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ART. XVI.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XXVII.—*Results of recent Dredging Expeditions on the Coast of New England.* No. 5; by A. E. VERRILL.

[Continued from page 46.]

THE shores of the islands and of Cape Elizabeth afford excellent collecting grounds at low water, owing to their diversified character. A large part of these shores are abrupt and rocky, and often formed of broken and precipitous ledges of hard metamorphic slates and thin-bedded grits, or altered sandstones, in some places passing into gneissose rocks, and generally dipping at a high angle. Tide-pools are of frequent occurrence, and often of large size, and afford excellent opportunities for obtaining the shallow-water and littoral species of animals, and many beautiful algæ. One very large pool on Ram Island Ledges was especially rich, and was visited several times with profit. In this pool young lobsters of all sizes were very abundant beneath the stones. Two species of Chitonidæ also occurred here, together with many other species not usually to be found at low-water mark. Hydroids and Bryozoa, of many species, were abundant in this and other similar pools. The shore species obtained upon the islands and outer shores of the bay were nearly all boreal or arctic forms. In the harbor of Portland, on the piles of the wharves, etc., a few more southern species were met with, though the northern ones predominate even there.

Several insects were met with between tides. Among these were *Chironomus oceanicus*, and the larvæ, about two inches long, of a fly, probably an *Eristalis*, which lived in small tide-pools, under stones, and extended their long tapering tails up to the surface; the pupa of a fly allied to *Ephydra*; a species of *Bledius*, and several other beetles; and two or three species of mites, were also collected between tides. The following were among the shore-dwelling species:

Crustacea.

Cancer borealis.	Gammarus marinus.	Cerapus rubricornis.
C. irroratus.	Hyale littoralis.	Unciola irrorata.
Hippolyte pusiola.	Talorchestia megaloph-	Jæra copiosa.
H. spina.	thalma Smith.	Idotea irrorata.
Crangon vulgaris.	Orchestia agilis Smith.	I. phosphorea Harger.
Eupagurus Bernhardus.	Calliopius læviusculus.	Erichsonia filiformis Har-
E. Kroyeri.	Pontagenia inermis.	ger.
Gammarus ornatus.	Amathella angulosa (?).	Balanus balanoides.

Annelids.

Lepidonotus squamatus.	Nephtys, sp.	Eulalia pistacia V.
Harmothoë imbricata.	Nereis virens.	Eteone, sp.
Eunoë (Erstedii).	N. pelagica.	Phyllodoce catenula V.

Rhynchobolus dibranchi- atus.	Autolytus cornutus.	Amphitrite brunnea(St.sp.).
Cirratulus cirratus.	Proceræa gracilis, new sp.†	Polycirrus, sp.
Lumbriconereis fragilis.	Polydora, sp.	Myxicola Steenstrupii.
Stephanosyllis ornata V., new sp.*	Nicomache, sp.	Fabricia Leidy V.
	Clymenella torquata V.	Potamilla oculifera V.
	Cistenides granulatus.	Spirorbis borealis.

Turbellaria.

Nemertes viridis.	Cosmocephala Stimpsonii V.	Fovia affinis.
Borlasia, sp.	Monotus spatulicauda.	Leptoplana ellipsoides, etc.
Tetrastemma, three sp.	Monocelis, sp.	

Mollusca.

The shore Mollusca were decidedly northern, and the species were not very numerous. Among the most abundant of them are the following:

Purpura lapillus.	Littorina palliata.	Saxicava arctica.
Buccinum undatum.	Lacuna vineta.	Mya arenaria.
Ilyanassa obsoleta.	Rissoa aculeus.	Macoma fragilis.
Tritia trivittata.	Littorinella minuta St.	Turtonia minuta.
Lunatia heros.	Skenea planorbis.	Mytilus edulis.
Littorina littorea.	Acmaea testudinalis.	Modiola modiolus.
L. rudis.	Æolis papillosa.	Amarœcium glabrum.

* *Stephanosyllis ornata* V., sp. nov.

Body moderately slender, thickest near the middle, tapering slightly anteriorly, and rapidly posteriorly, the caudal portion acuminate, with two slender caudal cirri. Antennæ and tentacular-cirri long, slender, and tapering, slightly and irregularly annulated, or transversely wrinkled; median antenna longest, reaching back to about the tenth segment; lateral antennæ about equal to the upper tentacular cirrus, or reaching to about the sixth body-segment; lower cirrus about half as long; dorsal cirrus of the second segment very long and slender, equaling or exceeding the median antenna; dorsal cirri of the third segment as long as those of the first, or longer, more than twice the diameter of the body; those of the fourth segment less than half as long; those farther back unequal in length. Head rounded in front and behind, broad, the anterior pair of eyes larger and wider apart than the posterior ones; "epaulets" conspicuous, lanceolate, extending back to the fourth segment. Color, in life, pale green, especially beneath and on the sides above; back, bright orange-red, with transverse lines of green at the articulations; setigerous lobes whitish; lateral cirri pale greenish white; antennæ and tentacular-cirri pale salmon, often tipped with pink; epaulets orange, centered with green, and bordered by a line of white, and with a red line along the edge; head pale yellow; eyes black. Length, 12^{mm}; breadth, .75^{mm}.

Casco Bay, 6 to 20 fathoms, stony; and in tide-pools at low-water. This was mentioned in No. xxvi, p. 43, as "*S. picta*;" that name is preoccupied.

† *Proceræa gracilis* V., sp. nov.

Body very slender, elongated. Head subcordate, longer than broad, rounded in front, posteriorly extending back in two short rounded lobes, not reaching beyond the buccal segment; anterior eyes considerably farther apart than the posterior ones. Antennæ and upper cirri of the first two segments very long and slender, faintly annulated; the median antenna is very much elongated, considerably longer than the lateral ones, and about equal to the dorsal cirri of the second segment; the lateral antennæ are about as long as the upper tentacular-cirri, or about five times the diameter of the body; the dorsal cirri of the third segment are about twice as long as the diameter of the body; the cirri on the succeeding segments are about half as long as the breadth of the body. Color, in life, pale greenish, with a narrow median dorsal line of dark brown, and a less distinct one on each side, at the base of the lateral appendages; eyes black. Length, about 25^{mm}; breadth, 1^{mm}, or less.

Casco Bay, 10 to 20 fathoms; and in tide-pools.

Radiata.

The most common shore species were:

Strongylocentrotus Drö-	Campanularia flexuosa.	Sertularella rugosa.
bachiensis.	Sertularia pumila.	Clava leptostyla.
Asterias vulgaris.	S. argentea.	Metridium marginatum.
Obelia geniculata.		

Several species of sponges are also common between tides.

On the sheltered muddy bottoms, from just below low-water mark, to the depth of about two fathoms, the eel-grass, *Zostera marina*, grows in abundance. Among this many species of crustacea, worms, and mollusks find congenial abodes, and furnish abundant food for the fishes that frequent such localities. Some of these are somewhat southern in character.

Among the Crustacea from the eel-grass were: *Hippolyte Gaimardii*; *Crangon vulgaris*; *Mysis stenolepsis* Smith; *M. Americana* Smith; *Calliopius læviusculus*; a new genus with very large epimera, allied to *Metopa*; a new species of *Munna*, a genus of isopod crustacea, new to the American coast; *Idotea irrorata*, etc.

From the piles of the wharves at Portland a great variety of sponges, hydroids, bryozoa, etc., were obtained; the slender branched sponge, *Chalina oculata*, was here particularly abundant and fine; also *Metridium marginatum*; and the compound Ascidian, *Amarœcium glabrum* V., with many other northern forms. The *Limnoria lignorum* was found in abundance, destroying the piles and timbers.

Among the more interesting littoral species obtained on the shores of Casco Bay and vicinity, were *Littorina littorea* and the *Cancer borealis*. The latter is a large crab which has hitherto been very rare in all collections, and but imperfectly known; this we found in large numbers on the ledges at the northern end of Peak's Island and Pumpkin Knob, in tide-pools, or clinging to the sea-weeds in more exposed situations, but never concealed beneath the rocks with the *Cancer irroratus*, which was there abundant. The carapaces and claws of the former were also found in abundance at considerable distances from the shores, whither they had been carried by the gulls and crows. Owing to the exposed situations in which they live, they must fall an easy prey to rapacious birds. We obtained eighty-five specimens in one morning. The *Littorina littorea* occurred sparingly at various localities on the islands, but was found in great abundance at Scarborough, on the piles of a bridge, by Dr. Edw. Palmer. It has been supposed by several writers that this shell has been recently and accidentally introduced from Europe; but Dr. Dawson informs me that he collected it more than thirty years ago in the Gulf of St. Lawrence. It is abundant at Halifax, and we have other specimens from

Kennebunkport, Me., Hampton beach, N. H., and Provincetown, Mass. There is really no sufficient evidence that it was not an inhabitant of our shores before the advent of Europeans, but local in its habitats. It may have become more diffused in recent times, by commerce, or it may have been overlooked formerly by collectors.

One of the localities, most interesting zoologically, that we visited, was a small shallow and sheltered cove, at the upper end of Quahog Bay, about thirty miles northeast from Portland. This place is well known to be inhabited by the round-clam or "Quahog" (*Venus mercenaria*), which is not found living elsewhere on the coast of Maine, so far as known to me. Indeed, this southern species is rare everywhere north of Cape Cod, on the New England coast, and is probably not to be found living north of Massachusetts Bay, except in the coves connected with Quahog Bay. It is also absent from the Bay of Fundy, but reappears in the southern and shallow parts of the Gulf of St. Lawrence. This anomalous distribution would be curious, even if it happened only in the case of this one species; but our investigation of this locality shows that there is quite a number of other southern species associated with the quahog, which have the same remarkable distribution, being absent along the rest of the northern coast of New England, and reappearing in the Gulf of St. Lawrence. There is, in fact, at this place a genuine colony of southern species, completely isolated from their co-species of the southern coast of New England, and surrounded on both sides by more northern forms. Several of these southern species, like the *Venus mercenaria*, *Crepidula convexa*, *Eurosalpinx cinerea*, *Eupagurus longicarpus*, *Epe-lyls trilobus* Smith, *Meckelia ingens* Leidy, *Asterias arenicola*, etc., were not even met with among the islands and coves of Casco Bay; while others, such as *Ilyanassa obsoleta*, *Crepidula fornicata*, *C. plana*, *Limulus Polyphemus*, etc., occurred more or less frequently in the more sheltered and shallow waters of Casco Bay, though they are not found on the more exposed shores of Maine and New Hampshire, farther to the south and west, but have their true homes south of Cape Cod. Native oysters also occur, in a similar way, farther eastward than Quahog Bay, near Damariscotta, though it is not probable that they are indigenous elsewhere on the New England coast, north of Cape Cod,—as they certainly are not north of Massachusetts Bay,—yet they reappear in the Gulf of St. Lawrence, with the other southern forms.

In fact, the southern part of the Gulf of St. Lawrence, from Chaleur Bay to Prince Edward Island and Cape Breton Island, is a region of shallow water, occupied by another southern colony, but a much larger one than that of Quahog Bay, and contain-

ing, perhaps, a few southern species that do not occur in the latter locality; though owing to the fact that we could spend but a few hours at this place, our collection is doubtless quite incomplete. On the other hand, we have, with the exception of the shells, very imperfect lists of the southern species inhabiting the colony in the Gulf of St. Lawrence, so that a complete comparison cannot be made, at present, except with the shells; these agree very closely, according to the lists given by Dawson, Bell, and Whiteaves.

As the existence of these isolated southern colonies has an important bearing upon the question of former changes of climate on our coast, and as other facts, to be mentioned further on, are intimately connected with them, I give here a list of the species obtained by us, in the cove referred to, so far as they have been identified.

List of species collected at low-water in a small cove at the upper end of Quahog Bay.

Those with an asterisk prefixed are decidedly southern species, belonging properly to the region south of Cape Cod.

ARTICULATA.

Crustacea.

Cancer irroratus.	Gammarus ornatus.	Limnoria lignorum.
*Eupagurus longicarpus.	Amphithoë, sp.	*Argulus, sp.
Crangon vulgaris.	*Epelys trilobus <i>Smith</i>	*Limulus Polyphemus.
*Mysis stenolepis <i>Smith</i> .	Idotea irrorata.	Balanus balanoides.

Annelids.

Lepidonotus squamatus.	*Rhynchobolus dibranchia-	Fabricia Leidy.
Nephtys ingens.	tus.	Spirorbis borealis.
Nereis virens.		

Turbellaria.

*Meckelia ingens.	Nemertes viridis.	*Nemertes socialis.
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MOLLUSCA.

Gastropods.

*Urosalpinx cinerea.	*Crepidula convexa.	Littorina palliata.
Purpura lapillus.	*C. fornicata.	Lacuna vineta.
*Plyanassa obsoleta.	*C. plana.	Rissoa aculeus.
Tritia trivittata.	Littorina rudis.	Acmaea testudinalis.
Natica heros.		

Lamellibranchs.

Saxicava arctica.	Macoma fragilis.	*Modiola plicatula.
Mya arenaria.	*Petricola pholadiformis.	Anomia aculeata.
*Venus mercenaria.	Mytilus edulis.	

Bryozoa.

Alcyonidium hispidum.	Alcyonidium hirsutum.
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RADIATA.

Echinoderms.

* Asterias arenicola.

Hydroids.

Sertularia pumila.

|Obelia geniculata.

|Clava leptostyla.

Polyps.

Metridium marginatum.

Although the species in this list, that are not marked as southern, have a continuous range northward to the Gulf of St. Lawrence, and many of them to the Arctic Ocean, North Pacific, and northern Europe, they all extend as far south as Long Island Sound, and several of them even to North Carolina. Most of them are, therefore, northern species having a wide distribution, and their presence in this particular locality has no special significance.

In Quahog Bay itself we found the bottom composed of soft sticky mud, and in this we dredged, in 4 to 6 fathoms, a great number of large and fine specimens of *Yoldia limatula* and *Macoma sabulosa*, with a number of other common species.

That the Quahog Bay colony has formerly, and within the human period, been more extensive than at present, is shown: 1,—by the fact that the quahogs have evidently been, at one time, more numerous and more generally diffused than now, for their shells are abundant in the mud, in places where no living ones could be found; 2,—by the occurrence of oysters, in great quantities and of large size, in the ancient Indian shell-heaps of this region, and also near Damariscotta, while at present the oysters found there are few and small; 3,—by the occurrence of the shells of the quahog, of large size, in the Indian shell-heaps on many of the islands in Casco Bay (these heaps consisting mainly of the shells of the "long clam," *Mya arenaria*, with a few bones of fishes, birds, and mammals).

That at a more remote period, the marine climate of this region was still warmer,* and the southern species were more abundant than during the period when the Indian shell-heaps were formed, is shown by the occurrence of great beds of oyster shells a few feet beneath the mud in Portland Harbor, where they are associated with quahogs and several other southern species, among which are *Callista convexa*, *Turbonilla interrupta*, and *Pecten irradians*. The latter is not known to live, at present, north of Cape Ann, on the New England coast. It is absent, apparently, from the colony in the Gulf of St. Lawrence, as well as from that of Quahog Bay. It is very rare north of Cape Cod.†

* The evidence here given is probably applicable chiefly to the temperature of the warmer months, or more properly to the reproductive season of the mollusks referred to, for the climatic distribution of most marine animals seems to depend mainly on the temperature of the season at which reproduction takes place.

† Willis includes this species in his nominal list of Nova Scotia shells, but without mentioning the special locality. It may, perhaps, occur in some of the sheltered localities near Halifax, where another southern colony exists.

The *Callista convexa* is still found sparingly in shallow, sheltered localities in Casco Bay, and rarely at Eastport, Me., but it is more common in the colony of the Gulf of St. Lawrence, and very common south of Cape Cod. But the oysters (*Ostrea Virginiana*) and "scallops" (*Pecten irradians*) had apparently become extinct in the vicinity of Portland Harbor before the period of the Indian shell-heaps, for neither of these species occur in the heaps on the adjacent islands, while the quahogs lingered on until that time, but have subsequently died out everywhere in this region, except at Quahog Bay. The oysters have survived only in the locality near Damariscotta, though far less abundant there than during the Indian period.

The beds of dead shells of oysters, *Pectens*, etc., were found in making excavations in the harbor with mud-digging machines. These beds extend up to or above low-water mark, and are of great extent. Mr. C. B. Fuller, who has made a good collection of these shells for the Portland Natural History Society, informs me that the farmers have, in some instances, found it profitable to cart away these ancient shells for fertilizing purposes. The position of these beds indicate that no important change in the relative level of the land and water can have occurred in that region since they were formed. These beds are, of course, easily distinguished from the much more ancient Post-Pliocene deposits that occur abundantly in the same region, but extend back several miles from the coast, and occur at all levels, from low-water mark to about 200 feet above high-water mark. The latter are characterized, in that region, by a more arctic assemblage of shells than that now inhabiting the adjacent waters, though most of the species still survive, in deep water, off the coast of Maine.

The facts above presented indicate: 1,—that in the Post-Pliocene and Champlain periods the coast was at a lower level, and the marine climate of Casco Bay was colder than at present, probably about like that of the present Newfoundland or Labrador coast; 2,—that at a subsequent period, when the coast had attained nearly or quite its present level, the marine temperature was considerably higher than at present; 3,—that the temperature of these waters has gradually declined, but was still somewhat higher at the period when the Indian shell-heaps were formed than at present.

That the existence and character of the southern colony in the Gulf of Saint Lawrence points to the same conclusion is sufficiently obvious. The survival of the southern species in that region is undoubtedly due to the great expanse of shallow water in that part of the gulf, which becomes well warmed up by the heat of the sun, in summer; and to the absence of tides sufficiently powerful to thoroughly mix up the very cold waters

of the northern and deeper portions of the gulf with the warm waters of the southern part. Tides like those of the Bay of Fundy and coast of Maine would undoubtedly at once diminish this contrast in the temperature of the different parts of the gulf, and greatly lessen the temperature of the southern part, by reason of the far greater volume of the cold water.

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 a continuous range from southern New England to the Gulf of Saint Lawrence. At that time there may have been a direct shallow passage from the Bay of Fundy across to the Gulf of Saint Lawrence, for the land is there narrow and low; but of this we have no direct evidence. A *deep* channel there would act like the Straits of Belle Isle, and admit the cold arctic current to the coast of Maine; this may have been the case in Post-Pliocene times.

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 coasts of northern New England, and in the Bay of Fundy, for the "Gulf of Maine" would then have much resemblance to the Gulf of Saint 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 favor 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 New England coast, as Professor Dana has suggested.

[To be continued.]

ERRATUM.—p. 134, for *Eurosalpinx* read *Urosalpinx*.