 25 cm barren zone observed in cores taken north and south of the causeway show the marked effect the causeway, completed in 1954, has had on the marine environment. In the Strait south of Point Tupper, a thin (5 to 10 cm.) barren zone overlies mollusc-bearing sediments and delimits the extent of the area affected by industries located along the eastern shore of the Strait. Exotic species mixed with endemic species in several of the cores may indicate the presence of interglacial or reworked interglacial deposits in the area.

RESUME

Les mollusques recueillis dans le détroit de Canso en 1973, dans le cadre d'une étude entreprise par la Section de géologie de l'environnement marin du Centre géo-scientifique de l'Atlantique, constituent des indicateurs utiles des transformations de l'environnement dans cette région. Les différences entre les faunes de surface et la représentation uniforme de la faune, sous une couche stérile de 10 à 25 cm observée dans des carottes prélevées au nord et au sud de la levée, démontrent l'important effet de la levée, construite en 1954, sur l'environnement marin. Dans le détroit, au sud de Point Tupper, une mince couche stérile de 5 à 10 cm recouvre des sédiments à mollusques et délimite la région affectée par les industries situées le long de la côte est du détroit. Des espèces exotiques, mêlées à des epèces endémiques dans certaines carottes, indiquent peut-être dans cette région la présence de dépôts interglaciaires ou de dépôts interglaciaires remaniés.

INTRODUCTION

In 1973 a project was carried out in the Strait of Canso by the Environmental Marine Geology Section of the Atlantic Geoscience Centre to evaluate the impact that the Canso Causeway (completed in 1954) and more recent industrialization south of the causeway has had on the marine environment. The area of study is shown in Figure 1.

The chartered vessel VILMA L served as a platform from which grab and dredge samples, and cores were taken. Eckman and Shipek grab samplers, and an Arctic dredge, developed by the National Museum of Canada, were used. Core samples were obtained using Lehigh and Phleger gravity corers. A few samples were obtained by SCUBA divers.

Pelecypods and gastropods were found to be major constituents of the marine benthos in the area. Of the 81 species identified, 68 were living when collected. Some or all of the remaining 13 species might be found alive by more extensive collecting. An additional 14 species were found only in the core samples. A complete list of species related to sub-areas and to methods of collection is presented in Table 1. The greatest variety of species was obtained from the grab samples. Dredging produced much greater numbers of specimens but yielded fewer species. The problem here would be that many of the minute shells could have been washed away. To save time, many of the dredge hauls were hosed heavily with the result that small specimens could have been forced out of the mouth of the dredge with the enclosing sediment. Proper washing with a fine spray would have required about an hour for each haul (Clarke, 1972, p. 1503). Adult specimens of about 20 per cent of the species identified measured less than 5 mm in length; 40 per cent were less than 10 mm long. Diver-collected samples produced only a few large species. The divers did not take bulk samples but picked up only larger, easily visible specimens. Grab sampling proved to be the most satisfactory method, giving the best representation of endemic species.

DISTRIBUTION OF SPECIES IN SURFACE SEDIMENTS

Stations throughout the area of study (Figs. 2, 3, and 4) were compared on the basis of the total number of molluscan species per station (Fig. 5) and living species only at each station (Fig. 6). Throughout the Strait south of the causeway no station yielded more

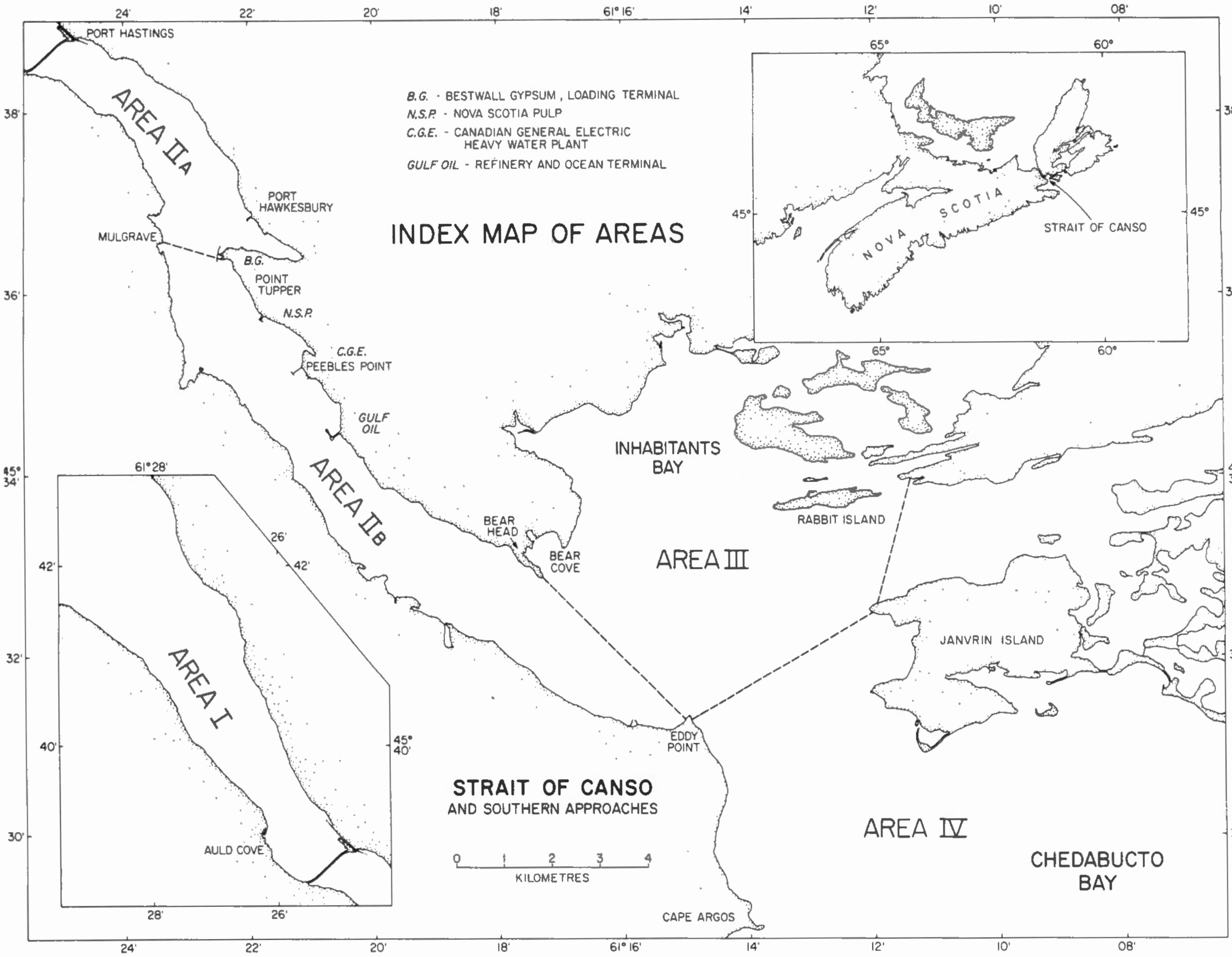


Figure 1. Location of study areas.

than 10 species total or 5 species living. Figure 6 best illustrates the extensive zone devoid of living molluscs. This zone extends from the causeway to several kilometres seaward of the area of industrialization. Beyond Bear Head, at the southern end of the Strait, areas of greater faunal diversity appear with as many as 15 species total and the same number living. However, the areas with up to 15 living species per station are much more restricted in extent than those with 15 species total (living plus dead) which is shown by a comparison of areas III and IV in Figures 5 and 6. North of the causeway the situation is similar to that in the Strait, i.e. low numbers, but without an extensive barren zone. A notable exception is the area immediately adjacent to the locks where higher numbers of species are found.

North of the causeway (area I), the vast majority of the species identified were found alive. Only four species, *Yoldiella fraterna, Anomia simplex, Cylichna alba* and *Turritellopsis acicula,* were represented by empty shells. Sampling in this area was quite concentrated, so if these species were still living in the area it is logical to expect that they would have been found alive in at least one sample. Therefore, these species apparently died out in area I in the recent past. The situation south of the causeway (area IIA) is in marked contrast to that for area I. Of the 31 species identified, only 15 species were living. In area I, 32 species are living. Table 2 emphasizes the contrast in fauna between these two areas.

Farther south from the causeway, area IIB is characterized by 49 species, 12 of which are apparently no longer endemic. The marked differences in fauna between areas IIA and IIB are shown by Table 3, and they would suggest a considerable dissimilarity in conditions between the two areas. Species marked by an asterisk were found in that part of area IIB most affected by industrialization but most occurrences were of dead specimens. However, a few living specimens of *Astarte undata, Cerastoderma pinnulatum, Hydrobia minuta, Macoma balthica, Modiolus modiolus, Mytilus edulis, Oenopota turricula* and *Pyramidella fusca* were obtained from the industrialized area. In areas III and IV beyond the limits of the Strait, living species outnumber those found only as dead shells (*see* Table 1).

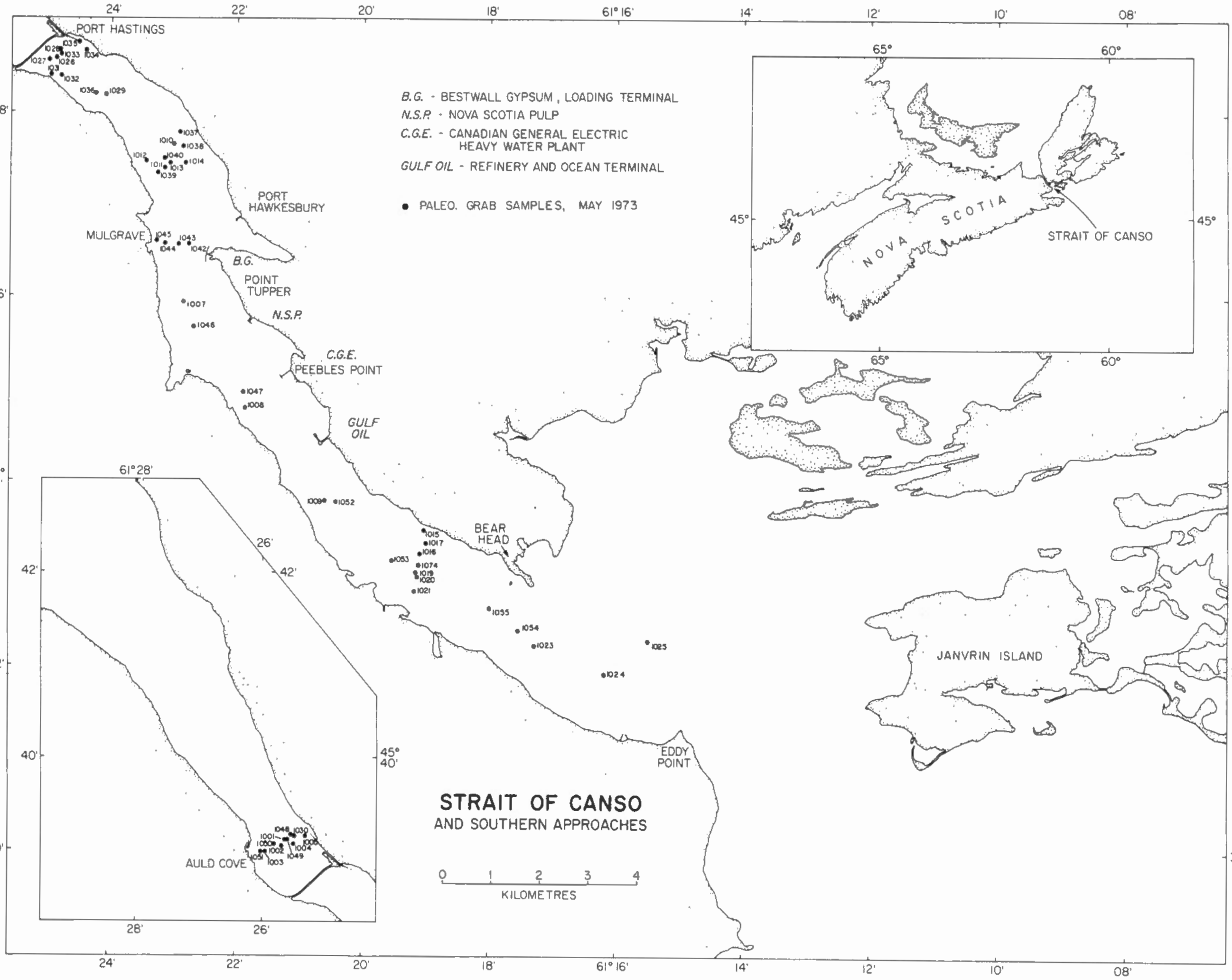


Figure 2. Paleontological grab samples in the Strait of Canso, May 1973.

MOLLUSCAN BIOTOPES

Cluster analysis was employed to determine molluscan biotopes. Presence-or-absence species data were analyzed using the Jaccards coefficient of association (Bonham-Carter, 1967). The dendogram, produced by the unweighted pair-group method, showed 6 major groupings at the 0.1 level of similarity. Only species from the grab samples were used, but because of limitations of the program, the analysis was confined to 76 species from 83 stations. Assemblages from the remainder of the stations were assigned to a biotope by comparing them with the computer-derived groupings. The species' groupings on which the biotopes are based are presented in Table 4 and their geographic expression is shown in Figure 7.

Biotope A is characterized by 24 species of which 4 are restricted to the biotope. Dominant species are defined here as those present at 50 per cent or more of the stations within the biotopes. The dominant species for Biotope A are *Cerastoderma pinnulatum* and *Mytilus edulis*. This biotope has its greatest areal extent in area IIA, with minor occurrences in areas I and IIB.

Only 6 species are delimited for Biotope B with three of them being dominant. *Oenopota incisula* occurs at 50 per cent of the stations and *Macoma balthica* and *Cylichna alba* each at 66 per cent. Biotope B is confined to the channel at depths below 38, and extends from the southern part of area IIB into area III.

The most widespread biotope is C, and it includes 63 species, 28 of which are apparently confined to the biotope. *Modiolus modiolus* is the dominant species here, and it is also dominant in Biotope D in conjunction with *Anomia simplex*. This latter biotope is confined primarily to the western side of the Strait in areas IIA and IIB. There is one small area north of, and adjacent to, the causeway. Twelve species comprise Biotope D with *Thais lamellosa* apparently confined to the biotope. Biotope E has 11 species, with one, *Musculus corrugatus*, found in no other biotope. The dominant species here is *Tellina agilis*. In area I this biotope shows considerable areal extent, particularly away from the causeway, but south of the cuaseway it is represented only in Bear Cove in area III. Closer to the causeway on the north, Biotope F is the major biotope and it is represented also in Inhabitants Bay (area III). Twenty-five species

TABLE 1. Distribution of molluscan species by area and comparison of grab, dredge, diver-collected and core samples.

Species	Grab Samples					Dredge Samples					Diver Samples					Core Samples				
Area	I	IIA	IIB	III	IV	I	IIA	IIB	III	IV	I	IIA	IIB	III	IV	I	IIA	IIB	III	IV
1. *Cingula aculeus* (Gould)	*															x		x		
2. *Crepidula fornicata* (Linné)	*										*									
3. *Lunatia pallida* (Broderip & Sowerby)	*							x												
4. *Lunatia triseriata* (Say)	*																			
5. *Mitrella lunata* (Say)	*																			
6. *Odostomia trifida* Totten	*																			
7. *Ovatella myosotis* Draparnaud	*																x			
8. *Yoldia limatula* (Say)	*																			
9. *Ensis directus* (Conrad)	*x																			
10. *Yoldiella fraterna* (Verrill & Bush)	x																			
11. *Mya arenaria* Linné	*x	*x	*																	
12. *Mysella planulata* (Stimpson)	*x	x	*x													x				
13. *Macoma balthica* (Linné)	*x	*x	*x	*x												x	x	x		
14. *Bittium alternatum* Say	*	x	*x	*x														x		
15. *Mytilus edulis* Linné	*	x	*x	*x												x	x	x		
16. *Yoldia sapotilla* Gould	*x	*	*	*		*x														
17. *Clinocardium ciliatum* (Fabricius)	*x	x	x	*x												x	x	x		
18. *Anomia simplex* d'Orbigny	x	x	x	x		x		x								x	x	x		
19. *Cerastoderma pinnulatum* (Conrad)	*x	*x	*x	*x	*x	*x		*x								x	x	x		x
20. *Modiolus modiolus* (Linné)	*x	*x	*x	*x	*x	*x		*x								x	x	x		x
21. *Hiatella arctica* (Linné)	*x	*x	*x	*x	*x	*		x			*					x	x	x		x
22. *Astarte undata* Gould	*	*x	*x	*x	x	x		x								x	x	x		x
23. *Acmaea testudinalis* (Müller)	*	*	*x	*x	*	*														
24. *Nassarius trivittatus* (Say)	*x	x	*	*x	*	*					*					x		x		
25. *Moelleria costulata* (Möller)	*	*	*x	*	*											x	x	x		
26. *Tellina agilis* Stimpson	*x		*x		*											x	x	x		
27. *Yoldiella inconspicua* Verrill & Bush	*x		*	*x												x				
28. *Cylichna alba* Brown	x		*x	*x													x			
29. *Littorina littorea* Linné	*		*x	*		*					*							x		
30. *Turbonilla interrupta* Totten	*		*x	*		*					*x					x	x	x		
31. *Cerastoderma echinatum* (Linné)	*x		*x													x		x		
32. *Gemma gemma* (Totten)	*x			*																
33. *Retusa canaliculata* (Say)	*			*x													x			
34. *Pitar morrhuana* (Linsley)	*			x							*x					x				
35. *Turritellopsis acicula* (Stimpson)	x			*																x
36. *Velutina undata* Brown	*				*															
37. *Trichotropis borealis* Broderip & Sowerby		*																		
38. *Colus* sp.		x																		
39. *Mercenaria mercenaria* (Linné)		x																		
40. *Thais lapillus* (Linné)		x																		
41. *Oenopota pyramidalis* (Strøm)		*	x																	
42. *Oenopota incisula* (Verrill)		*x	*	*																
43. *Mya truncata* Linné		*x	x	*x													x			
44. *Crenella decussata* Montagu		x	*	*x		x										x	x	x		x
45. *Crenella glandula* Totten		x	x	*x																
46. *Cyclocardia borealis* (Conrad)		x	x	x														x		
47. *Oenopota turricula* (Montagu)		*	*x	*x	x			*												x
48. *Thyasira equalis* (Verrill & Bush)		x	*	*x	*															
49. *Anomia aculeata* Müller		x	x		x	x										x		x		
50. *Turtonia minuta* (Fabricius)		*		x														x		
51. *Tachyrhynchus erosus* (Couthouy)		x		*x																
52. *Littorina saxatilis* (Olivi)		x		*												x				
53. *Admete couthouyi* Jay			*																	
54. *Musculus corrugatus* (Stimpson)			*																	
55. *Pyramidella fusca* C.B. Adams			*															x		
56. *Oenopota bicarinata* (Couthouy)			*															x		
57. *Puncturella noachina* (Linné)			*					*										x		
58. *Lepeta caeca* (Müller)			*																	
59. *Thracia septentrionalis* Jeffreys			*																	
60. *Anomia aculeata ephippium* Linné			x													x		x		
61. *Astarte striata* (Leach)			x															x		
62. *Chlamys islandicus* (Müller)			x													x		x		
63. *Arctica islandica* (Linné)			*	*x																
64. *Nucula delphinodonta* Mighels & Adams			*x	*x																
65. *Thyasira ferruginosa* (Forbes)			*x	*x																
66. *Cyclopecten vitreus* (Gmelin)			*x	x												x				
67. *Cingula castanea* (Möller)			*	*												x				

Table 1 (cont.)

Species	Area	Grab Samples					Dredge Samples					Diver Samples					Core Samples				
		I	IIA	IIB	III	IV	I	IIA	IIB	III	IV	I	IIA	IIB	III	IV	I	IIA	IIB	III	IV
68. *Hydrobia minuta* (Totten)				*	*													x			
69. *Natica clausa* Broderip & Sowerby				x	*x																
70. *Lacuna vincta* (Montagu)				*		x															
71. *Placopecten magellanicus* (Gmelin)				x		x			x			*							x		
72. *Nucula tenuis* (Montagu)					*x												x	x			x
73. *Thyasira gouldi* (Philippi)					*x																
74. *Crassostrea virginica* (Gmelin)					x														x		
75. *Yoldia myalis* Couthouy					x																
76. *Alvania janmayeni* (Friele)					*	*															
77. *Nuculana minuta* (Fabricius)								*x													
78. *Buccinum ciliatum* (Fabricius)									*												
79. *Neptunea despecta tornata* (Gould)									x												
80. *Urosalpinx cinerea* (Say)									*x												
81. *Lunatia heros* (Say)												*									
82. ?*Cerithiopsis* sp.																	x				
83. *Odostomia seminuda* C. B. Adams																	x				
84. *Cumingia tellinoides* (Conrad)																	x	x			
85. *Macoma calcarea* (Gmelin)																		x			
86. *Kellia suborbicularis* (Montagu)																		x			
87. *Spisula polynyma* (Stimpson)																		x			
88. *Spiratella lesueri* d'Orbigny?																		x			
89. *Diplodonta punctata* (Say)																		x			
90. *Thracia conradi* Couthouy																		x			
91. ?*Emarginula* sp.																		x			
92. *Chione cancellata* (Linné)																		x			
93. *Rimula frenulata* Dall																		x			
94. *Skenea planorbis* (Fabricius)																			x		x
95. *Acteocina* sp.																					x
No. of species (living only)		18	7	18	11	8		4	3		5										
No. of species (dead only)		4	16	12	7	5		4	6												
No. of species (living and dead)		14	8	19	25	2		4	3		2										
Total no. of species		36	31	49	43	15		12	12		7						28	28	29		10
Per cent dead species		11	52	24	16	33															
Per cent living only		50	23	37	26	53		33	25		71										

* - Living

x - Dead

TABLE 2

North of Causeway (Area I)		South of Causeway (Area IIA)	
Living	Dead Only	Living	Dead Only
		Mya truncata	
		Oenopota incisula	
		Oenopota pyramidalis	
		Oenopota turricula	
		Trichotropis borealis	
		Turtonia minuta	
Cerastoderma echinatum			
Cingula aculeus			
Crepidula fornicata			
Ensis directus			
Gemma gemma			
Littorina littorea			
Lunatia pallida			
Lunatia triseriata			
Mitrella lunata			
Odostomia trifida			
Ovatella myosotis			
Pitar morrhuana			
Retusa canaliculata			
Tellina agilis			
Turbonilla interrupta			
Velutina undata			
Yoldia limatula			
Yoldiella inconspicua			
Acmaea testudinalis		*Acmaea testudinalis*	
Astarte undata		*Astarte undata*	
Cerastoderma pinnulatum		*Cerastoderma pinnulatum*	
Hiatella arctica		*Hiatella arctica*	
Macoma balthica		*Macoma balthica*	
Modiolus modiolus		*Modiolus modiolus*	
Moelleria costulata		*Moelleria costulata*	
Mya arenaria		*Mya arenaria*	
Yoldia sapotilla		*Yoldia sapotilla*	
Bittium alternatum			*Bittium alternatum*
Clinocardium ciliatum			*Clinocardium ciliatum*
Mysella planulata			*Mysella planulata*
Mytilus edulis			*Mytilus edulis*
Nassarius trivittatus			*Nassarius trivittatus*
	Anomia simplex		*Anomia simplex*
	Cylichna alba		
	Turritellopsis acicula		
	Yoldiella fraterna		
			Anomia aculeata
			Colus sp.
			Crenella decussata
			Crenella glandula
			Cyclocardia borealis
			Littorina saxatilis
			Mercenaria mercenaria
			Tachyrhynchus erosus
			Thais lapillus
			Thyasira equalis
Living species X100 / Total species	89%		48%

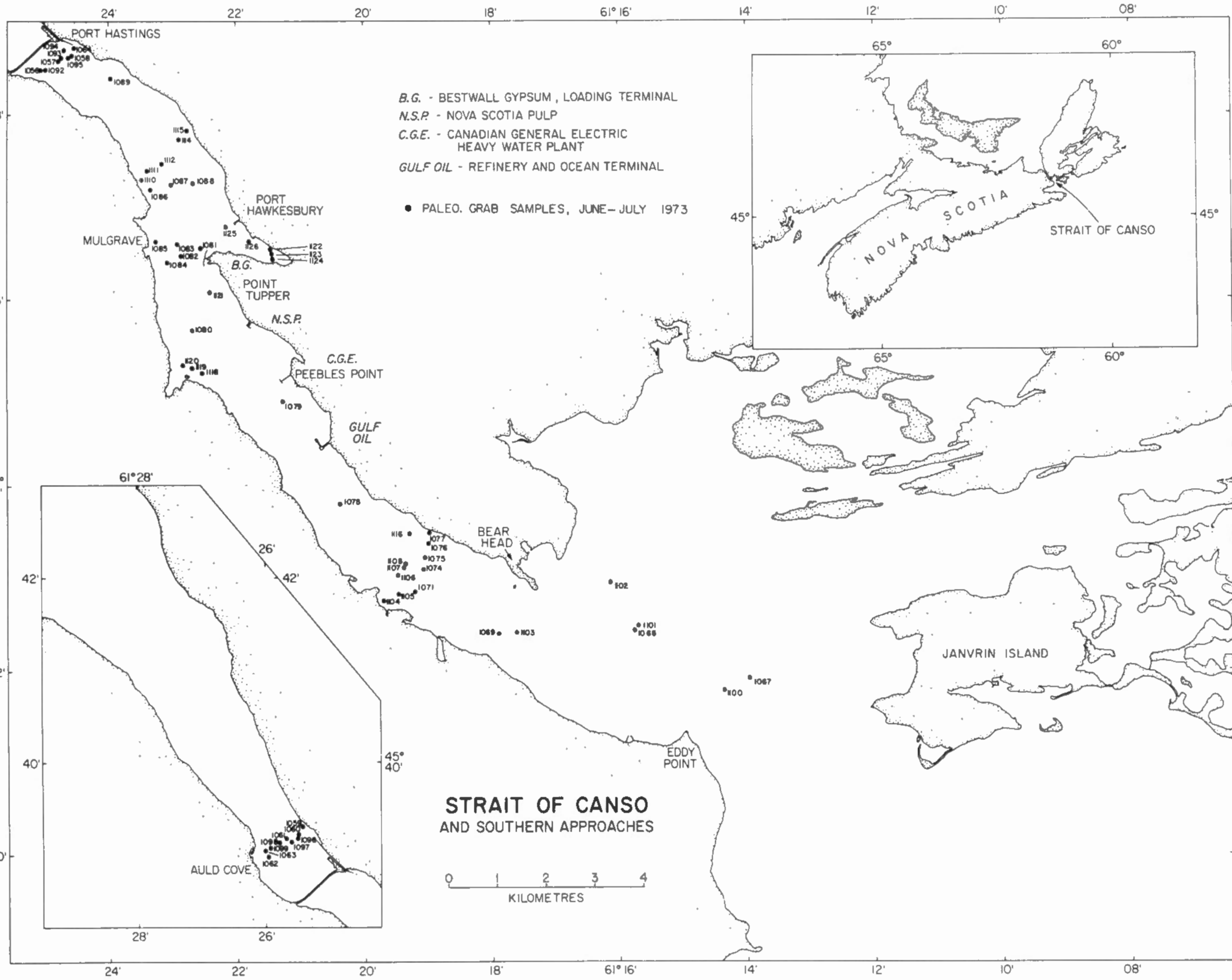


Figure 3. Paleontological grab samples in the Strait of Canso, June and July, 1973.

are characteristic, seven of which are restricted to the biotope. The dominant species are *Yoldia sapotilla* and *Yoldiella inconspicua*.

A comparison of the most common species in each biotope is presented in Table 5. The dominant species, i. e. those present at 50 per cent or more of the stations in each biotope, are listed above the centre line in order of abundance. Those species below the line occurred at 25 to 49 per cent of the stations.

A major feature of the Strait is the barren zone shown by the shaded areas in Figure 7. In area IIA the zone apparently follows the channel, but is much more widespread in area IIB where the main influence is probably related to industrialization along the eastern shore of the Strait. Another barren zone extends from the outer part of area III into area IV. This latter zone is based on samples from only one station between Eddy Point and Rabbit Island, and a line of seven stations between Cape Argos and Janvrin Island; therefore, it may not be nearly so extensive as conjectured. Empty shells found in parts of the barren zone were species corresponding to those of adjacent biotopes. In Figure 7 these areas are indicated by zero followed by the letter of the appropriate biotope in parentheses, e. g. O (A), superimposed on the shaded area.

CORE ANALYSIS

Examination of the core samples in the light of the biotopes established for the grab sample collections indicates the presence at depth of assemblages referable to biotopes A, B, C, D and E. Figure 8 shows the locations of the core stations, and Figure 9 presents a reconstruction of subsurface conditions based on 22 of the cores.

Biotope D is present beneath George Bay and the northern part of the Strait where it forms a persistent zone at a depth in the core between 18 and 30 cm. It apparently dies out about 4 km north of the causeway. The thickness of this zone varies between 5 and 10 cm. It is overlain and underlain by sediments characterized by species of Biotope C. Closer to the causeway the upper 10 to 25 cm of the cores are generally barren of molluscs. However, in cores 1160 and 1161 close to the causeway a wedge of Biotope C, 8 to 10 cm thick,

TABLE 3

AREA IIA		AREA IIB	
Living[1]	Dead Only	Living[1]	Dead Only
		Admete couthouyi	
		Arctica islandica	
		Cerastoderma echinatum	
		Cingula castanea	
		*Cyclocardium vitreus	
		Cylichna alba	
		*Hydrobia minuta	
		*Lacuna vincta	
		Lepeta caeca	
		Littorina littorea	
		Musculus corrugatus	
		*Nucula delphinodonta	
		Oenopota bicarinata	
		*Puncturella noachina	
		*Pyramidella fusca	
		Tellina agilis	
		Thracia septentrionalis	
		Thyasira ferruginosa	
		Turbonilla interrupta	
		Yoldiella inconspicua	
Trichotropis borealis			
Turtonia minuta			
Acamaea testudinalis		*Acmaea testudinalis	
Astarte undata		*Astarte undata	
Cerastoderma pinnulatum		*Cerastoderma pinnulatum	
Hiatella arctica		*Hiatella arctica	
Macoma balthica		*Macoma balthica	
Modiolus modiolus		*Modiolus modiolus	
Moelleria costulata		*Moelleria costulata	
Mya arenaria		Mya arenaria	
Oenopota incisula		*Oenopota incisula	
Oenopota turricula		*Oenopota turricula	
Yoldia sapotilla		Yoldia sapotilla	
Mya truncata			*Mya truncata
Oenopota pyramidalis			Oenopota pyramidalis
	Bittium alternatum	Bittium alternatum	
	Crenella decussata	Crenella decussata	
	Mysella planulata	*Mysella planulata	
	Mytilus edulis	*Mytilus edulis	
	Nassarius trivittatus	*Nassarius trivittatus	
	Thyasira equalis	Thyasira equalis	
	Anomia aculeata		Anomia aculeata
	Anomia simplex		*Anomia simplex
	Clinocardium ciliatum		Clinocardium ciliatum
	Crenella glandula		Crenella glandula
	Cyclocardia borealis		*Cyclocardia borealis
	Colus sp.		
	Littorina saxatilis		
	Mercenaria mercenaria		
	Thais lapillus		
	Tachyrhynchus erosus		
			Anomia aculeata ephippium
			*Astarte striata
			Chlamys islandicus
			Natica clausa
			Placopecten magellanicus

[1] Also found dead at many stations.

* Present in the industrialized area.

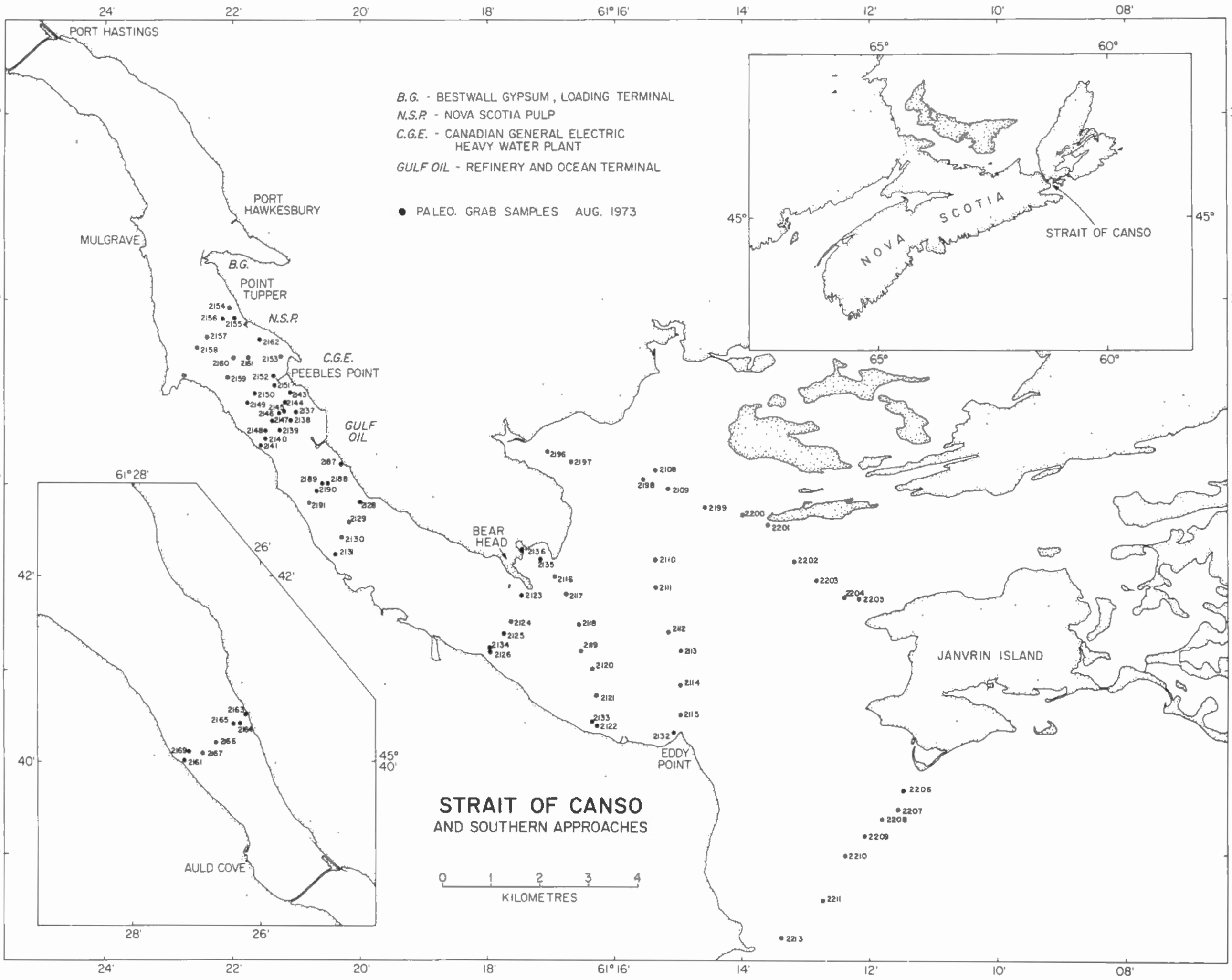


Figure 4. Paleontological grab samples in the Strait of Canso, August 1973.

occurs in the upper part of the barren zone. The barren zone is indicated by O in Figure 9. Most cores north of the causeway penetrated Biotope C below the barren zone.

Immediately south of the causeway the barren zone at the tops of the cores is between 15 and 20 cm thick. However, in core 2016B, Biotope A lies between the barren zone and the underlying Biotope C, and in core 2015 the succession below the barren zone is Biotope D, over Biotope A, over Biotope C. This marks the only occurrence of Biotope D south of the causeway. Two cores, 1146 and 3100, taken in the vicinity of Port Hawkesbury, are barren to a depth of about 35 cm. Core 1146 ends in Biotope C, but in core 3100, Biotope E underlies Biotope C at a depth of about 60 cm. Elsewhere throughout the Strait and into Chedabucto Bay the top of the core reflects the sea-floor situation, and the whole area apparently is underlain by Biotope C with barren zones interspersed.

Fifty-six molluscan species have been identified from the cores, and of these, 14 species are unique to the cores (*see* Table 1). Six of these 14 unique species are of particular interest because they suggest more southern affinities. Geographic ranges of all species identified from the Canso area are given in Table 6. The species are illustrated in Plates I to VII.

Kellia suborbicularis, from a depth of 20 cm in core 1146 (area IIA), is a pelecypod which has not been found living north of New England. It was the sole species present in the sample, and was represented by one single valve. Core 1146 was taken just off Port Hawkesbury. Because of the fresh appearance of the shell, its occurrence in the midst of a barren zone and the location of the core site in the harbour area, the shell's presence may well be adventitious. Core 3100, taken in close proximity to core 1146, contained *?Diplodonta punctata* at a depth of 70 cm. This species has a present northern limit in the vicinity of North Carolina, and it occurred in association with *Tellina agilis*, the index species for Biotope E. Only single valves of the two pelecypod species were found and preservation of *D. punctata* was such as to preclude positive identification.

Core 3118, taken near the southern end of Canso Strait, has yielded three apparently exotic species. A single worn gastropod, tentatively identified as

TABLE 4

Species on which biotopes are based

SPECIES	BIOTOPES					
	A	B	C	D	E	F
Cerastoderma pinnulatum (Conrad)	50	–	42	13	29	40
Mytilus edulis Linné	50	33	5	50	–	–
Oenopota turricula (Montagu)	44	–	5	–	–	–
Mya truncata Linné	39	–	7	–	–	–
Clinocardium ciliatum (Fabricius)	22	–	8	–	–	–
Macoma balthica (Linné)	22	66	15	13	–	5
Modiolus modiolus (Linné)	22	33	63	63	43	25
Anomia simplex d'Orbigny	16	–	10	63	–	5
Crenella glandula Totten	11	–	6	–	–	10
Hiatella arctica (Linné)	11	–	23	–	–	–
Thais lapillus (Linné)	11	–	–	13	–	–
Anomia aculeata Müller	5	–	6	–	–	–
Colus sp.	5	–	–	–	–	–
Littorina saxatilis (Olivi)	5	–	2	–	–	–
Mercenaria mercenaria (Linné)	5	–	–	–	–	–
Moelleria costulata (Möller)	5	–	7	–	–	–
Mysella planulata (Stimpson)	5	16	1	25	–	10
Nassarius trivittatus (Say)	5	–	16	–	–	5
Nucula delphinodonta Mighels & Adams	5	–	9	–	–	25
Retusa canaliculata (Say)	5	–	3	–	–	10
Tachyrhynchus erosus (Couthouy)	5	–	–	–	–	–
Trichotropis borealis Broderip & Sowerby	5	–	–	–	–	–
Turtonia minuta (Fabricius)	5	–	1	–	–	–
Yoldia sapotilla Gould	5	–	6	–	–	60
Cyclichna alba Brown	–	66	3	–	–	25
Oenopota incisula (Verrill)	–	50	9	–	–	–
Astarte undata Gould	–	–	27	25	–	5
Thyasira equalis (Verrill & Bush)	–	–	10	13	–	5
Crenella decussata (Montagu)	–	–	9	–	–	10
Acmaea testudinalis (Müller)	–	–	8	13	–	–
Thyasira ferruginosa (Forbes)	–	–	7	–	–	15
Bittium alternatum Say	–	–	6	–	–	–
Littorina littorea Linné	–	–	6	–	29	–
Arctica islandica (Linné)	–	–	5	–	–	10
Cyclocardia borealis (Conrad)	–	–	5	–	–	–
Cyclopecten vitreus (Gmelin)	–	–	5	–	–	–
Puncturella noachina (Linné)	–	–	5	–	–	–
Yoldiella inconspicua Verrill & Bush	–	–	5	13	43	55
Gemma gemma (Totten)	–	–	3	–	–	–
Mya arenaria Linné	–	–	3	–	–	–
Alvania janmayeni (Friele)	–	–	3	13	14	–
Anomia aculeata ephippium Linné	–	–	2	–	–	–
Astarte striata (Leach)	–	–	2	–	–	–
Cerastoderma echinatum (Linné)	–	–	2	–	–	–
Cingula aculeus (Gould)	–	–	2	–	–	10
Hydrobia minuta (Totten)	–	–	2	–	–	–
Lacuna vincta (Montagu)	–	–	2	–	14	–
Oenopota pyramidalis (Strøm)	–	–	2	–	14	–
Placopecten magellanicus (Gmelin)	–	–	2	–	–	–
Tellina agilis Stimpson	–	–	2	–	–	–
Turbonilla interrupta Totten	–	–	2	–	14	–
Velutina undata Brown	–	–	2	–	–	–
Admete couthouyi Jay	–	–	1	–	–	–
Chlamys islandicus (Müller)	–	–	1	–	–	–

Table 4 (cont'd)

SPECIES	BIOTOPES					
	A	B	C	D	E	F
Cingula castanea (Möller)	–	–	1	–	–	–
Crassostrea virginica (Gmelin)	–	–	1	–	–	–
Ensis directus (Conrad)	–	–	1	–	–	–
Lunatia triseriata (Say)	–	–	1	–	–	–
Lepeta caeca (Müller)	–	–	1	–	–	–
Natica clausa Broderip & Sowerby	–	–	1	–	–	–
Nucula tenuis (Montagu)	–	–	1	–	–	–
Ovatella myosotis Draparnaud	–	–	1	–	–	–
Oenopota bicarinata (Couthouy)	–	–	1	–	–	–
Pitar morrhuana (Linsley)	–	–	1	–	–	–
Pyramidella fusca C. B. Adams	–	–	1	–	–	–
Thracia septentrionalis Jeffreys	–	–	1	–	–	–
Thyasira gouldi (Philippi)	–	–	1	–	–	–
Turritellopsis sp.	–	–	1	–	–	–
Musculus corrugatus (Stimpson)	–	–	–	–	14	–
Crepidula fornicata (Linné)	–	–	–	–	–	5
Lunatia pallida (Broderip & Sowerby)	–	–	–	–	–	5
Mitrella lunata (Say)	–	–	–	–	–	5
Odostomia trifida Totten	–	–	–	–	–	5
Yoldia limatula (Say)	–	–	–	–	–	5
Yoldia myalis Couthouy	–	–	–	–	–	5
Yoldiella fraterna (Verrill & Bush)	–	–	–	–	–	5

Numbers indicate the percentage of stations within the biotope at which each species occurs.

TABLE 5

Most common species in each biotope

A	B	C	D	E	F	
Cerastoderma pinnulatum *Mytilus edulis*	*Cyclichna alba* *Macoma balthica* *Oenopota incisula*	*Modiolus modiolus*	*Anomia simplex* *Modiolus modiolus* *Mytilus edulis*	*Tellina agilis*	*Yoldia sapotilla* *Yoldiella inconspicua*	Present at 50% or more of the stations
Oenopota turricula *Mya truncata*	*Modiolus modiolus* *Mytilus edulis*	*Cerastoderma pinnulatum* *Astarte undata*	*Astarte undata* *Mysella planulata*	*Modiolus modiolus* *Yoldiella inconspicua* *Acmaea testudinalis* *Littorina littorea*	*Cerastoderma pinnulatum* *Cyclichna alba* *Modiolus modiolus* *Nucula delphinodonta*	Present at between 25 and 49% of the stations

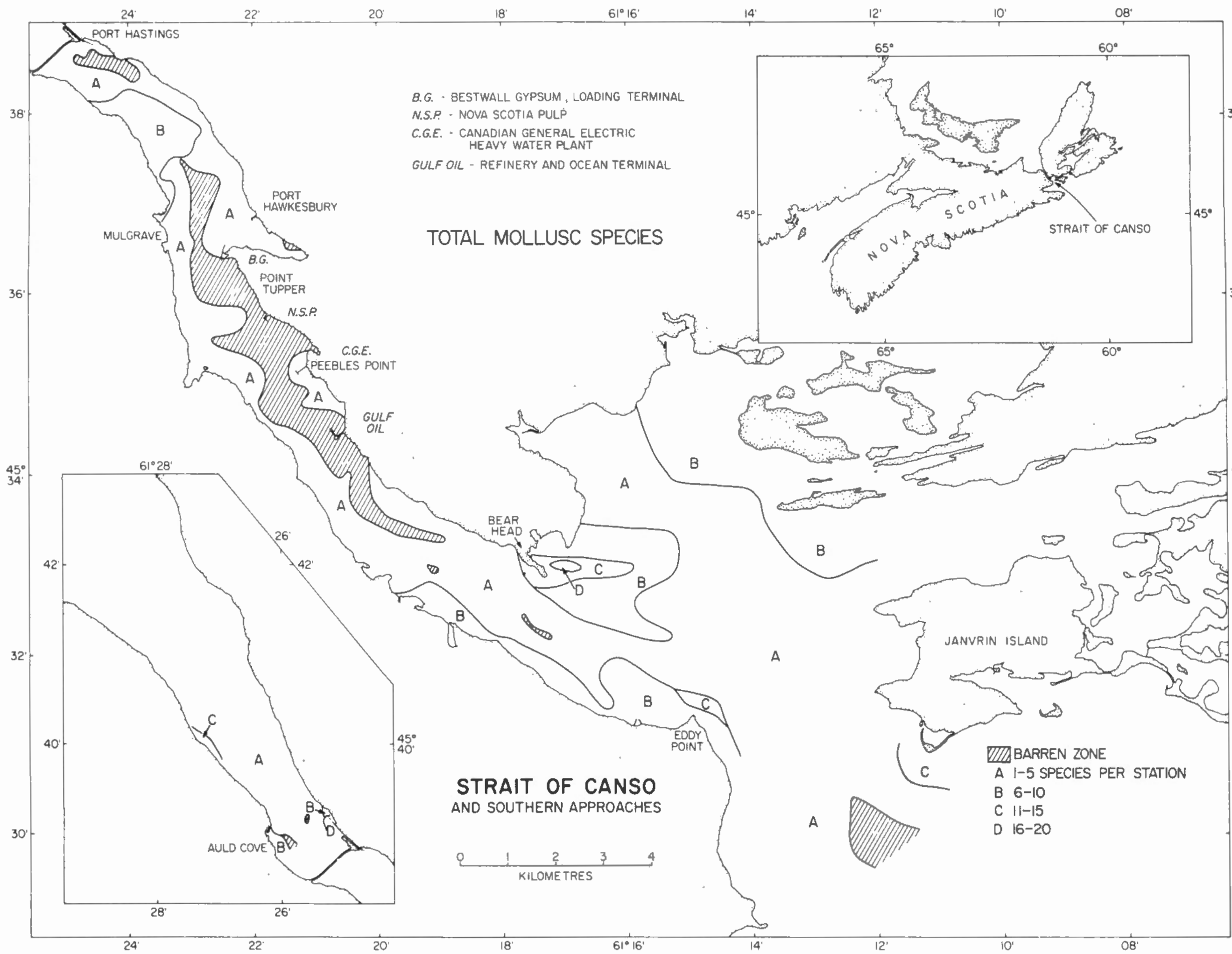


Figure 5. Distribution of the total molluscan species (living plus dead) based on the number of species per station.

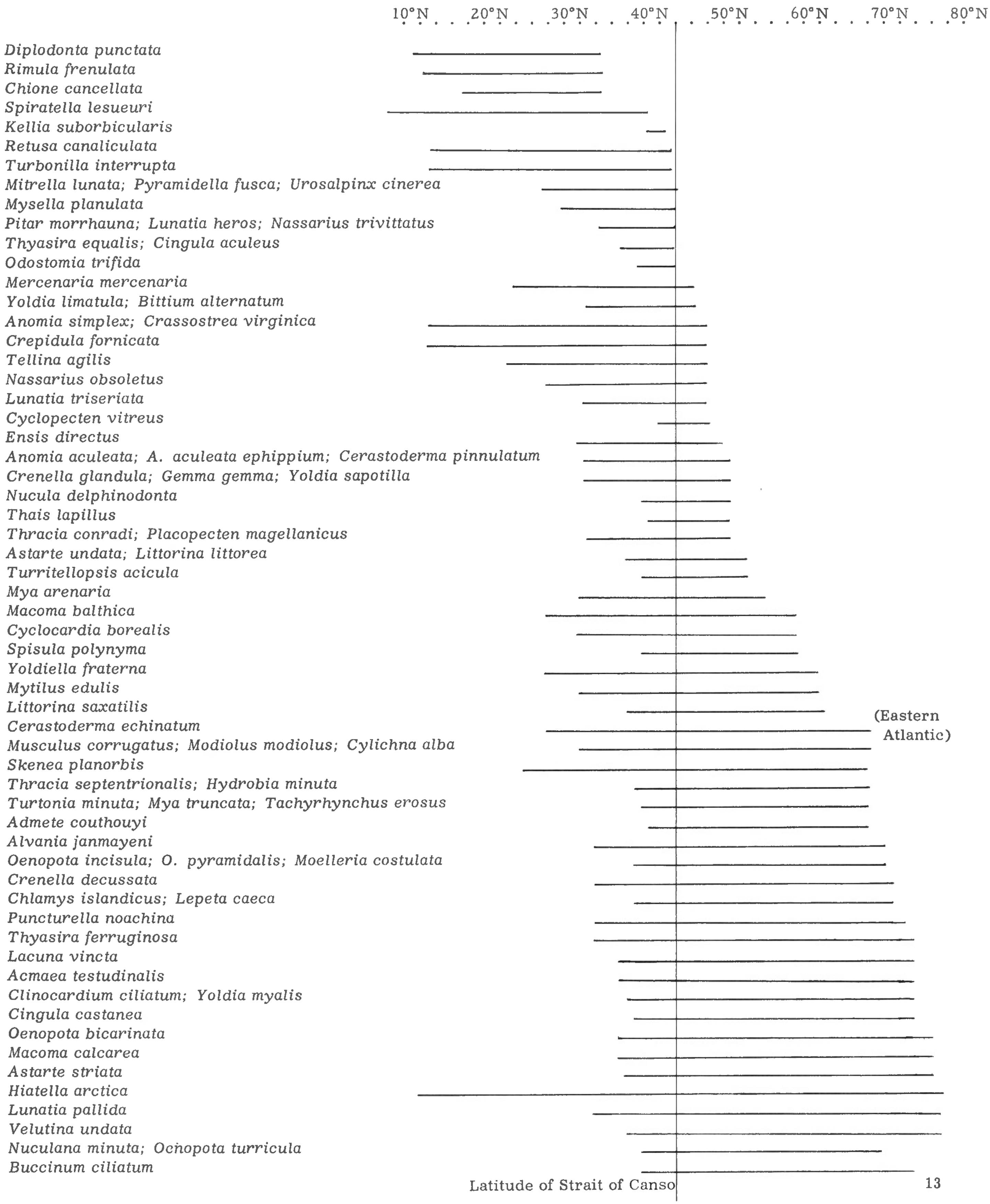
Emarginula sp., was found at a depth of 20 cm in conjunction with 7 species common to the Strait of Canso area at present. *Emarginula* is a southern genus, not occurring north of North Carolina, and 4 of the 7 species with which it was found have southern limits of range north of that state. A fragment of a pelecypod thought to be *Chione concellata* and an unbroken gastropod tentatively identified as *Rimula frenulata* occurred at a depth of 30 cm in the core. The northern limit of range of these species is also North Carolina, and they were associated in the core with 8 species, of which 3 do not range as far south as North Carolina. Two of these more northern species occurred as complete specimens, whereas all other specimens showed evidence of reworking.

Five specimens of the pteropod, *Spiratella lesueuri*, were found at a depth of 56 cm in core 2106B in close proximity to the causeway. Pteropods are small pelagic gastropods that are very abundant in the open seas. They may be washed ashore occasionally but are found more commonly in bottom samples from the open ocean. *S. lesueuri* has a geographic range from Cape Cod, Massachusetts to Brazil (42°N lat. to 40°S lat.) and its presence at such a depth in the core with species characteristic of Biotope C is anomalous.

Shell fragments from till ridges on Janvrin Island have been dated at 34 000+ years B.P. (Grant, 1972, p. 46). No identifications were given and Grant stated that the enclosing till had been reworked by at least two younger ice movements and that the shells, therefore, might not date from the initial formation of the ridges. Without identifications any conclusion as to whether or not the fragments were incorporated from an earlier deposit (interglacial?) that could have been a source for these warmer water species is impossible. In southwestern Nova Scotia, shells dated at approximately 38 000 years B.P. are indicative of water temperatures similar to or slightly warmer (cf. Cape Cod area) than those prevailing in that area at present (Clarke, *et al.*, 1972). However, the 6 exotic species from the Canso cores are not common to the southwestern Nova Scotia assemblages, but indicate even warmer conditions. Because of the scarcity of these species, the uncertainty of their identification because of poor preservation, and their occurrence in the cores with, or above, species endemic to the Canso area, their true significance is in doubt.

TABLE 6

Present-day Ranges of Species Identified from Strait of Canso



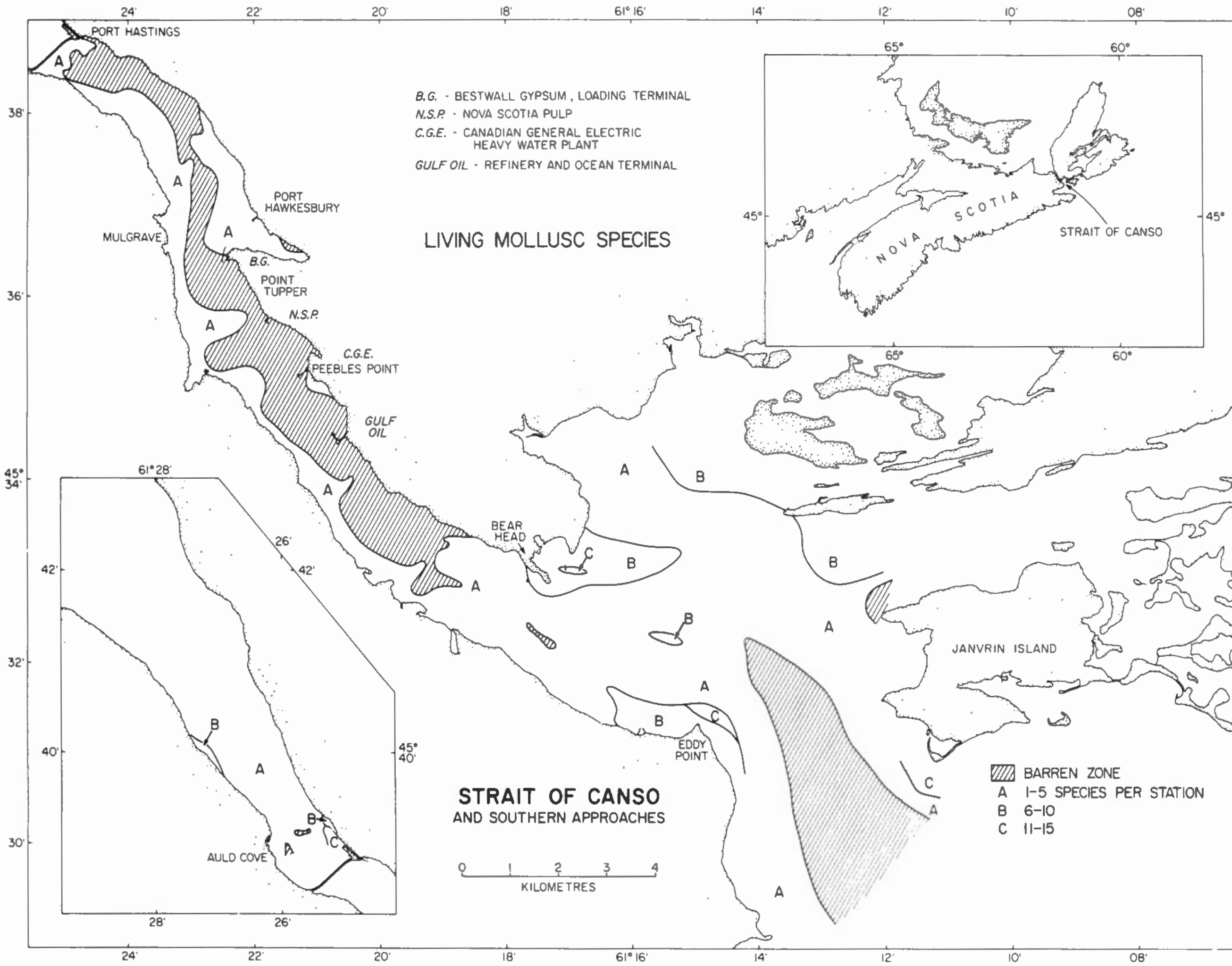


Figure 6. Distribution of the living molluscan species based on the number of species per station.

CONCLUSIONS

Sampling Methods

Various methods were used to obtain bottom samples including grab sampling, dredging and collection of shells by divers. Where depths are suitable for diving, bulk sampling by divers would probably give the best result. At Canso, the divers were able to collect some of the more mobile molluscs (e. g. scallops) that were missed by the grab and dredge. However, they confined their collecting to large, easily-seen species. For this project, the best over-all indication of the endemic species was obtained by grab sampling.

Effects of the Causeway

Prior to construction of the causeway, molluscan species had unimpeded movement throughout the area of the Strait. Although most molluscs spend their adult lives in very circumscribed areas, as larvae they are free-swimming and may be dispersed widely from their point of origin by waves and currents. Bottom sampling north and south of the causeway has shown that now there are marked differences in the fauna on either side of the barrier. North of the causeway (area I) 32 species were found to be living in the area, whereas south of the causeway (area IIA) only 15 species were noted alive. Eight species were common to both areas, but most of these were species ubiquitous throughout the whole study area. Immediately adjacent to the causeway to the north, 29 species (25 living + 4 dead) were recorded in contrast with 18 species (9 living + 9 dead) immediately south of the causeway. Six of the living species occurred on both sides of the causeway.

Cluster analysis also emphasizes the faunal differences on either side of, and adjacent to, the causeway (Fig. 7). To the north, Biotope F is predominant with small local expressions of Biotopes A and D (one station each). One station at the northern entrance to the canal was referred to Biotope C. Immediately south of the causeway Biotopes A and C are of about equal importance with 6 and 5 stations respectively. The one station with Biotope A north of the causeway adjoins

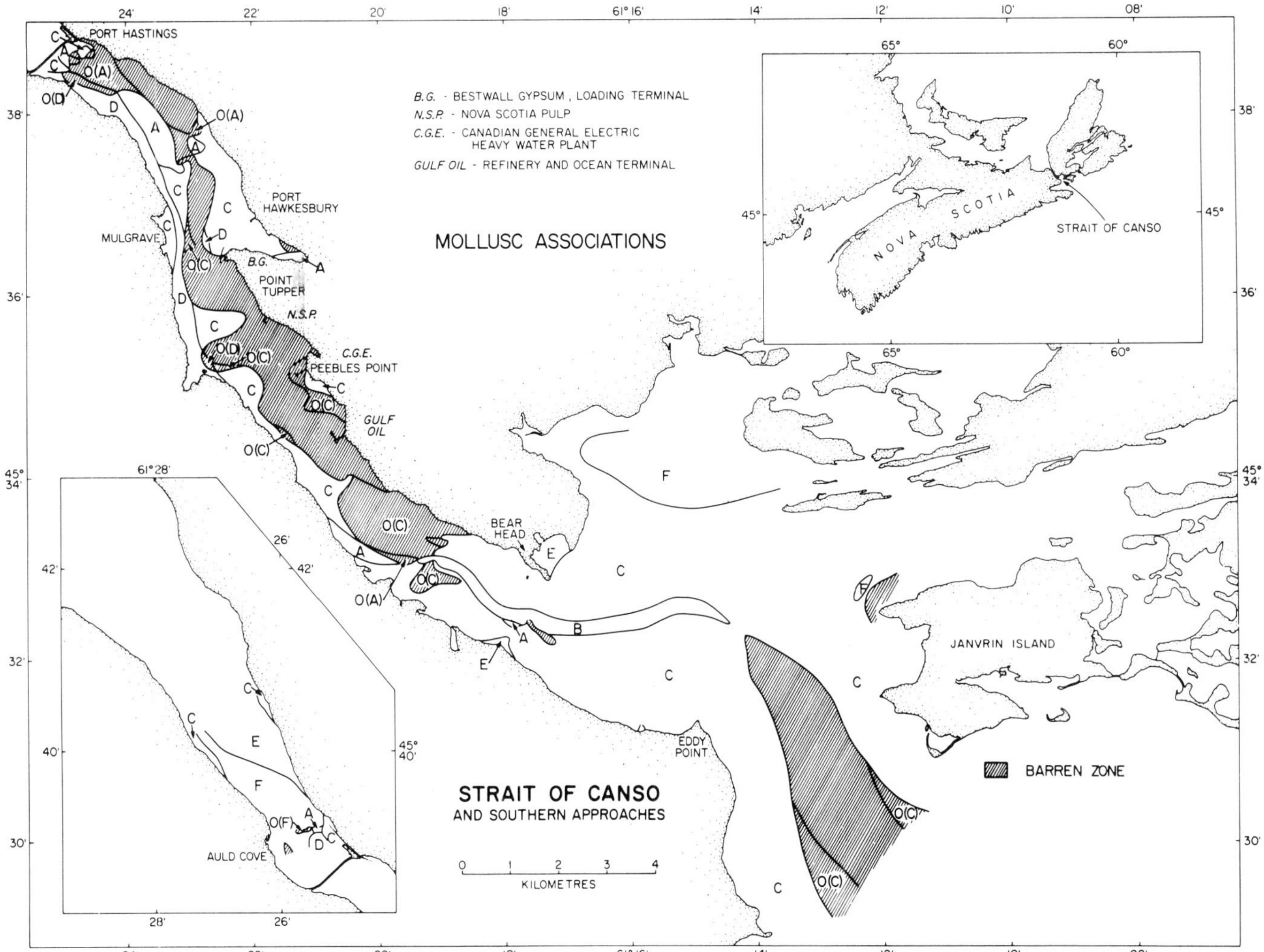


Figure 7. Molluscan biotopes in the Strait of Canso, derived by using the Jaccards coefficient of association (Bonham-Carter, 1967) at the 0.1 level of similarity.

the station with Biotope C in that area. Therefore, it would seem that there is some movement of species through the canal.

Cores taken to the north and south of the causeway reveal a barren zone varying in thickness from 10 to 25 cm at the tops of the cores (Fig. 9). Cores 1160 and 1161 show a thin wedge of Biotope C within the barren zone close to the causeway on the north. The barren zone persists to a distance of about 4 km north of the causeway, and in all cores obtained from this area, is everywhere underlain by Biotope C. Immediately south of the causeway, in core 2105 (west side of the Strait), wedges of Biotopes D and A come between the barren zone and the underlying Biotope C. On the east side of the Strait, Biotope D is missing, and in core 2106, Biotope A lies between the barren zone and Biotope C.

The presence of Biotope C at similar depths below the sediment-water interface on both sides of the causeway is proof of the uniformity of conditions prior to construction of the causeway. The condition of the upper 10 to 25 cm of the cores in the vicinity of the causeway gives evidence of the disruption of the bottom faunas caused by the construction, and the differences in present biotopes to the north and south show that conditions on either side of the causeway are now dissimilar.

Area of Industrialization

From Point Tupper south to within about 2.5 km of the southern end of the Strait the bottom sediments are characterized by an extensive zone barren of molluscs. Throughout this area, molluscan faunas are confined to a narrow band along the western side of the Strait with the exception of a small area in the vicinity of Peebles Point where a single complete specimen of *Hydrobia minuta* was collected from a depth of 3 m. *H. minuta* is a small gastropod that inhabits salt-marsh pools and it was probably fairly close to its point of origin where found. Between Point Tupper and the causeway the barren zone is confined primarily to the deeper waters of the channel and to a limited area immediately adjacent to Port Hawkesbury.

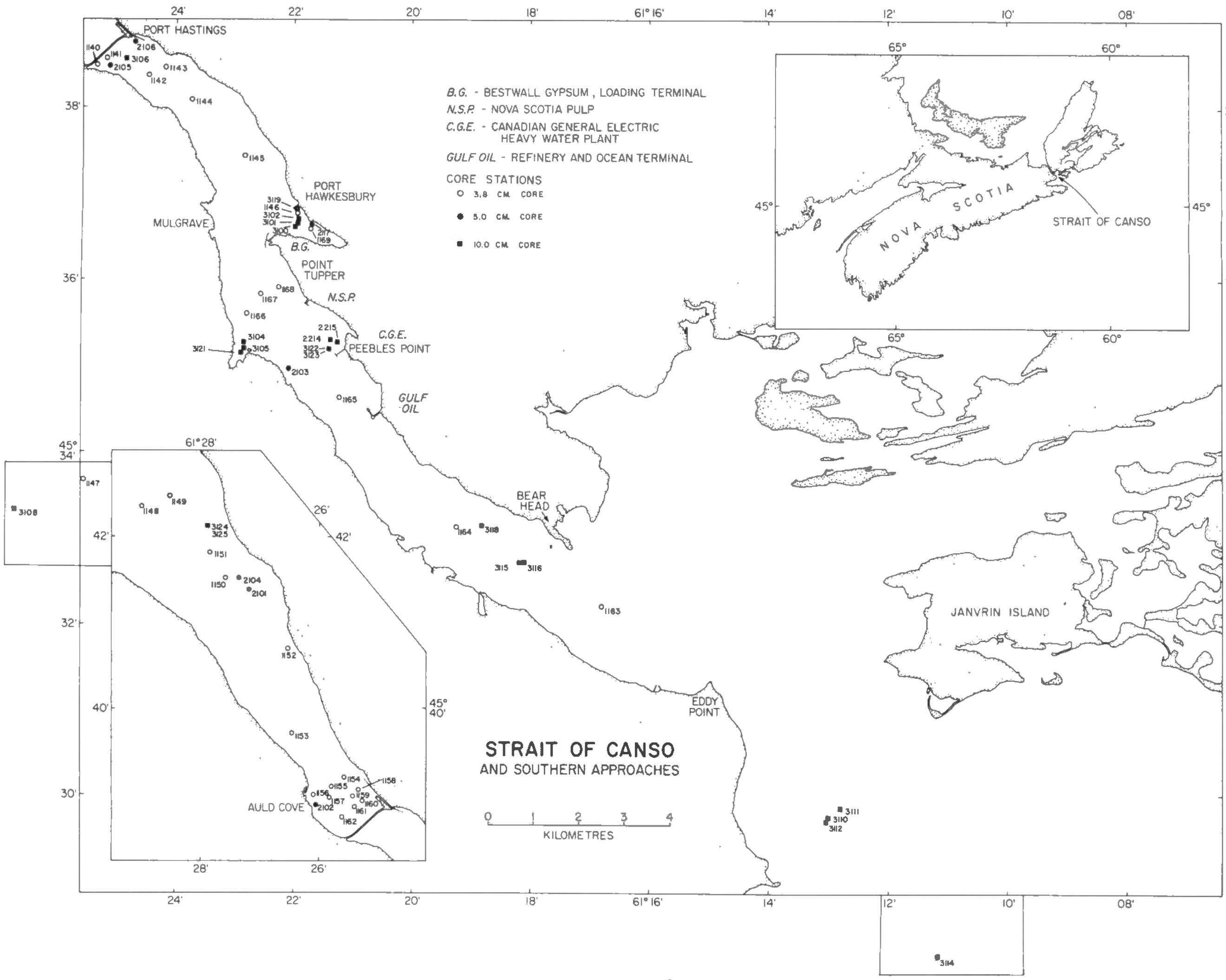


Figure 8. Core stations in the Strait of Canso, May to August, 1973.

Seaward from the barren zone normal molluscan communities are found across the width of the Strait and into Chedabucto Bay. The extensive barren zone shown between Eddy Point and Janvrin Island is probably more apparent than real and reflects the limited number of stations in that area.

Analysis of the cores shows that the entire area of the barren zone in the industrialized area is underlain by Biotope C and that the barren zone is confined to the upper 5 to 10 cm of the cores. Therefore, the elimination of the bottom fauna is a recent phenomenon and is probably directly attributable to industrial influences. North of Point Tupper the barren zone apparently reflects a dual cause - the effect of waters carried northward along the channel from the industrialized area, and the influence of the causeway construction. The barren zone thickens towards the causeway in this area. The cause of the several barren zones at greater depth in the cores is not known.

Exotic Species

The biotopes represented in the cores show that, during the time interval involved, conditions (depth, water temperature, salinity, etc.) were reasonably uniform. There is no suggestion of an earlier warmer period.

The few, different species could be identified only tentatively because of their minute size and/or fragmentary nature, but they definitely do not belong to the endemic fauna. They suggest waters much warmer than those of the area at present, and therefore would hint at a possible interglacial origin. The date of 34 000+ years B.P. for shell fragments found on Janvrin Island (Grant, 1972) is not finite and therefore those shells could date from pre-Wisconsin time. Grant did not list identifications, but perhaps the nature of the fragments precluded naming the species. The depth of the exotic species in the cores would tend to rule out their introduction into the area by ships arriving from southern waters.

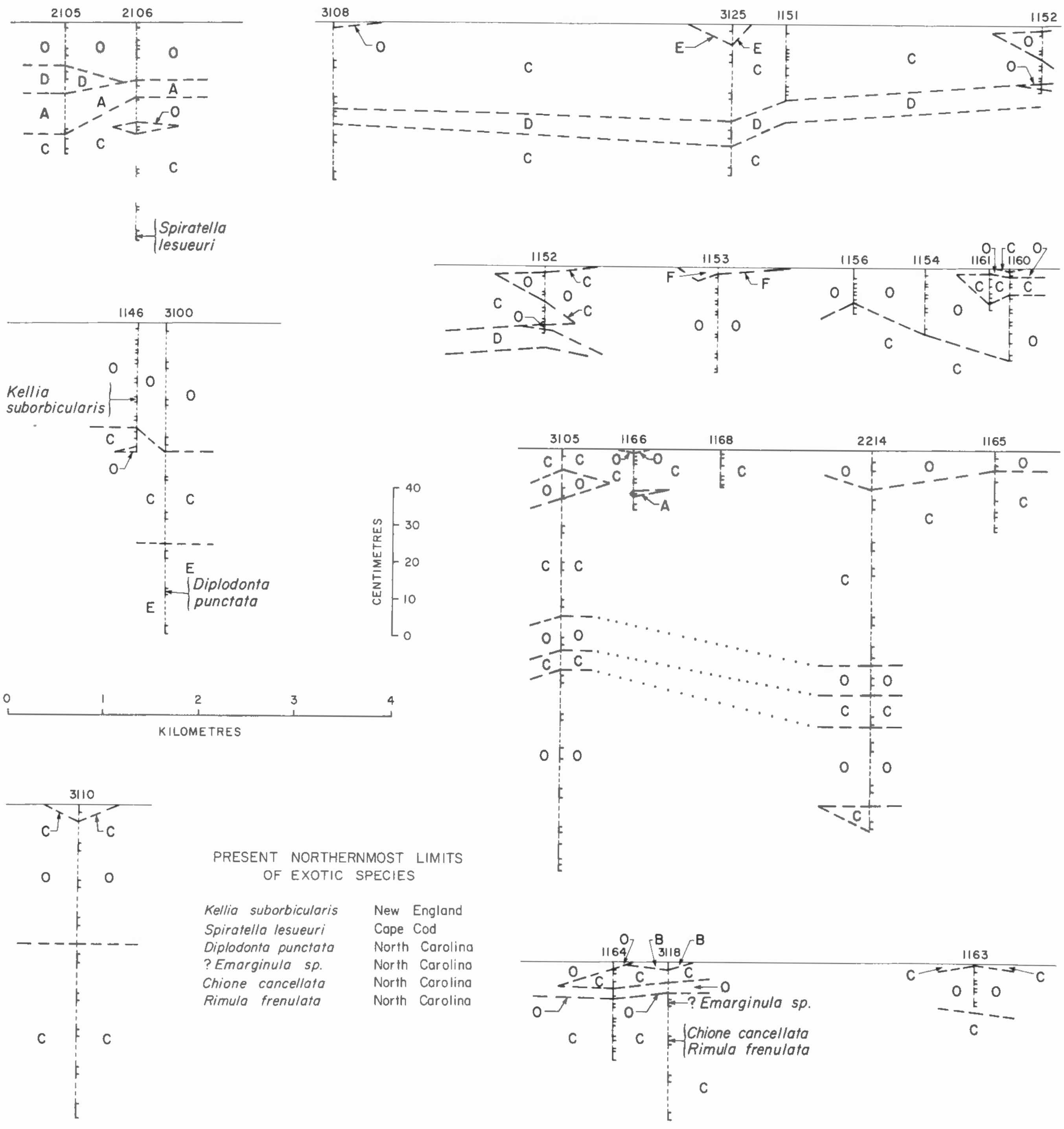


Figure 9. Subsurface distribution of surface molluscan biotopes.

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GASTROPODA

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Alvania janmayeni (Friele)
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Hydrobia minuta (Totten)
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Lacuna vincta (Montagu)
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= *Pleurotoma bicarinata* Couthouy, 1838, Boston J. Nat. Hist., v. 2, p. 104, pl. 1, fig. 11.

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Urosalpinx cinerea (Say)
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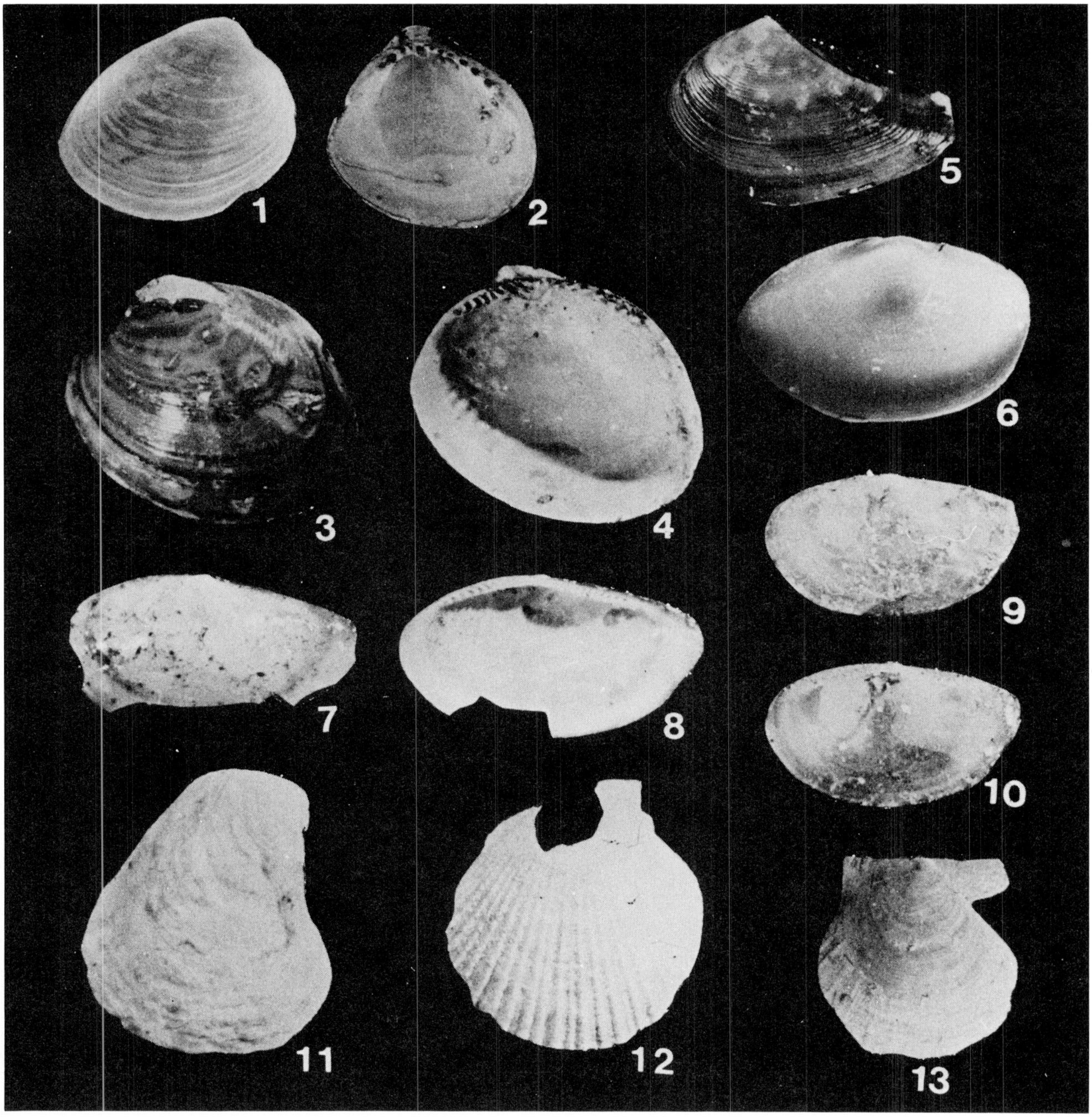

PLATE I — MOLLUSCA - PELECYPODA

Nuculidae, Nuculanidae, Ostreidae, Pectinidae

Figures 1, 2. *Nucula delphinodonta* Mighels & Adams. 1, exterior of left valve, X16, station 2108; 2, interior of left valve, X16, station 1105; hypotypes, GSC Nos. 40252 (fig. 1), 40253 (fig. 2).

Figures 3, 4. *Nucula tenuis* (Montagu). 3, exterior of right valve; 4, interior of left valve, X7, station 1055; hypotypes, GSC Nos. 40254 (fig. 3), 40254a (fig. 4).

Figure 5. *Nuculana minuta* (Fabricius). Exterior of left valve, X4, station 2104; hypotype, GSC No. 40255.

Figure 6. *Yoldiella inconspicua* Verrill & Bush. Exterior of right valve, X24, station 1005; hypotype, GSC No. 40256.

Figures 7, 8. *Yoldia limatula* (Say). 7, exterior of left valve; 8, interior of right valve, X4, station 1050; hypotypes, GSC Nos. 40257 (fig. 7), 40257a (fig. 8).

Figures 9, 10. *Yoldia sapotilla* Gould. 9, exterior of left valve; 10, interior of right valve, X4, station 1001; hypotypes, GSC Nos. 40259 (fig. 9), 40258a (fig. 10).

Figure 11. *Crassostrea virginica* (Gmelin). Exterior of shell, X5, station 1100; hypotype, GSC No. .40259.

Figure 12. *Chlamys islandicus* (Müller). Exterior of right valve, X3, station 2118; hypotype, GSC No. 40260.

Figure 13. *Cyclopecten vitreus* (Gmelin). Exterior of right valve, X14, station 2116; hypotype, GSC No. 40261.

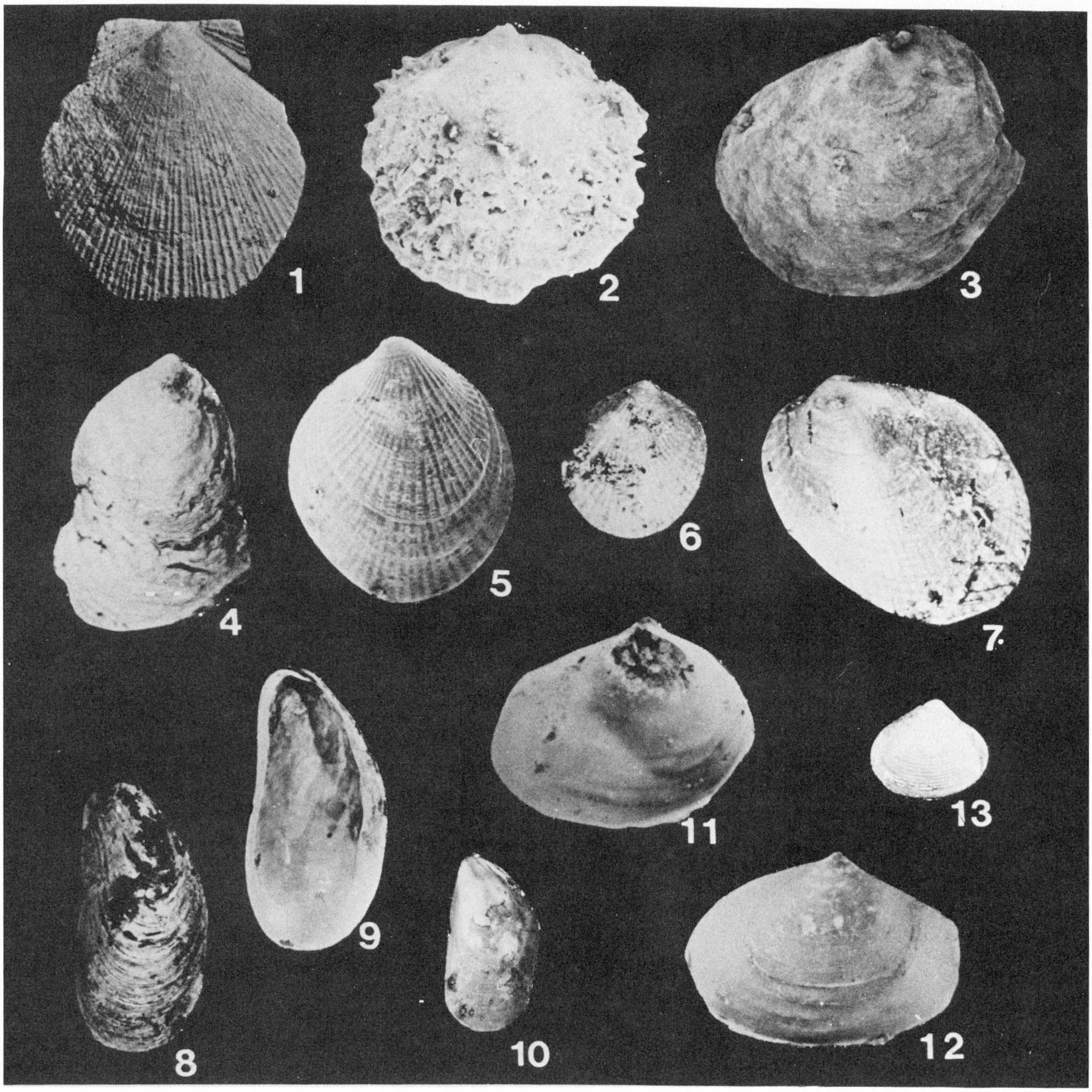

PLATE II - MOLLUSCA - PELECYPODA

Pectinidae, Anomiidae, Mytilidae, Thraciidae, Astartidae

Figure 1. *Placopecten magellanicus* (Gmelin). Exterior of right valve of juvenile specimen, X2, station 2206; hypotype, GSC No. 40262.

Figure 2. *Anomia aculeata* Müller. Exterior of shell, X21, station 2116; hypotype, GSC No. 40263.

Figure 3. *Anomia aculeata* var. *ephippium* Linné. Exterior of shell, X16, station 2116; hypotype, GSC No. 40264.

Figure 4. *Anomia simplex* d'Orbigny. Exterior of shell, X8, station 1040; hypotype, GSC No. 40265.

Figure 5. *Crenella decussata* (Montagu). Exterior of left valve X14, station 1111; hypotype, GSC No. 40266.

Figure 6. *Crenella glandula* Totten. Exterior of right valve, X8, station 2126; hypotype, GSC No. 40267.

Figure 7. *Arvella faba* (Müller). Exterior of left valve, X11, station 2135; hypotype, GSC No. 40268.

Figures 8, 9, *Modiolus modiolus* (Linné). 8, exterior of left valve; 9, interior of right valve, X0.45, station 1010; hypotypes, GSC Nos. 40269 (fig. 8), 40269a (fig. 9).

Figure 10. *Mytilus edulis* (Linné). Interior of worn specimen with tip of beak missing, X1, GSC locality 60756; hypotype, GSC No. 20149.

Figures 11, 12. *Thracia septentrionalis* Jeffreys. 11, interior of left valve; 12, exterior of left valve, X10, station 2132; hypotype, GSC No. 40270.

Figure 13. *Astarte striata* (Leach). Exterior of left valve; X1, Hudson Bay; hypotype, GSC. No. 22039.

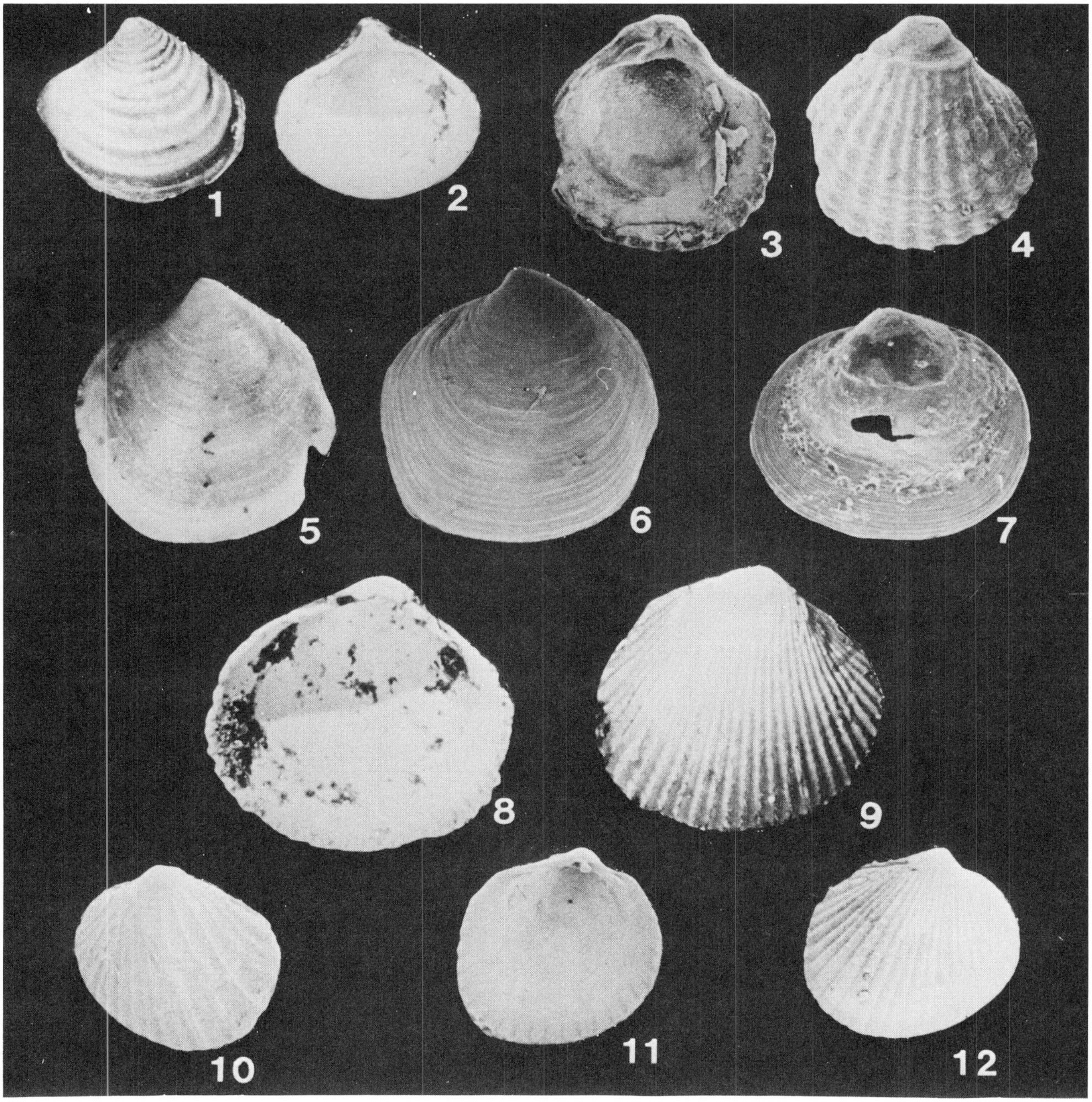

PLATE III — MOLLUSCA - PELECYPODA

Astartidae, Carditidae, Thyasiridae, Ungulinidae, Cardiidae

Figures 1, 2. *Astarte undata* Gould. 1, exterior of left valve; 2, interior of right valve, X8, station 2126; hypotypes, GSC Nos. 40271 (fig. 1), 40271a (fig. 2).

Figures 3, 4. *Cyclocardia borealis* (Conrad). 3, interior of left valve, 4, exterior of right valve, X19, station 2191, hypotypes, GSC Nos. 40272 (fig. 3), 40272a (fig. 4).

Figure 5. *Thyasira equalis* (Verrill & Bush). Exterior of left valve, X14, station 1102; hypotype, GSC No. 40273.

Figure 6. *Thyasira ferruginosa* (Forbes). Exterior of left valve, X16, station 1100; hypotype, GSC No. 40274.

Figure 7. *?Diplodonta punctata* (Say). Exterior of left valve, X47, station 3100; hypotype, GSC No. 40275.

Figures 8, 9. *Clinocardium ciliatum* (Fabricius). 8, interior of left valve; 9, exterior of right valve, X4, station 2112; hypotypes, GSC Nos. 40276 (fig. 8), 40276a (fig. 9).

Figure 10. *Cerastoderma echinatum* (Linné). Exterior of left valve, X34, station 1024; hypotype, GSC No. 40277.

Figures 11, 12. *Cerastoderma pinnulatum* (Conrad). 11, interior of left valve; 12, exterior of right valve, X16, station 1005; hypotypes, GSC Nos. 40278 (fig. 11), 40278a (fig. 12).

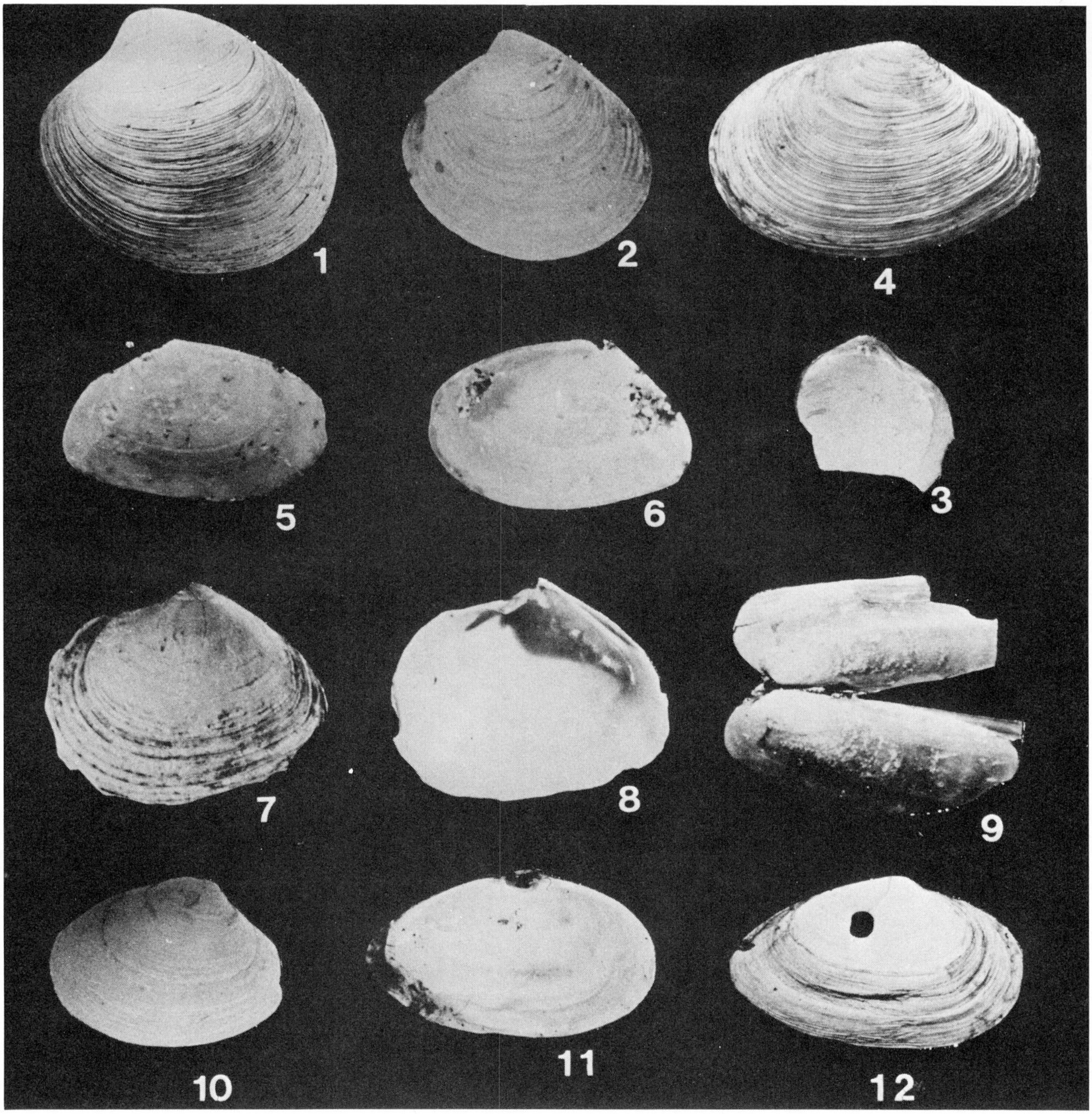

PLATE IV — MOLLUSCA - PELECYPODA

Veneridae, Tellinidae, Semelidae, Cultellidae, Mactridae, Myidae

Figure 1. *Mercenaria mercenaria* (Linné). Exterior of left valve, X1, station 1124; hypotype, GSC No. 40279.

Figure 2. *Pitar morrhuana* (Linsley). Exterior of left valve, X12, station 1151; hypotype, GSC No. 40280.

Figure 3. *Macoma balthica* (Linné). Interior of left valve of broken specimen, X15, station 1025; hypotype, GSC No. 40281.

Figure 4. *Macoma calcarea* (Gmelin). Exterior of left valve, X1, GSC locality 60740; hypotype, GSC No. 20158.

Figures 5, 6. *Tellina agilis* Stimpson. 5, exterior of right valve; 6, interior of right valve, X7, station 2135; hypotype, GSC No. 40282.

Figures 7, 8. *Cumingia tellinoides* (Conrad). 7, exterior of left valve; 8, interior of right valve, X8, station 1151; hypotypes, GSC Nos. 40283 (fig. 7), 40283a (fig. 8).

Figure 9. *Ensis directus* (Conrad). Attached valves, posterior ends missing, X12, station 2169; hypotype, GSC No. 40284.

Figure 10. *Spisula polynyma* (Stimpson). Exterior of left valve, X16, station 2105; hypotype, GSC No. 40285.

Figure 11, 12. *Mya arenaria* Linné. 11, interior of left valve; 12, exterior of right valve, X1, station 2136; hypotypes, GSC Nos. 40286 (fig. 11), 40286a (fig. 12).

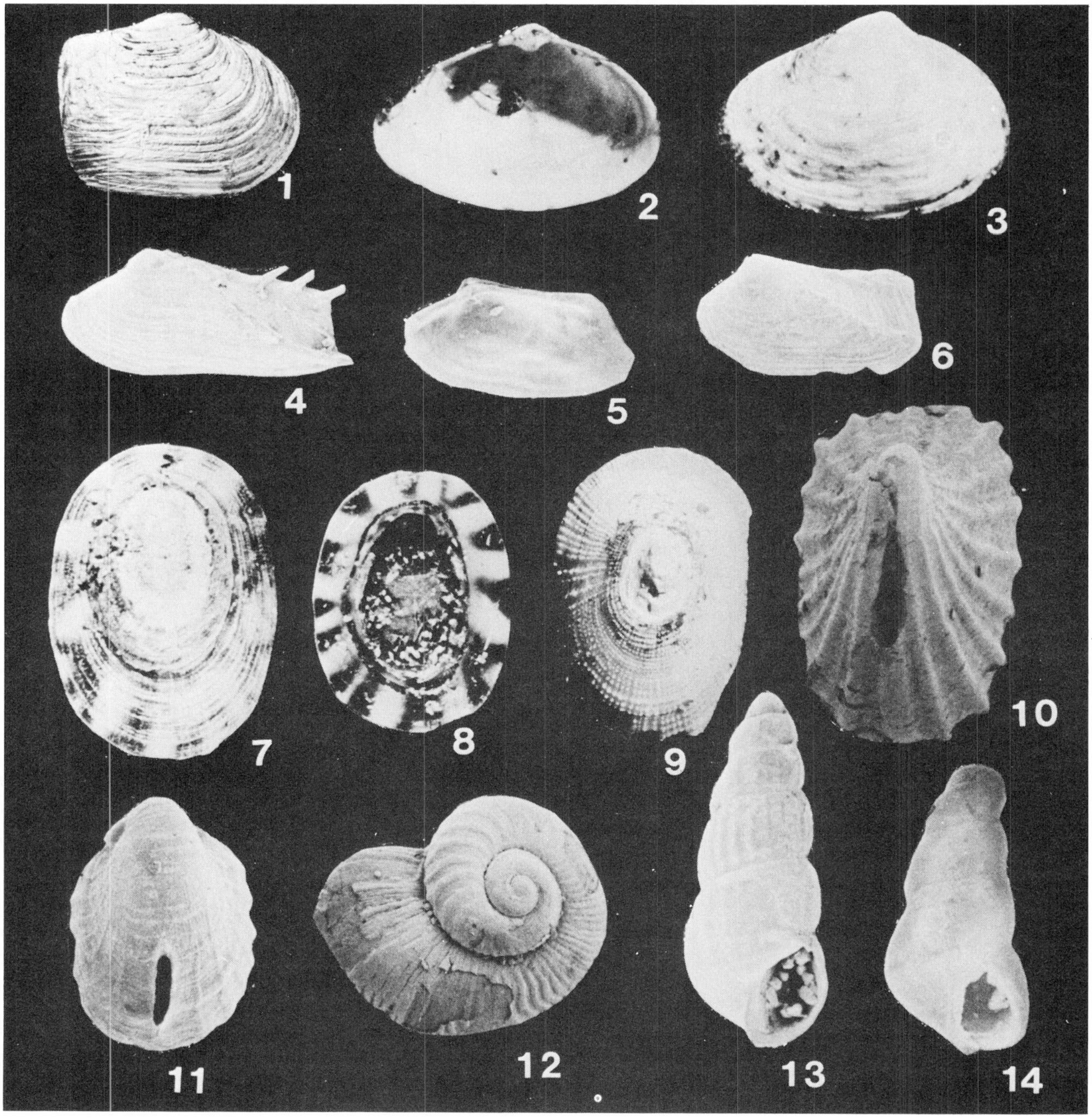

PLATE V — MOLLUSCA - PELECYPODA-GASTROPODA

Myidae, Hiatellidae, Acmaeidae, Lepetidae, Fissurellidae, Turbinidae, Pyramidellidae

Figures 1, 2, 3. *Mya truncata* Linné. 1, exterior of right valve of adult, X1, GSC locality 60767; hypotype, GSC No. 20161; 2, interior of left valve of juvenile; 3, exterior of right valve of juvenile, X5, station 1102; hypotypes, GSC Nos. 40287 (fig. 2), 40287a (fig. 3).

Figures 4, 5, 6. *Hiatella arctica* (Linné). 4, exterior of left valve of juvenile, X20, station 1024; 5, interior of right valve; 6, exterior of left valve, X20, station 1005; hypotypes, GSC Nos. 40288 (fig. 4), 40289 (fig. 5), 40289a (fig. 6).

Figures 7, 8. *Acmaea testudinalis* (Müller). 7, exterior; 8, interior, X9, station 1095; hypotypes, GSC Nos. 40290 (fig. 7), 40291 (fig. 8).

Figure 9. *Lepeta caeca* (Müller). Exterior of shell, X9, station 2118; hypotype, GSC No. 40292.

Figure 10. *Puncturella noachina* (Linné). Exterior of shell, X17, station 2118; hypotype, GSC No. 40293.

Figure 11. *Rimula frenulata* Dall? Exterior of shell, X29, station 3118; hypotype, GSC No. 40294.

Figure 12. *Moelleria costulata* (Möller). Apical view, X25, station 1005; hypotype, GSC No. 40295.

Figure 13. *Turbonilla interrupta* Totten. Oral view, X21, station 2116; hypotype, GSC No. 40296.

Figure 14. *Pyramidella fusca* C. B. Adams. Oral view, X29, station 2156; hypotype, GSC No. 40297.

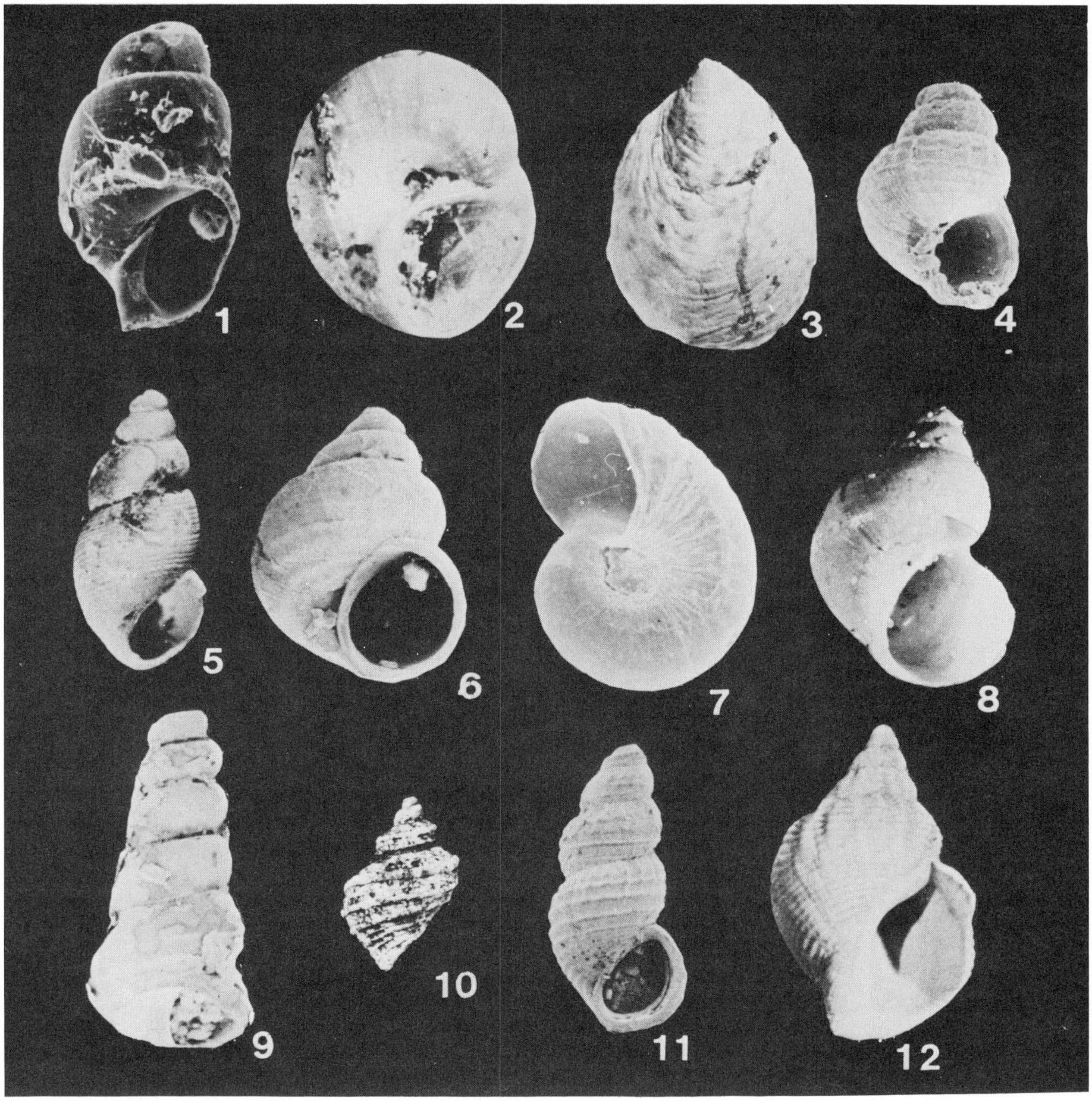

PLATE VI — MOLLUSCA - GASTROPODA

Pyramidellidae, Naticidae, Crepidulidae, Rissoidae, Skeneidae, Lacunidae, Turritellidae, Trichotropidae, Cerithiidae, Muricidae

Figure 1. *Odostomia trifida* Totten? Oral view, X57, station 1051; hypotype, GSC No. 40298.

Figure 2. *Lunatia pallida* (Broderip & Sowerby). Basal view, X28, station 1051; hypotype, GSC No. 40299.

Figure 3. *Crepidula fornicata* (Linné). Exterior of shell, X7, station 1063; hypotype, GSC No. 40300.

Figure 4. *Alvania janmayeni* (Friele). Oral view, X19, station 2110; hypotype, GSC No. 40301.

Figure 5. *Cingula aculeus* (Gould). Oral view, X9, station 2169; hypotype GSC No. 40302.

Figure 6. *Cingula castanea* (Möller). Oral view, X24 station 2203; hypotype, GSC No. 40303.

Figure 7. *Skenea planorbis* (Fabricius). Basal view, X58, station 1164; hypotype, GSC No. 40304.

Figure 8. *Lacuna vincta* (Montagu). Oral view, X11, station 1104; hypotype, GSC No. 40305.

Figure 9. *Turritellopsis acicula* (Stimpson). Oral view, X16, station 3110; hypotype, GSC No. 40306.

Figure 10. *Trichotropis borealis* Broderip & Sowerby. Aboral view, X2, GSC locality 27345; hypotype, GSC No. 20134.

Figure 11. *Bittium alternatum* Say. Oral view, X14, station 1102; hypotype, GSC No. 40307.

Figure 12. *Urosalpinx cinerea* (Say). Oral view, X3, station 2103; hypotype, GSC No. 40308.

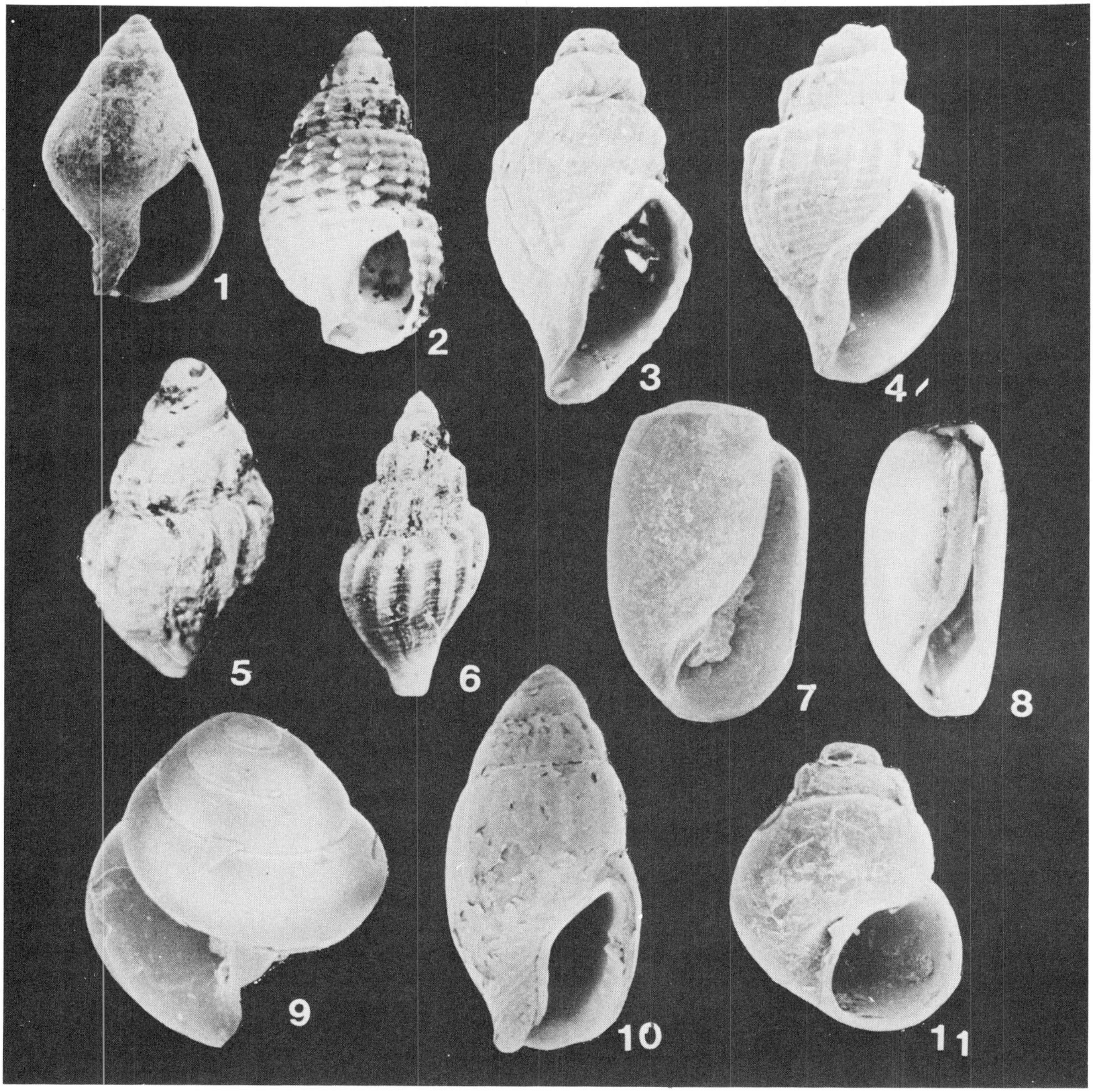

PLATE VII — MOLLUSCA - GASTROPODA

Columbellidae, Nassariidae, Turridae, Retusidae, Acteocinidae, Spiratellidae, Ellobiidae, Amnicolidae

Figure 1. *Mitrella lunata* (Say). Oral view, X22, station 1050; hypotype, GSC No. 40309.

Fiugre 2. *Nassarius trivittatus* (Say). Oral view, X6, station 1005; hypotype, GSC No. 40310.

Figure 3. *Oenopota bicarinata* (Couthouy). Oral view, X17, station 2121; hypotype, GSC No. 40311.

Figure 4. *Oenopota incisula* (Verrill). Oral view, X17, station 1086; hypotype, GSC No. 40312.

Figure 5. *Oenopota pyramidalis* (Strøm). Aboral view, X11, station 2121; hypotype, GSC No. 40313.

Figure 6. *Oenopota turricula* (Montagu). Aboral view, X23, station 2116; hypotype, GSC No. 40314.

Figure 7. *Retusa canaliculata* (Say). Oral view, X29, station 1005; hypotype, GSC No. 40315.

Figure 8. *Cyclichna alba* Brown. Oral view, X15, station 1101; hypotype, GSC No. 40316.

Figure 9. *Spiratella lesueuri* d'Orbigny. Oral view, X58, station 2106B; hypotype, GSC No. 40317.

Figure 10. *Ovatella myosotis* Draparnaud. Oral view, X17, station 2163; hypotype, GSC No. 40318.

Figure 11. *Hydrobia minuta* (Totten). Oral view, X28, station 2136; hypotype, GSC No. 40319.