

**CIHM
Microfiche
Series
(Monographs)**

**ICMH
Collection de
microfiches
(monographies)**



Canadian Institute for Historical Microreproductions / Institut canadien de microreproductions historiques

© 1994

Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- | | |
|--|--|
| <input type="checkbox"/> Coloured covers/
Couverture de couleur | <input type="checkbox"/> Coloured pages/
Pages de couleur |
| <input type="checkbox"/> Covers damaged/
Couverture endommagée | <input type="checkbox"/> Pages damaged/
Pages endommagées |
| <input type="checkbox"/> Covers restored and/or laminated/
Couverture restaurée et/ou pelliculée | <input type="checkbox"/> Pages restored and/or laminated/
Pages restaurées et/ou pelliculées |
| <input type="checkbox"/> Cover title missing/
Le titre de couverture manque | <input checked="" type="checkbox"/> Pages discoloured, stained or foxed/
Pages décolorées, tachetées ou piquées |
| <input type="checkbox"/> Coloured maps/
Cartes géographiques en couleur | <input type="checkbox"/> Pages detached/
Pages détachées |
| <input type="checkbox"/> Coloured ink (i.e. other than blue or black)/
Encre de couleur (i.e. autre que bleue ou noire) | <input checked="" type="checkbox"/> Showthrough/
Transparence |
| <input type="checkbox"/> Coloured plates and/or illustrations/
Planches et/ou illustrations en couleur | <input type="checkbox"/> Quality of print varies/
Qualité inégale de l'impression |
| <input type="checkbox"/> Bound with other material/
Relié avec d'autres documents | <input type="checkbox"/> Continuous pagination/
Pagination continue |
| <input type="checkbox"/> Tight binding may cause shadows or distortion
along interior margin/
La reliure serrée peut causer de l'ombre ou de la
distorsion le long de la marge intérieure | <input type="checkbox"/> Includes index(es)/
Comprend un (des) index |
| <input type="checkbox"/> Blank leaves added during restoration may appear
within the text. Whenever possible, these have
been omitted from filming/
Il se peut que certaines pages blanches ajoutées
lors d'une restauration apparaissent dans le texte,
mais, lorsque cela était possible, ces pages n'ont
pas été filmées. | Title on header taken from:/
Le titre de l'en-tête provient: |
| | <input type="checkbox"/> Title page of issue/
Page de titre de la livraison |
| | <input type="checkbox"/> Caption of issue/
Titre de départ de la livraison |
| | <input type="checkbox"/> Masthead/
Générique (périodiques) de la livraison |

Additional comments:/
Commentaires supplémentaires:

Pagination is as follows : p. 167-185.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
								✓			

The copy filmed here has been reproduced thanks to the generosity of:

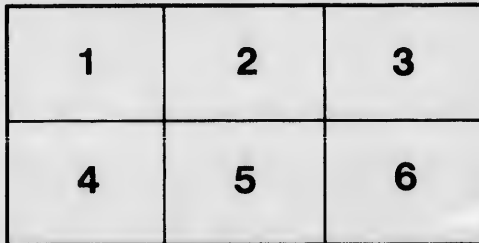
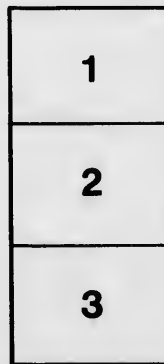
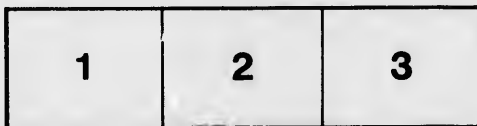
Harriet Irving Library
University of New Brunswick

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol \rightarrow (meaning "CONTINUED"), or the symbol ∇ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:



L'exemplaire filmé fut reproduit grâce à la générosité de:

Harriet Irving Library
University of New Brunswick

Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole \rightarrow signifie "A SUIVRE", le symbole ∇ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.



VII.—*Southern Invertebrates on the Shores of Acadia.*

By W. F. GANONG.

(Presented by Dr. L. W. Bailey, May 28, 1890.)

It has long been known that the Marine Invertebrate Fauna of the eastern coast of Canada is not of a homogeneous character. On the contrary, in all the southern part of the Gulf of St. Lawrence, and at certain other sheltered and isolated points on the coasts of New Brunswick, Nova Scotia and possibly Newfoundland, there occur certain groups of species of a distinctly southern facies, mingled with the ordinary forms of a northern type. These southern forms, moreover, are in all cases specifically identical with those which flourish and are evidently at home to the south of Cape Cod, yet are entirely cut off from them, except for similar small isolated colonies on the coasts of Maine and Massachusetts, by hundreds of miles of sea-coast occupied only by northern forms. Such a condition presents a problem of exceptional interest, and one of which the solution is not yet certain. It may not be out of place to collect the scattered records and show the present status of the question, and to point out what still remains to be done towards its final solution.

The history of our knowledge of the subject can be briefly traced. Writers as long ago as Lescarbot and Champlain, and perhaps even earlier,¹ speak of the occurrence of the oyster, our most conspicuous southern form, in the Gulf of St. Lawrence and Bras d'Or Lakes. Denys in 1672, and Charlevoix in 1744 refer to it also, the work of the former giving facts upon its distribution which are of some value in connection with our present subject. But none of these writers knew that it is, so to speak, out of place; nor does any other author appear to have spoken of this fact until we come to the scientific writers of the latter half of the present century.

The very first scientific writer who assigned our Marine Invertebrates to a definite fauna was H. Milne-Edwards in his "Mémoire sur la distribution géographique des crustacés,"² published in 1838. He included all the forms from Newfoundland northward in a *région polaire*, all from Newfoundland to Carolina in a *région Pennsylvanienne*, and all thence to South America in a *région Caraïbe*. But there is nothing in his work to show that he knew that his Pennsylvanian region could be naturally divided. This was in part proven, however, in 1841, by Dr. A. A. Gould,³ who showed that Cape Cod forms a natural boundary between northern and southern forms. Then Dana, in 1852, took a long step

¹ In Hakluyt's "Voyages and Navigations," Vol. iii, pp. 170-174 (of the 1810 ed.) is a description of the natural products of Newfoundland, written in 1578, in which oysters are mentioned. The writer probably saw these at Cape Breton. See 'Bull. Nat. Hist. Soc. of N.B.,' No. 8, 1889, p. 5, foot note.

² In 'Ann. Sci. Nat.,' ii, x, p. 129, 1838.

³ 'Journal Boston Soc. Nat. Hist.,' iii, pp. 483-494, 1841, and Inv. of Mass., 1st ed. p. 316.



nearer to the truth, when in his "Crustacea of the United States Exploring Expedition" he limited a group between East Cape of Newfoundland and Cape Cod, and called it the *Nova Scotian Fauna*. He called the assemblage to the north of Newfoundland, the Arctic Fauna, that from Cape Cod to Cape Hatteras, the Virginian, and that from the latter point to Florida the Carolinian. The next year, in an article in the American Journal of Science,¹ he changed the name Nova Scotian to *Acadian*, and this was the earliest use in this connection of this word, which is usually given a later date and wrongly attributed to Lütken. It was in 1857 that Lütken published his often-quoted work "On the Distribution of Norwegian Echinoderms,"² in which, reasoning from this group, he limited the fauna exactly as Dana had done, using the same names as Dana, and not distinguishing the southern or Virginian forms intermingled with the Acadian. Neither of these writers speaks specially of the Gulf of St. Lawrence, but they probably meant to include all but its northern part in the Acadian. It is important to note that they arrived at the same conclusions from studies on different groups. Forbes, also, about 1859³ as a result of studies on Mollusca, and a comparison with those of Europe, applied the name *Boreal* as about equivalent to Acadian, but he made Cape Breton its northern limit.

The next distinct advance was made in 1863⁴ by Packard, who, as the result of his studies on the coast of Labrador came to the conclusion that the Acadian fauna does not immediately adjoin the Arctic or Polar, but that there is an intermediate fauna occupying the seas of Labrador and Newfoundland. This indeed had been foreshadowed by Dr. Gould in 1841,⁵ when he said, speaking of the Mollusca of this region, that "about 20 species may be regarded as intermediate," etc., (p. 316). This intermediate fauna, Packard considered, occupies a part of the coast of Labrador, all of the northern part of the Gulf of St. Lawrence, including the Mingan Islands and a part of Anticosti, the shores and banks of Newfoundland, the fishing banks off the coast of Nova Scotia and St. George's banks and perhaps even to the coast of New Jersey. Being thus, south of Labrador, a shoal fauna, he proposed for it the name *Syrtsian fauna*, which it now retains. In 1867, Packard set forth his views at greater length in an elaborate memoir,⁶ and it may be said that his conclusions have in general been substantiated both by his own subsequent researches⁷ and by the extensive dredgings of the United States Fish Commission under Professor Verrill and others. Packard, however, pays but little attention to the decidedly Virginian species which occur isolated in the midst of Acadian forms. Verrill's subsequent work has limited the faunae sharply, and has clearly shown their range southward, leaving little to be desired in this direction.

So much for faunae of our coast in general. But even before our Acadian fauna was definitely limited, it was recognized that some forms belonging to the southward are living on our shores. This is perhaps the case on the southern coast of Newfoundland.

¹ 'Am. J. Sci.,' ii, xvi, p. 325, 1853.

² 'Om de Nordiske Echinodormers Geographiske Udbredning. Videnskabelige Meddelelser... I Kjöbenhavn, 50-100, 1857.

³ 'Natural History of European Seas,' p. 235, 1859.

⁴ 'A list of animals dredged near Caribou Island, Southern Labrador.' 'Canadian Naturalist,' viii, pp. 401-420, 1863.

⁵ 'Rep. on Inv. of Mass.'

⁶ 'Observations on the Glacial Phenomena of Labrador and Maine,' etc. 'Mem. Bost. Soc. Nat. His.,' i, pp. 210-303, 1867.

⁷ 'American Naturalist,' Vol. viii, pp. 145-155.

About 1840 the Norwegian government sent to Newfoundland a Professor Stuwitz to make studies on its fauna. Jukes, the geologist, who knew Stuwitz well, tells¹ us that "Professor Stuwitz informed me that on the southern part of the bank, (*i.e.* the Grand Bank) and also to a certain extent on the southern coasts of Newfoundland, the shells and animals had a more tropical character than would be supposed from the latitude, and from the existence of other animals of an Arctic character. He attributed this to the action of the Gulf stream, not so much from its raising the temperature of the surrounding water, as from its current sweeping the animals further north than they would otherwise reach." We have no data² as to what these southern animals are, but considering the distance of the Gulf stream from the coast of Newfoundland, it would seem that some simpler explanation of their presence there is required.³ This subject will be referred to again.

The first man to recognize the southern character of the assemblage of animals about Northumberland Straits was undoubtedly Sir William Dawson. Before the year 1857 he had collected the Mollusca extensively and his collections made at that time are now in the Peter Redpath museum of McGill College. But not having the means of publishing his researches at the time, the fact of the occurrence of this southern outlier was probably first given to the scientific world through the publications of his friend and co-worker John Willis, of Halifax. Willis and Sir William Dawson had both communicated these observations to other naturalists by letter, but the former's excellent and complete (for its time) list of 1862⁴ was probably the first formal publication in which these facts were shown, his previous nominal lists being of little value in this direction. In this list also he gave the locality "Sable Island" to several decidedly southern species, thus pointing out the existence of a southern colony there. He also mentioned the occurrence of two or three southern forms in Halifax Harbour. To Sir William Dawson then, must be assigned the credit of first recognizing, and to John Willis, the credit of first publishing the existence of southern colonies on the coast of Acadia.⁵ So far as the Gulf is concerned, a great deal was added to our knowledge by the researches of Mr. Whiteaves, who in 1871, 72 and 73⁶ dredged both in its deeper and shallow waters. Not only did he more definitely limit and show the character of the Acadian and Syrtensian faunae, but on his third expedition in particular he added a number of southern species to those known from the southern part of the Gulf. A list of species occurring around Prince Edward Island, published by Sir William Dawson in his geological report on the island in 1871 is very valuable also. This southern character has been still further confirmed by studies made by Rev. H. W.

¹ "Excursions in and about Newfoundland," J. B. Jukes, London 1842, Vol. II, p. 191.

² Stuwitz died in 1842 while studying in Newfoundland. We cannot find that many of the results of his labours have been published. He is referred to in Lütken's work on "Distribution of Norwegian Echinodermata," cited above. Confer "Newfoundland: as it was and is in 1877." Rev. Philip Toque, London and Toronto, 1878.

³ *Physalia*, the Portuguese man-of-war, has been seen on the coast of Newfoundland, (*op. cit.*), but so has it been also in the Bay of Fundy, 'American Naturalist,' xxiii, p. 821. No trustworthy conclusions as to distribution of southern forms can be drawn from jelly-fishes or floating forms which may be blown hundreds of miles away from their natural course.

⁴ Now very rare. It has lately been republished by the Nova Scotian Inst. of Natural Science.

⁵ We do not mean to imply that the southern forms were not known to occur in the Gulf, but that they were not known to be southern. As early as 1820, *Venus mercenaria*, *Modiola plicatula* and *Crepidula fornicata* were known from the oyster beds. See 'Trans. Lit. and His. Soc. of Quebec,' Vol. I, pp. 188-198, 1820.

⁶ In Three Reports publ. in "Rep. Marine and Fisheries of Canada," 1870-71, 1871-72, 1872-73, and also 'Can. Naturalist,' vi, pp. 351-354, 1872, vii, pp. 86-100, 1873, and vii, pp. 257-267, 1874, and in other journals.

Winkley¹ which have been corroborated by similar studies made by the present writer, the results of which are embodied in the table below.

About the year 1876, T. A. Verkrüzen, a German naturalist, visited Nova Scotia and Newfoundland to study the Mollusca, and as a result, published several papers. The most important of these for our present purpose is that of 1878,² in which he gives lists of species taken by him in St. Mary's Bay and Annapolis Basin. A considerable number of Virginian forms was found by him in the former locality. Still later, the present writer has succeeded in collecting some evidence of the occurrence of several Virginian species in Mims Basin, and possibly of one or two in Oak Bay, an arm of the St. Croix River in New Brunswick.

But north of Cape Cod and south of Acadia there is at least one other southern colony which stands isolated from its neighbours, not considering Massachusetts Bay in which, as would be expected, there is a commingling of southern with the northern forms. In 1873 the United States Fish Commission, under the superintendence of Professor Verrill, made a careful study³ of the fauna of Casco Bay, Maine, in the course of which there was discovered at Quahog Bay, about thirty miles from Portland, a well-marked southern colony similar to that of the Gulf of St. Lawrence, though much smaller.⁴

And now let us sum up the present opinion of students as to the faunae of our east coast.⁵ On the north, occupying Baffin's Bay and all the region to the west, east and north is a circum-polar or Arctic fauna. How far south on the north-east coast of Labrador

¹ See 'Bull. N.B., Nat. Hist. Soc.' No. vii, pp. 69-71, 1888.

² In 'Jahrbücher der Deutschen Malakozoologischen Gesellschaft,' v, pp. 208-230, 1878. He has other articles, on the Mollusca of the Newfoundland coast and banks in other numbers of the same journal. Verkrüzen is (or was a year ago) living in Hamburg, Germany. He has given up his studies in the science of Conchology for the science of Philately, or postage stamps. Before doing so, however, and before selling his collections, he summed up his knowledge of East Canadian Mollusca in a series of articles in a Berlin periodical 'Der Sammler,' in the numbers for November 1st and November 15th, 1885, February 1st and March 1st, 1886. His work has not been considered for much account by American conchologists, as he made species and varieties upon the smallest provocation and most imperfect specimens. With regard, however, to common and well-known species, his observations are probably trustworthy.

³ See 'Proc. Am. Assoc.' for 1873, pp. 372-378.

⁴ We do not give lists of the species characteristic of each fauna as such does not come within the scope of this paper. Neither does a comparison of each with those on the other side of the Atlantic, though a very exact comparison can be made.

⁵ We should not neglect in this connection to mention and give our tribute to the work in our waters of those naturalists who, though not directly concerned in the establishment of the faunae whose development we have traced nevertheless contributed much by their labours to make the limitation of these faunae possible. First among these would come Dr. William Stimpson, who was probably the first American naturalist to make use of the naturalists' dredge. He spent three months of the summer of 1852 dredging about Grand Manan, and he clearly demonstrated the northern character of the fauna of the Bay of Fundy. ('Synopsis of the Marine Invertebrata of Grand Manan,' 'Smithsonian Contr. to knowledge,' vi, pp. 67, 1854.) Indeed, he had already pointed this out in an earlier paper in 1851, ('Proc. Bos. Soc. Nat. Hist.,' iv, pp. 95-100, 1851,) and had given what is probably the true explanation of its cause. Stimpson's reputation as a scientific investigator is growing as time goes on, and it was a great loss to his department of science when the destruction of his collections by the great Chicago fire in 1871, was followed soon after by his death. Sir William Dawson and Whiteaves, also by their studies on the fauna of Gaspé ('Can. Naturalist,' iii, pp. 321-331, 1858,) and the River St. Lawrence ('Can. Naturalist,' xii, pp. 48-51, 1869 and pp. 270-273, 1869,) have made it well-known and established its position. The earlier papers, ('Rep. Canadian Geological Survey' for 1857 (1858). 'Can. Naturalist,' iv, pp. 197-220, 141-251, 1859,) of Dr. Robert Bell also were valuable. Everybody knows the results of Verrill's careful studies at Eastport and in the Gulf of Maine in connection with the U. S. Fish Commission.

this extends, is uncertain, but certainly it does not on the surface reach the Straits of Belle Isle, though some of its members are found in the deep parts of the Gulf. Overlapping this at its southern surface limit, (and indeed beginning at the southern part of Greenland), occurs the Syrtensian fauna. This occupies all the northern part of the Gulf of St. Lawrence as far west as Anticosti where it begins to mingle with the Acadian fauna, and predominating over the latter extends up the St. Lawrence River. It occupies with some slight admixture of circum-polar forms, all the deeper part of the Gulf, *i. e.*, that part north of a line drawn from Gaspé to the Magdalenes and thence to the north of Cape Breton, all of the coasts of Newfoundland except possibly a portion of its southern shore, the passage between Newfoundland and Cape Breton, the Grand Bank, and all the fishing banks off the Nova Scotia and Maine coasts as far south as St. George's Bank. It has outliers, moreover, at Orphan and Bradelle Banks near Bay Chaleur, at the mouth of the Bay of Fundy and at one or two points in the Gulf of Maine. The Acadian fauna occupies all of the Gulf of St. Lawrence south of the line from Gaspé to the Magdalenes and Cape Breton and intermingles with the Syrtensian at the west of Anticosti and up the St. Lawrence River. It probably is present on a part of the southern shores of Newfoundland which are protected from the cold currents of the Gulf and Banks. It occupies all of the coasts of Cape Breton and Nova Scotia, probably is present to some extent on Sable Island; is present throughout the Bay of Fundy except for the deep Syrtensian area near its mouth, all along the coast of Maine and south to Massachusetts Bay where it begins to intermingle with the Virginian species which are found there. It extends even beyond Cape Cod to Nantucket shoals and through the deep part of Long Island Sound at least as far as Stonington, Conn. It also has a branch outside of Long Island which extends southward to a bank off the coast of New Jersey where its last traces disappear. The Virginian fauna has its northern limit at Cape Cod or rather at Massachusetts Bay, and extends southward to the vicinity of Cape Hatteras, where the Carolinian begins and extends to Florida. But it has outliers much farther north, namely, the southern colonies which have been referred to, which live and are commingled with Acadian forms in the Gulf of St. Lawrence, possibly in the most sheltered spots on the south coast of Newfoundland, at Sable Island, at certain sheltered points on the Atlantic coast of Nova Scotia, at St. Mary's Bay, at Minas Basin, possibly at Oak Bay, N.B., at Casco Bay and to some extent in Massachusetts Bay. It is to these outlying Virginian forms, and to the explanation of their occurrence so far from their proper home and kindred that we shall devote our attention throughout the remainder of this paper.¹

¹ It is strong evidence that these faunas have been correctly defined, that different students from a study of three different groups should have come to the same conclusions. This has been the case with Dana and Smith with Crustacea, Lütken with Echinodermata, Packard, Verrill, Whiteaves and others with Mollusca.

A List of Marine Invertebrates belonging to the Virginian fauna, which occur upon the coasts of Acadia and Maine :—

Name of Species.	Gulf of St. Lawrence	Bay of Fundy	Sable Island	Halifax Har. St. Mary's Bay and vicinity.	St. Mary's Bay.	Annapolis Basin.	Minas Basin.	Chamberland Bay.	Oak Bay, N. E.	Quebec Bay. (Quebec Bay)	Massachusetts Bay.	Further Distribution.	Special Localities.
Group I.—MOLLUSCA.													
CLASS LAMELLIBRANCHIATA.													
1 <i>Teredo dilatata</i> Stimpson.....	*	*	*	*	*	*	*	*	*	*	*	Cape Ann to S. Carolina to Florida Cape Cod to W. Indies to Long Id. Id. to West Indies .. to S. Carolina.... to Florida to Yucatan to Texas..... to Florida to Florida Keys..	Maelsten Islands: Rare at East Pt.
2 <i>Maetra lateralis</i> Say.....	*	*	*	*	*	*	*	*	*	*	*		
3 <i>Cumlingia tellinoides</i> Conrad.	*	*	*	*	*	*	*	*	*	*	*		
4 <i>Montacuta elevata</i> Stimpson.	*	*	*	*	*	*	*	*	*	*	*		
5 <i>Petricola pholadiformis</i> Lamarck.....	*	*	*	*	*	*	*	*	*	*	*		
6 <i>P. pholadiformis</i> , var. <i>daetylus</i> Say.....	*	*	*	*	*	*	*	*	*	*	*		
7 <i>Cytherea convexa</i> Say.....	*	*	*	*	*	*	*	*	*	*	*		
8 <i>Venus mercenaria</i> Lin.....	*	*	*	*	*	*	*	*	*	*	*		
9 <i>Modiola plicatula</i> Lamarck...	*	*	*	*	*	*	*	*	*	*	*		
10 <i>Pecten irradians</i> Lamarck... (<i>P. concentricus</i> Say.)	?	*	*	*	*	*	*	*	*	*	*		
11 <i>Ostrea virginiana</i> Lister... (including <i>O. borealis</i> Lamarck)	*	*	*	*	*	*	*	*	*	*	*		
CLASS GASTROPODA.													
12 <i>Utriculus canaliculatus</i> Stimpson.....	*	*	*	*	*	*	*	*	*	*	*	to West Indies.. to Georgia..... to N. coast of S. A. to Florida..... to West Indies... to S. Carolina... to West Indies.. to Delaware..... to New Jersey... to Florida Keys... to Barbadoes.... to Florida..... to Florida..... to Florida.....	Found on Le Havre Bank.
13 <i>Bulla solitaria</i> Say.....	*	*	*	*	*	*	*	*	*	*	*		
14 <i>Crepidula fornicata</i> Lamarck.	*	*	*	*	*	*	*	*	*	*	*		
15 <i>Crepidula convexa</i> Say.....	*	*	*	*	*	*	*	*	*	*	*		
16 <i>Crepidula plana</i> Say.....	*	*	*	*	*	*	*	*	*	*	*		
17 <i>Bitium nigrum</i> Stimpson....	*	*	*	*	*	*	*	*	*	*	*		
18 <i>Centhopsis Greenii</i> Verrill... (<i>Bitium Greenii</i> St.)	*	*	*	*	*	*	*	*	*	*	*		
19 <i>Odotostoma bisuturalis</i> Gould.	*	*	*	*	*	*	*	*	*	*	*		
20 <i>Odotostoma tritida</i> Gould....	*	*	*	*	*	*	*	*	*	*	*		
21 <i>Odotostoma seminuda</i> Gould..	*	*	*	*	*	*	*	*	*	*	*		
22 <i>Turbonilla interrupta</i> Adams.	*	*	*	*	*	*	*	*	*	*	*		
23 <i>Astyris lunata</i> Dall..... (<i>Columbella lunata</i> Sowerby.)	*	*	*	*	*	*	*	*	*	*	*		
24 <i>Nassa obsoleta</i> Say.....	*	*	*	*	*	*	*	*	*	*	*		
25 <i>Urosalpinx cinerea</i> Stimpson. (<i>Buccinum cinerum</i> Gould.)	*	*	*	*	*	*	*	*	*	*	*		
Group II.—ECHINODERMATA.													
CLASS ASTEROIDEA.													
26 <i>Asterias Forbesii</i> Verrill..... (<i>Asterias aronicola</i> Stimpson.)	*	*	*	*	*	*	*	*	*	*	*	to Gulf of Mexico	
CLASS HOLOTHUROIDEA.													
27 <i>Candina arenata</i> Stimpson....	*	*	*	*	*	*	*	*	*	*	*	to Vineyard Id.. to Block Id.	
28 <i>Molpadia oölitica</i> Selenka....	*	*	*	*	*	*	*	*	*	*	*		

* The authorities for the facts contained in this list are as follows:—The column on "Gulf of St. Lawrence" is drawn from Whiteaves (papers referred to on p. 16^a, footnote) and Dawson, 'Rep. on Geol. Structure of P. E. I.'

1862 by C. B. Fuller,¹ as occurring in the St. Croix River, near Oak Bay. There is a possibility, of course, that there was a mistake in the identification, but if correct it helps to confirm the occurrence of a southern colony at that locality.

Of much importance in this connection, also, are some facts contained in the list of Algae of Acadia, by Messrs. G. U. Hay and A. H. Mackay. In their list several species are given as occurring in the Gulf and not in the Bay of Fundy, which are decidedly southern, as *Lyngbya majuscula*, *Punctaria plantaginica*, *Gracillaria multipartita*, *Polysiphonia Olneyi* and *P. Harveyi*; and a few others have a somewhat, though less marked southern facies, such as *Lyngbya aestuarii*, *Uva Hopkirkii*, *Ectocarpus tomentosus*, *Ceramium circinnatum* and *C. tenuissimum*, *Polysiphonia fibrillosa*. But these are sufficient to show that the Algae agree with the animals in having Virginian members in the Gulf. It is to be noticed also in the same list that many forms common to the Gulf and to Halifax Harbour have not been found in the Bay of Fundy, and a few of these species are somewhat southern in their character,—tending to confirm the presence at Halifax of a small Virginian colony.²

Such are the facts that we have been able to collect as to the present occurrence of these southern forms in Acadia. But the list is very imperfect. In many cases the observations have been of the most casual character and there is not the slightest doubt that further study will fill out the columns of the list more fully. The Mollusca is the only group which has been studied with any care, and even of it our knowledge is very imperfect. We cannot doubt that other southern Echinodermata will be found in the Gulf, as well as at some of the other localities. Of the Crustacea, still less is known, and Mr. S. I. Smith, in his work on the distribution of the stalk-eyed Crustacea of the eastern United States³ says: "The shallow south-western part of the Gulf of St. Lawrence, including the region of Northumberland Straits, as shown particularly by its Molluscan fauna, is much more southern in its character than the rest of the Gulf, but too little is known of the stalk-eyed Crustaceans of this region to illustrate the fact." But of the Worms, Cœlenterates and Sponges, we have almost no knowledge whatever. It would be very strange, if along with Mollusca and Echinodermata from the south, there should be no southern representatives of the other groups.

So much for the facts of distribution as we find them to-day. How came to pass this anomalous condition of affairs? It is obvious that we must seek its origin in very recent

¹ 'Second Annual Report on Nat. Hist. and Geol. of Maine,' pp. 129-133. In '7th Rep. Maine Board of Agriculture.'

² We believe that the small colony of southern Algae, mentioned by Dr. W. G. Farlow, "Marine Algae of New England," 'Rep. U. S. Fish Com. for 1879,' p. 6 of the reprint, as occurring at Goose Cove, near Squam on the north side of Cape Ann, is an isolated southern colony similar in its origin to the Quahog Bay colony and the others we have mentioned. Dr. Farlow points out that the cove has a narrow entrance, and that its water is much warmer than that of the ocean outside. There is at present a dam across the mouth of the cove, but from his description it appears that it was a cove with a narrow entrance before the dam was placed there, and the damming has, perhaps, made but little difference. A shallow cove sheltered from the direct action of cold currents, and without great tides, has just the conditions which have been favourable to the persistence of southern colonies of animals at Quahog Bay, at places on the Atlantic coast of Nova Scotia, and on a larger scale in the Gulf of St. Lawrence itself. It is a very simple explanation of Dr. Farlow's little colony at Squam, and an extremely probable one, to consider that its origin was the same as that of the others we have considered. The northern species found at Gay Head and Montauk, mentioned by him (p. 7) have an exact parallel in the northern animals found in the same localities which are well known to be the result of a branch of the cold Labrador current which enters Long Island Sound.

³ In 'Trans. Conn. Acad.,' Vol. v.

There is a possibility that it helps to

in the list of several species are decidedly *Polysiphonia* marked southern *circinnatum* that the Algae to be noticed in the southern in the Virginian colony.² occurrence of the most doubt that the only edge is very im- in the Gulf, known, and Mr. of the eastern Lawrence, includ- molluscan fauna, little is known of the Worms, would be very should be no

me to pass this in very recent

ine Board of Agri-

marine Algae of New Equam on the north and the others were much warmer from his description damming has, per- rents, and without colonies of animals at St. Lawrence itself, le one, to consider found at Gay Head the same localities enters Long Island

times, since we well know from Post-pliocene deposits that no part of the southern colonies could have existed here at the time¹ they were laid down. Since then, the introduction of the Virginian forms must have been very recent (speaking of course in a geological sense), we may hope to find some traces even within the limits of historic times to show whether these forms are increasing or diminishing in number and range. Three sources of information are open to us:

I.—*Fossil or other dead shells*.—As the shores of Acadia are steadily sinking, as will be referred to presently, we cannot expect to find any beach or other raised deposits such as have yielded us abundantly Post-pliocene shells. But dredgings which have been made at the harbour of Portland, Maine, have shown the existence under the water of large deposits of the shells of southern species, such as the oyster, *Venus mercenaria*, *Pecten irradians*, *Turbonilla interrupta*, etc.,² none of which are now found alive at that place. Dredgings in the harbours of Acadia have not been examined by naturalists, but we venture the prediction that when they are, in some of them, traces of these southern forms will be found. But though dredged shells of southern facies have not been found within our limits, one or two have been found on the beaches. Thus, shells of the oyster have been seen at Sable Island,³ where none now live, and it has been said that oyster shells have been seen by the inhabitants on a shoal near the Magdalen Islands.⁴ In Cole Harbour, 10 miles east of Halifax, where no living oysters are now found, it is said that "numbers of shells (i.e., of the oyster), often of very large size, are dislodged and brought up whenever an anchor is heaved."⁵ These facts all point to a late wider range of these forms on the Maine and on our coasts.

II.—*Indian shell-heaps*.—On the coast of Maine, in the Casco Bay region and near Damariscotta, there have been found Indian shell-heaps which contain large quantities of oyster and quahog shells, at places where these molluscs are now either entirely extinct, or else very scarce and small.⁶ At St. Margaret's Bay, near Halifax, where quahogs are now very scarce, (so scarce that they have been stated by one observer to be extinct), the shell-heaps are made up in large part of their shells.⁷ A shell-heap in Shelburne Harbour is almost composed of them, and there are no where living oysters in the vicinity at present.⁸ Another form of southern facies, *Crepidula fornicata*, has been discovered by Mr.

¹ Gesner in his "5th Report on Geology of N.B.," p. 60, mentions a bed of blue marl on Bay Chaleur, which, he says contained *Venus mercenaria* and *Pecten concentricus*. Mr. G. F. Matthew tells the writer that Gesner's identifications must have been incorrect; there are northern species with which these are easily confounded.

² "Proc. Am. Assoc.," for 1873, p. 375.

³ A. L. Adams, "Field and Forest Rambles," p. 35, given by him on authority of Mr. Gilpin, of Halifax.

⁴ Report of Commissioners appointed to enquire into Oyster and Lobster Fisheries of Canada, Ottawa 1887, p. 65, and elsewhere.

⁵ "Trans. N. S. Inst. Nat. Sci.," Vol. ii, Part 2, pp. 42-43.

⁶ "Proc. Am. Assoc.," for 1873, p. 375.

⁷ J. M. Jones, "Smithsonian Annual Report," for 1863, pp. 370-371. Rev. Mr. Patterson, in his History of Pictou, mentions that the shell-heaps in that vicinity contained very many large oyster shells, while all living ones in the neighbouring waters are very small. This may be due in part to over-fishing; for Denys tells us that in his time (1672) they were in Pictou River "as large as a slice." But the degeneration is due probably in part also to natural causes.

⁸ On the authority of Professor L. W. Bailey, as this paper passes through the press. He says;—"in one of them [i.e., the shell-heaps], there were but few if any clams, and in their place nothing but oysters, embracing both the long and the broad forms. The locality is not far from Sandy Point on the eastern side of Shelburne Harbour, and the fishermen informed me that the 'oldest inhabitant' had never seen a live oyster in that vicinity." This is most important evidence, showing the range of the oyster in late times far beyond the limits mentioned above.

G. F. Matthew in a shell-heap at Passamaquoddy Bay,¹ and although this region has been carefully explored by several persons, no living specimen has ever been found.² There is no doubt that very much of value in this connection is buried in Acadian shell-heaps, and all persons who investigate them for archaeological or other reasons should be very careful to preserve specimens of all shells found in them. But such facts as are known, point clearly to the same conclusion as other facts we have quoted—that the southern fauna of which these species are members, is shrinking on our shores.

III.—*Old Books.* In the first work ever written on the Natural History of Acadia, Nicolas Denys' "Description géographique de l'Amerique septentrionale," and his "Histoire naturelle de l'Amerique septentrionale," (1672), p. 221, we are told that in a pond at the mouth of Grand Pabos River in Gaspé, "oysters are there in abundance." Denys has always been considered a most accurate and trustworthy observer, and he was an eyewitness of nearly everything he describes. Moreover his testimony on this point is to a certain extent corroborated by another work of nearly the same period, the "True and Genuine Description of New France,"³ of 1664. On page 16 it is stated that "in the neighbourhood of Percé Island, numbers of very good oysters are found." No oysters are to-day found living in the Gaspé peninsula.

Another trustworthy work extends the range of the oyster in another direction. In the "Geographical History of Nova Scotia," of 1749, ⁴ p. 28, we read, "It is said that in Port La Heve is a curious bed of fine oysters, which are of an excellent Flavor, and the best in this country." No living oysters are now known west of Halifax.⁵ Still another work, which seems in general to be very accurate, "The Present State of Nova Scotia" of 1787, ⁶ p. 52, tells us that on Sable Island, in a salt-water pond communicating with the sea, was an abundance of "oysters and other shell-fish, which afford a scanty subsistence to the wretches who are so unhappy as to be wrecked on this desolate island." No living oysters are now to be found there, though as mentioned above, dead shells have been seen on the shores. These facts indicate that the oyster is slowly contracting the limits of its range on our coasts. There is similar evidence to show that it is likewise contracting on the coasts of Maine and Massachusetts.

Another fact taught us by the above is, that all of the places mentioned were involved in the changes which produced the present condition of affairs, and our explanation must include them all; in other words that the southern forms once occupied *all* the coast line of Acadia, including Sable Island, and the colonies remaining are but broken and scattered fragments of the Virginian fauna which in times very recent occupied our entire coast region and extended in an unbroken line southward to beyond Cape Cod. The question

¹ Bull. N. B. Nat. Hist. Soc., No. III, p. 24.

² A. L. Adams, in his work "Field and Forest Rambles," makes the statement on p. 35 that oyster and quahog shells occur in the shell-heaps about Passamaquoddy Bay. No other investigators, however, have seen any trace of these species, and Adams must here be in error. Usually, however, his work is accurate and trustworthy.

³ Translated and published under title "Canada in the 17th Century," Montreal, 1883.

⁴ Published at London.

⁵ Though More's "History of Queen's Co., N. S.," (Halifax, 1873) includes the oyster among the animals of that county. It is probably an error.

⁶ Published at Edinburgh. We have carefully read this work, and it seems in general to be very reliable. It does, however, make one statement which can hardly be credited—that oysters have been found at Chignecto and exported. He probably confounds Chignecto (i. e., the present Cumberland Bay) with Baie Verte.

is connected closely with the physiography, past and present, of the shores of Acadia, and this we must now briefly examine.

The physiography of the coasts of Acadia, as we see them to-day, presents a striking diversity of conditions. In the first place, on the north, from Bay Chaleur to Cape Breton and all about Prince Edward Island, is a region of almost uniformly shallow waters and low shores composed for the most part of sand and easily-eroded sandstones. This shoal region extends out from the shore, with some local deeper portions, to the Magdalen Islands, and is marked off from the deep part of the Gulf, as pointed out by Mr. Whiteaves, by a line drawn from the north of Cape Breton to the Magdalens, and thence to the entrance of Bay Chaleur. Moreover, these waters are affected by but slight tides, the average rise and fall being only about 3 to 4 feet, and the maximum in Northumberland Strait not exceeding 5 feet. The absence of strong tides means the absence of strong currents, and this again means the absence of deep channels and of cold bottom waters to be mixed up with the warmer surface strata. The whole region also is nearly free from fogs, these being for the most part kept off by Nova Scotia and Cape Breton. All of these conditions, shoal waters with sandy bottoms, slight tides and absence of cold bottom waters, and freedom from fogs are favourable to the maintenance of a high summer temperature, and they work so well together that the temperature for the three summer months in the region of the Straits of Northumberland averages at least 60° F, and possibly higher.¹ This is just the condition needed for the development of the young of the southern forms existing there, the adults of which can stand a great degree of long-continued cold, and the species be perpetuated provided the temperature is high in the reproductive season. As Professor Verrill and Mr. Dall² have pointed out, there is reason to believe that the distribution of marine animals depends more upon the temperature of the waters in the reproductive season than upon the mean annual temperature or the extremes of heat or cold to which the adult animals are subject. We find, then, in the *surroundings* of the southern forms of the Gulf a sufficient explanation for their persistence there; how they came there is another question.

In the Bras d'Or lakes, though the shores are mostly rocky, we have again but slight tides, and in the shoal and warmed waters of the coves, oysters and doubtless other southern molluscs are found. It is probable that very similar conditions may exist in some of the most sheltered bays on the southern coast of Newfoundland, where slight tides in the most shallow coves may allow of the persistence of some southern forms. Upon the Atlantic coast of Nova Scotia we have again slight tides, and in many places shoals of sands and sheltered coves, and these would allow of the waters becoming much warmed in summer were it not for the cold Labrador current which, as will presently be shown, sweeps down upon the coast in this vicinity. But notwithstanding this, the waters to the eastward, north of Halifax, become warm enough in summer to allow the oyster to extend from the Gulf of St. Lawrence into Chedabucto Bay and westward in sheltered situations to within 30 miles of Halifax.³ Beyond that point the influence of the Labrador

¹ No exact statistics on this point seem available, and the average given is an estimate based upon the answers given to inquiries made by the writer of persons who have been in the region. It is quite lukewarm in places, as bathers have informed us.

² 'Proc. Biol. Soc.,' Washington, Vol. v.

³ As stated by Whiteaves on authority of Captain Purdy.

current is much more strongly felt¹ and nearly all of the southern forms first thin out and then totally disappear.

A curious condition is presented to us by Sable Island, which lies directly in the path of the icy-cold Labrador current. Yet the island bears a marked colony of southern mollusca. The explanation of their persistence there is undoubtedly to be found again in the great sandy shoals and very slight tides of the region. The waters on these miles of shoals must be heated by the sun, and this heated water is not mixed with colder by tidal currents,² the movement of the main Labrador current being too slow on the shoals to supply cold water faster than it can be heated.

Sable Island stands upon a great bank, which is one of a long series extending from the Grand Bank of Newfoundland on the north to St. George's Bank, off Cape Cod on the south, and so numerous are they that they form an almost unbroken line from their northern to their southern limits. The depth of water varies from zero on Sable Island bank down to sixty fathoms, a general average being about 30 to 40 fathoms. Their extent, position and depths are shown upon all modern charts of this region. There is deep water, one hundred fathoms and more, to the westward between them and Nova Scotia, and on their outer faces they sink down to considerable depths. They are swept by the cold Labrador current, as is shown by the Arctic character of their fauna, and are a most important element in the problem we are discussing.

Passing in the next place to the Bay of Fundy, we find in general bold and rocky shores with an almost entire lack of shoals, and strong tides which vary from 12 feet at its mouth to over 50 at its head. Just outside of Nova Scotia the Labrador current sweeps southward and the strong currents always attendant on strong tides sweep some portion of it into the Bay. The water being usually deep, more than one hundred fathoms near its mouth, the sun can warm but a thin stratum of surface, and even this is being constantly mixed up by the tides with colder water from below. The consequence is that throughout the main part of the Bay the summer temperature never becomes raised above 45° F., which is far too low for the reproduction of Virginian forms, and none of them whatever are known from the Bay itself. It is only in some of its shallowest and most sheltered branches, such as St. Mary's Bay, the marshes of Minas Basin and Oak Bay, N.B., that the summer temperature becomes high enough to enable a very few Virginian species to maintain a precarious foothold. Much the same conditions hold upon the eastern part of the Maine coast, but in passing westward and southward the tides are of less height and the cold currents less felt until they become so far ameliorated in Massachusetts Bay that some Virginian forms can live in the Bay itself. The Quahog Bay locality of Verrill is, however, an isolated colony in a shallow and sheltered basin.

The marine currents of this region have not been fully worked out, but so far as

¹ Its influence is felt as far north and east as Halifax in the deeper water. Professor Verrill has dredged off Halifax Harbour some species which showed that the fauna was "more arctic in character than even that of Grand Manan." *Am. J. Sci.*, Vol. v, 1873, p. 11.

The water in Queen's Co. for instance during the hottest months of summer is intensely cold, far too cold for bathing as I have been informed by a reliable friend.

² This would be especially true of the shoal ponds of the island connected with the sea. One of these, large enough to serve as a harbour for vessels, was open in the early history of the island, but has been closed in the present century. Perhaps it is in such ponds that the southern forms have been able to persist.

known they are as follows :—Moving southward through Baffin's Bay and Davis Strait is a current which is joined to the south and west of Greenland by the Greenland current which comes southward to the east of Greenland. The two united form the Labrador current which sweeps along Labrador and Newfoundland and over the Grand Bank. On the southeastern slope of the latter, it meets the northern edge of the Gulf Stream, and while a part of its volume dips beneath the latter, the remainder is deflected to the westward. It sweeps around the southern shore of Newfoundland, and is rejoined by a branch which it sent through the Straits of Belle Isle, and which passing through the deep trough of the Gulf, comes out between Cape Breton and Newfoundland. The re-united cold waters then sweep over all the banks off the Nova Scotia coast, including Sable Island, and bathing the south-eastern portion of Nova Scotia itself, continues on to St. George's Bank and the Nantucket shoals. Much warmed on the surface by the higher southern temperature and by the Gulf stream, with which it is in contact all along its eastern border, it continues on southward, sending perhaps a branch into Long Island Sound, until it dips beneath the Gulf stream near Cape Hatteras, and continues southward as a bottom current. Altogether outside of the Labrador current comes the Gulf Stream. Its limits vary with the season, its northern edge moving northward in summer, and to the southward in winter, but it never comes near enough to the coast of Acadia to reach the banks; and there is no evidence to show that branches are sent from it to Sable Island, to Newfoundland, or to other parts of Acadia proper, as some writers have imagined in order to explain the occurrence of the southern forms in these localities.¹

So much for the physiography of the shores of Acadia to-day; we must now briefly inquire what evidence we can find as to recent changes in these conditions.

Many indications point to the conclusion that our shores are not in a condition of stability, but are steadily sinking, and this subsidence extends far beyond our own limits. Thus, on the coast of New Jersey, as observed by Gesner² and others, a depression is going on and has already progressed several feet. Also at Nantucket Island and at Portland, Maine, the same phenomena are observed. At Grand Manan, as shown by stumps of trees, still undecayed, in place in channels between some of the islands,³ there has been a subsidence of at least eighteen feet, and it may have been very much greater. Additional evidence is afforded by the peat beds which now dip to the beaches and are covered by high tides. At the head of the Bay of Fundy, Gesner,⁴ Dawson,⁵ Matthew,⁶ Hind,⁷ Murphy⁸ and others have pointed out abundant indications of a subsidence now taking place, which, as shown by buried trees and stumps in position near and below low tide

¹ Yet southern forms may be brought to the north by it, and such forms as are free living carried by long-continued southerly winds to our shores. The Portuguese man-of-war found occasionally in the Bay of Fundy and in Newfoundland are evidence of this. (See Antea, p. 169). Yet this could not apply to the larvae of mollusca, etc., which must in general find in a very few days after birth a firm surface to which to affix themselves, or they perish. Hence Sable Island could not have been colonized in this way from the south, even if there is a branch of the Gulf Stream running to it, which is improbable.

² "On elevations and depressions of the earth in North America." *Proc. Geol. Soc. of London*, 1861, p. 381.

³ And as has been pointed out to the present writer by Mr. Simeon Cheney, of Grand Manan. They occur in Nantucket Island and at other places.

⁴ *Proc. Geol. Soc.*, 1861.

⁵ *Bull. N. B. Nat. Hist. Soc.*, No. 5, pp. 17-19.

⁶ *Trans. N. S. Inst.*, Vol. vii, Pt. I, p. 48.

⁷ "Acadian Geology."

⁸ *Rep. Geol. of N. B.*

mark, must have progressed to an extent of at least forty-five feet, and Mr. Chalmers has lately seen evidence which indicates that it was at least 80 feet.¹ And this depression must have taken place very recently, for the wood is still undecayed. At Baie Verte Gesner points out that old Fort Moncton is now reached by the tides which cover its causeway at high water, and gives other evidence to show a subsidence in very recent times. In Cape Breton, the story is the same, for at Louisburg, as he tells us, the tide now flows within the walls where a hundred years ago was dry land. Stumps of trees below low water mark are also found at North Cape, and point to the same conclusion. Around Pictou there is an extensive subsidence in progress, as is shown by Rev. Mr. Patterson in his History of Pictou.² On Prince Edward Island, every geologist who has visited it has seen evidence of considerable subsidence. Gesner³ and Dawson⁴ have remarked on this, the former showing that it must have taken place to an extent of at least nineteen feet. At Baie du Vin, in Miramichi Bay, Gesner noticed a peat bog dipping under the sea, and similar bogs have been seen by Mr. Chalmers⁵ at Point Escumenee and other places on the New Brunswick coast, portions of which are several feet below high-tide mark. He concludes that as these bogs could only have started above high-water mark, a subsidence of from ten to fifteen feet is indicated, and perhaps somewhat more. Again, at Sable Island, there can hardly be any question that an extensive subsidence is going on. This island has been reduced within three hundred years from a length of eighty to a length of thirty-three miles, and from a height of three hundred to a height of one hundred feet. Messrs. S. D. Macdonald⁷ and J. M. Oxley,⁸ who have studied the characters and history of the island, both see in it evidence of extensive subsidence. Mere washing away by storms and current action they consider insufficient to explain the phenomena presented.

As to Newfoundland there appears to be some doubt, and the little evidence we have is conflicting. Sir Wm. Dawson states in "Acadian Geology" that it is sinking. On the other hand, Packard expresses⁹ the opinion that the land is rising in the vicinity of the Straits of Belle Isle, though he has but few and imperfect data for his conclusion. Yet in another

¹ See "Summary Report of Progress Can. Geol. Survey for 1889," p. 29. In a letter to the writer Mr. Chalmers says that the evidence of the buried peat beds as shown by borings in connection with the Chignecto Ship railway indicate a depression of at least 80 feet.

² As pointed out by Mr. Edward Jack, in an article in St. John. Daily Sun, Aug. 2nd, 1889.

³ The effects of subsidence are in this work much mixed up with the effects of silting up, but the fact of subsidence is plain.

⁴ Gesner in the same paper, has also given evidence to show that an elevation is taking place at certain points. But the evidence is drawn from two sources which are not necessarily reliable. One of these is from the shoaling of water as in the vicinity of Halifax. This does not necessarily imply elevation unless the bottom is of rock, for the currents are constantly changing the characters of ordinary shoals. Also raised beaches have been quoted, but unless these contain remains almost absolutely identical with those in the neighbourhood, they do not prove the land is rising. They prove the land has risen, but there is nothing about them to show that the land may not be sinking again. Gesner says the remains in these beaches are identical with living forms of the neighbourhood, but Gesner was not an over-careful naturalist, as his mistake about the presence of southern forms in Bay Chaleur marl beds shows. The same criticism may be made on much of the evidence of E. Réclus, in his work "The Earth." In certain places he takes the presence of raised beaches as indicating that the land is rising. They prove that it has risen at some time, but do not prove that it is not sinking at present.

⁵ Rep. on Geol., P. E. I., 1871.

⁶ Rep. Can. Geol. Survey, 1887, Part. N.

⁷ Trans. U. S. Inst. Nat. Sci., Vol. vi.

⁸ Scribner's Magazine, Vol. i, p. 603.

⁹ Memoirs Boston Soc. Nat. Hist., Vol. i, p. 220.

place he gives us himself what he considers good evidence of a subsidence which has taken place since the formation of the Post-pliocene beaches, and this subsidence he estimates at at least three hundred feet. He says; "Again, dredging was carried on off Henly Harbour on a pebbly bottom 300 feet below the surface, which formed the continuation of the same beaches which rose some 200 feet above the sea-level. It follows from this that, as both the jagged rocks and submerged beach must have formerly formed a coast line, the land once stood at least 300 feet higher than at present, and it is more than probable, much higher." Of course this does not show that the subsidence is still progressing, simply that it has taken place since the formation of the Post-pliocene beaches. Other evidence is adduced by Mr. Edward Jack,¹ but it is based upon the presence of raised beaches at Notre Dame Bay, and while raised beaches prove that an elevation has at some recent time taken place, they do not prove that the elevation is still going on, or that a subsidence may not be at present taking place. Mr. Jack quotes an article by Julian Moreton,² in which it is considered that the land is rising in the same region since the water in the coves is rapidly shoaling. The shoaling of water is good evidence of rising of the land when the bottom is of solid rock, or when no detritus can be laid down, but very poor evidence where the bottom is of shifting materials. The submergence of human works and of recent land vegetation are the best kinds of evidence of progressing subsidence.

Proceeding further north, there is found upon the south-eastern coast of Greenland evidence of progressing subsidence which has been noticed by several writers.³

In general terms then, a subsidence of the land is taking place on all our eastern coast from New Jersey to Greenland and in Acadia it has progressed to an extent of at least eighty feet, and perhaps much more.⁴ This of course implies that the land has in very recent times, after the deposition of the Post-pliocene beaches, stood at an equal height above its present level. Such an elevation would produce very great changes in the coast line of Acadia, and this in time must greatly affect the directions of the currents and the character of the tides. It is in this that Professor Verrill has found the explanation of the phenomena we are considering, and there can hardly be any doubt that in the main it explains the known facts. Sir William Dawson has accepted this explanation.⁵

Professor Verrill says, "The *origin* of the southern species in the gulf is a totally different matter. I can explain their presence there in no other way than to suppose that they are survivors from a time when the marine climate of the whole coast, from Cape Cod to Nova Scotia and the Bay of Fundy was warmer than at present, and these species had

¹ St. John Daily Sun, Aug. 2nd., 1880.

² Journ. Royal Geog. Soc., Vol. xxxiv, 1864, p. 265.

³ Réclus. "The Earth." 'Encycl. Britannica,' Art. "Greenland."

⁴ It seems not improbable that this subsidence which is going on may be progressing more rapidly to the north than on the south. This was precisely what occurred in the great submergence which preceded the formation of the Post-pliocene beaches. These beaches are at Nantucket, Mass., about 85 feet above sea-level; near Boston 75-100 feet; coast of Maine over 200 feet; in Acadia, 350-400 feet; Labrador, 500-800 feet, and Greenland 1000 feet. The last great submergence then was greatest northward. Perhaps that which is now going on may be similar.

⁵ 'Canadian Naturalist,' Vol. vii, 1874 277-281.

⁶ 'Proc. Am Assoc,' for 1873.

a continuous range from southern New England to the Gulf of St. Lawrence. * * *

The causes of such changes in the temperature of the water may have been entirely local, and due to changes in the relative level of the land and water in adjacent regions. Thus a rise of the land in the region of Saint George's Bank, to the extent of 250 feet, would produce an island quite as large as the State of Massachusetts, and would thus very materially alter the climatic conditions of the "Gulf of Maine," between it and the New England coast. And it would add a great body of land, now represented by Le Have Bank, etc., to the southern part of Nova Scotia, and thus greatly narrow the channel between those banks and St. George's, as well as make it more shallow; this would, doubtless, greatly modify the tides, and greatly diminish their force and height on the northern coasts of New England, and in the Bay of Fundy, for the "Gulf of Maine" would then have much resemblance to the Gulf of St. Lawrence in form and in the character and position of its main channel, and, therefore, its tides would also be similar; the small tides would allow greater differences between the temperatures of the shallow waters and deep waters, and would thus favour the southern species inhabiting shallow water. A rise of the land, of about the same amount, in the region of Newfoundland, would lay bare a great part of the Grand Banks, close up the Straits of Belle Isle, and more than double the size of Newfoundland, which would, doubtless, produce great climatic changes on the Newfoundland coast, as Professor Dana has shown."

As this is the most complete discussion and full explanation of this problem that has yet appeared, we quote it in full. It will be noticed that its essential point is, an elevation which brought the Nova Scotia and Maine Banks to the surface and thus allowed the water along the shore to become warm by turning aside the Labrador current. This, however, requires a much greater subsidence than we have other evidence of, especially for the region of St. George's Bank. We cannot say that this subsidence has not taken place; there is nothing in it inherently impossible, and we know that the coast of Scandinavia has been recently submerged to a depth of at least 150 metres, and has risen to that extent. But the greatest subsidence of which we have evidence in Acadia is only about eighty or ninety feet.

It seems quite possible that along with the undoubted deflection of the Labrador current from the coast, there was some change in the temperature of the current itself. We have historical evidence of a fairly satisfactory character to show that the climate of the eastern coast of Greenland, along which passes the Greenland current, which joins the Labrador current and forms part of it, was nine hundred years ago much milder than now. About the year 1000 there were settlements on the east coast, the ruins of which are still to be seen, in situations now ice-bound and uninhabitable. The history of Iceland, moreover, shows that its climate in recent times was milder than now. Both of these regions are bathed in part by the cold Greenland current, and their former milder climate must have been connected with some change in the character or temperature of that current. Perhaps connected with the same question is the fact that the Greely expedition found in Grinnell Land remains of Esquimaux huts and recent relics, very far north of where the Esquimaux ever think now of settling. This seems to point to a former milder climate there in recent times, which again may be connected with some change in the currents of the region or some other wide-spread cause of amelioration of climate around the northern seas.

As to the causes of changes in the currents of this northern region we have few data. Perhaps they are connected with the extensive elevations and subsidences now taking place around the northern ocean. The shores of Scandinavia, of Spitzbergen and of Arctic Siberia, are well known to be rising, and in the former case this is known to have progressed to a height in places of 300 or 400 feet. On the other hand, parts of Greenland are as certainly and steadily sinking. Now the Arctic ocean is a great enclosed basin with but three openings—the narrow and shallow Behring's Strait, the passage between Labrador and Greenland, and that between Greenland and Scandinavia. It is through the latter of these, especially along its eastern part, that there moves northward the great body of warm surface water which is popularly supposed to be the continuation of the Gulf Stream, but which is now believed to be the northward movement of a great body of water as a part of the general oceanic circulation maintained by opposition of temperature. So great is the volume of this warm water that it raises the temperature of all Eastern Europe far above that of the corresponding latitudes to the west. Under this there moves slowly southward a great body of cold water, and to the west this colder water is not at all, or only slightly overlaid by warmer water and becomes a surface current, the Labrador and Greenland currents, and these currents must be considered as a part of the compensating southward movement of cold water to balance the northward movement of the great volume of Atlantic warmer water moving north-eastward. It seems not impossible nor improbable, that when Spitzbergen and Scandinavia were lower than now and their seas deeper, and when Greenland was higher and its seas shallower, in other words when the north-eastern Atlantic was deeper and the northwestern Atlantic shallower, that the cold under-currents of the former may have been increased in amount and the cold surface-currents of the west similarly decreased in volume and rate. This means that a process of emergence of the land is attended by a retreat of cold currents from the coast, and a sinking by a closer approach of cold currents. This is paralleled in the case of the Post-pliocene deposits which, as Sir William Dawson has shown,¹ show a gradual amelioration of the temperature of the Post-pliocene coast waters, and this was attended by a rising of the land, the highest beaches and deposits being the oldest, and it is exactly what we find to-day in Acadia, where a sinking of the land is attended by a closer approach of cold currents to the coast. But whatever the explanation may be, it appears as if in connection with the throwing off of the Labrador current from our coast, that current itself may have been of a less Arctic character when it reached our shores. This, of

¹ Sir William Dawson has shown that in the Post-pliocene seas of Acadia, the Labrador current must have flowed much as it does now, only with greater force and a lower temperature. By it the true Acadian fauna was forced southward to Maine and Massachusetts, but as Packard has pointed out, there was not much change on Post-pliocene shores from present conditions to the south of Cape Cod, that cape forming then as now a natural boundary between northern and southern forms. The sequence of changes in Acadia then would seem to be as follows, beginning with the Champlain era:—

- (1.) A great submergence of 300 to 400 feet in Acadia, allowing the Labrador current to directly wash the diminished coast line and bring to it Arctic conditions.
- (2.) A gradual but intermittent rising of the land during which the cold current was pushed off and there was a gradual amelioration of climate and the deposition of new and lower beaches. This rising continued until the land stood much above its present level, bringing up the Nova Scotia banks and exhibiting the extreme of amelioration. It was then that the Virginian forms came northward and occupied all of our waters.
- (3.) A subsidence began again and is still going on. This is attended with a return of cold currents and greater severity of marine climate which is driving out the southern and bringing back the northern forms.

*see back
our sink of
4. rising
7. 10. 11. 12. 13. 14. 15. 16. 17.*

course, is subsequent to the deposition of the Post-pliocene deposits and at a time almost within the range of historical records.

In reality, it is the matter of summer temperature that is all important. Probably a rise of the temperature of the Atlantic coast of Acadia during the three summer months to an extent of not more than twenty degrees Fahrenheit, or perhaps less, would allow our entire coast to be re-peopled by the southern invertebrates which once occupied them. At present the temperature of these waters in summer is not far from 45° F. These same southern forms live and reproduce in parts of Massachusetts Bay, where the summer temperature cannot be more than 15° F. above this. It appears as if this rise of 15° F. is amply explained by the known facts. The facts known to us certainly prove that a subsidence of the land is taking place along all our eastern coast, and that it has progressed to an extent of at least more than eighty feet; perhaps it is much greater. This implies a recent elevation of the land above its present level to the same extent, and the inevitable effect of this elevation must have been to bring the banks from Grand Bank to St. George's nearer to the surface, which in turn must have thrown the bulk of the Labrador current off the coast. The water on and inside the banks would then become much warmer under the summer sun, both on account of their greater shoalness and on account of the turning aside of the cold current. The tides, as Professor Verrill shows, must have been much affected even if the elevation was not nearly so great as Professor Verrill has supposed. By shoaling the Bay of Fundy the basin to be filled at its head would be greatly diminished, and it would have less of the funnel shape; both of which are conditions favouring high tides and rapid currents. The shoaling of the bay and the diminution of high tides and currents would diminish greatly that mixing of deep cold bottom water with surface strata which is the great cause of the low temperature of shallow waters about the Bay of Fundy and Atlantic coast. If we add to this the very probable closing of the Straits of Belle Isle and consequent cutting off of the branch of the Labrador current through the Gulf, and the very possible higher temperature or diminished force of the Labrador current itself and its attendant diminution of the prevalence of fogs, we have a set of conditions all pointing in the same direction and all tending to show an amelioration of the summer temperature of our coast even greater than appears to be required to allow of the spread northward of the Virginian forms. It may be that the temperature was much higher than the minimum required, consequent on a much greater elevation of the banks than we have any proof of, and that the Virginian forms did not creep northward under difficulties, but found most congenial conditions here and flourished as well as in their present homes.

The question now arises, are there other colonies on our coast of a similar character? Of this too little is yet known to give a positive answer. But it seems probable that the conditions which allowed the Virginian fauna to come north to us, may have allowed our Acadian fauna to advance northward on the coast of Labrador, and possibly in some sheltered inlet on that coast some truly Acadian littoral forms may yet be found. It may even be, when James and Hudson Bays are explored with reference to their marine invertebrates, that a true Acadian colony may there be found, cut off by more northern forms from their homes in the Gulf of St. Lawrence. It is barely possible that in the same way Syrtensian colonies may have been left still further north amongst purely Arctic forms. It is quite likely too that the reverse might take place, and has taken place, that as the marine cli-

mate of a region has become ameliorated, and southern forms could thus creep northward, in local deep areas, northern forms might be left cut off by shoaler waters and more southern species, from their congeners to the north. The bearing of such a question on paleontology is obvious, and is doubtless fully recognized. It is to be hoped that if such colonies, either southern or northern, become fossilized and are studied by future geologists, the science will have reached such a state that they will not draw wrong conclusions as to the prevailing climatic conditions, or the relations or rather non-relations of these species to those which immediately precede or follow them in lower or later strata.

A very interesting question, and one of much importance from an economic standpoint on account of its connection with the oyster fishery, is as to the future of the Virginian colonies in our waters. So far as the facts are known, the subsidence in our coast is still going on, and the effect of this must be to make the conditions more and more favourable to northern forms, and less and less so to the southern colonists—in other words, the southern forms are approaching extinction. That this process may be arrested and the conditions begin to mend is, of course, at any time possible, and must in time occur, but that time may be decades of centuries away. Still, the prospect is not all dark for the future of the oyster fishery in Acadia, for while these processes are rapid from a geological stand-point, they are very slow from a human point of view, and the lifetime of a generation can perceive little or no change. So slow are the processes that they need not be taken into account by practical men, and government or individuals can wisely and safely treat our oyster fishery as if, so far as natural causes are concerned, it would last forever.

There is still much to be learned in connection with this question. There is very much needed, a more definite knowledge of the marine currents of our coast, knowledge indeed which is imperatively demanded for commercial reasons as well. The progress of geological science will doubtless solve the larger questions as to the changes of elevation and depression of land on a large scale in the northern regions and their effects on great currents, and geology will be greatly aided in this by accurate observations of local elevations and depressions. A search for other colonies to the north should also be made, as well as for the suspected Virginian colony on the southern coast of Newfoundland. And local naturalists will render a great service and derive much pleasure and profit by attempting to fill out the many blanks in the table above, as well as by a study of other groups in the same localities. They will find in this an entirely unworked field.

